U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Technologies and Innovations Enabled by the U.S. Department of Energy Advanced Manufacturing Office

September 2021

Prepared by Pacific Northwest National Laboratory
for the U.S. Department of Energy Building Technologies Office

Technology Tracking Effort through FY21

The investigation described in this report identified and documented the research and development (R&D) innovations and technologies that resulted from U.S. Department of Energy (DOE) support through the Advanced Manufacturing Office (AMO) in the Office of Energy Efficiency and Renewable Energy (EERE).

Pacific Northwest National Laboratory (PNNL) has performed technology tracking for AMO over several decades resulting in numerous published "Impacts" reports. The goal of technology tracking is to discover which R&D projects or technologies will result in a commercialized or near market-ready technology (within 3-5 years).

Since FY2019 the project/technology portfolio tracked by PNNL included R&D projects resulting from several AMO funded consortia initiatives (CESMI, CMI, IACMI, MDF, Power America, RAPID, REMADE)[1]. Through FY2021 the number of active technologies and projects tracked by PNNL was 733 and Table 1 shows the project/technology status breakdown in detail.

Technology Status	Count
Commercial	55
Emerging (< 3years to market)	102
Potential (3-5 years to market)	136
TBD (No response from point of contact)	371
Stopped	53
Archive - Commercial	4
Archive - Emerging	12
TOTAL	**733**

Table 1. Total Active Technology/Projects through FY2021

The 371 "TBD" technologies are a result of several factors; difficulties brought about by the CV19 pandemic in contacting primary investigators (PIs) or organization point of contact (POC), PI or POC contact information has changed (some project/technologies have not responded over past two data gathering cycles, and lastly establishing correct protocols for information transfer regarding consortia projects. Table 2 is a breakdown of the "TBD" projects/technologies consortia and all other funding (AMO office funding R&D initiatives, NGEM, LEEP- {Cyclotron Rd., Chain Reaction & Innovation Crossroads}, SBIR, STTR etc.) and last known technology status where applicable

TBD Technology Counts & Status	TBD	Comm	Emerging	Potential	Total
Consortia funding	199	-	4	6	209
All other funding	72	28	40	22	162
TOTAL	**271**	**28**	**44**	**28**	**371**

Table 2. Total Active Technology/Projects through FY2021

Since FY2019 PNNL has recorded that 105 projects have stopped or ended because of either a lack of funding, technical barriers or market conditions/competition. Table 3 shows the number of archived technologies projects from 1976 through FY2021. In FY2021, 16 technologies were archived, the four commercial technologies reached the 10 year tracking limit for commercial/in-use technologies.

Archive Technologies	Count
Archive Commercial (technology no longer available)	311
Archive Emerging (technology did not go to market)	325
TOTAL	**636**

Table 3. Total Archived Technologies since 1976 through for FY2021

[1] For more information: https://www.energy.gov/eere/amo/research-development-consortia

Patent IP has been collected by PNNL since FY2019 and to date 1,574 patent awards and 231 patent applications have been identified as at least funded in part by AMO funding. Analysis work is in progress to establish the types of organization receiving patent awards as well as in which areas of research. Furthermore, the ongoing analysis will include patent searches based on known organization, inventor, DOE contract number and patent families. Once the AMO patent portfolio has been established it will be further analyzed based on cooperative patent classification codes (CPCs). The initial results of the AMO patent portfolio analysis results will be released in FY2022.

PNNL have been constructing a database of all the technologies tracked over the past 5 decades (technologies date back to 1976). Through FY2021, PNNL has assembled a database core consisting of 1,405 project/technologies (12,856 database information records) including annual updates. PNNL has well over 2,000 AMO factsheets and other relevant information related to these projects/technologies and are in the process of making those documents accessible from within the database. Additionally, work is in progress to incorporate the associated energy savings and technology deployments data recorded by PNNL into this database. PNNL anticipates being able to preview and demonstrate this database in early 2022.

The remainder of this report consists of short summaries on technologies that are newly commercialized or in-use and new emerging technologies that are expected to market-ready or on-use within 3 – 5 years. Also included is a listing of 664 projects/technologies that PNNL is actively tracking in FY2022 with the current and previous technology status.

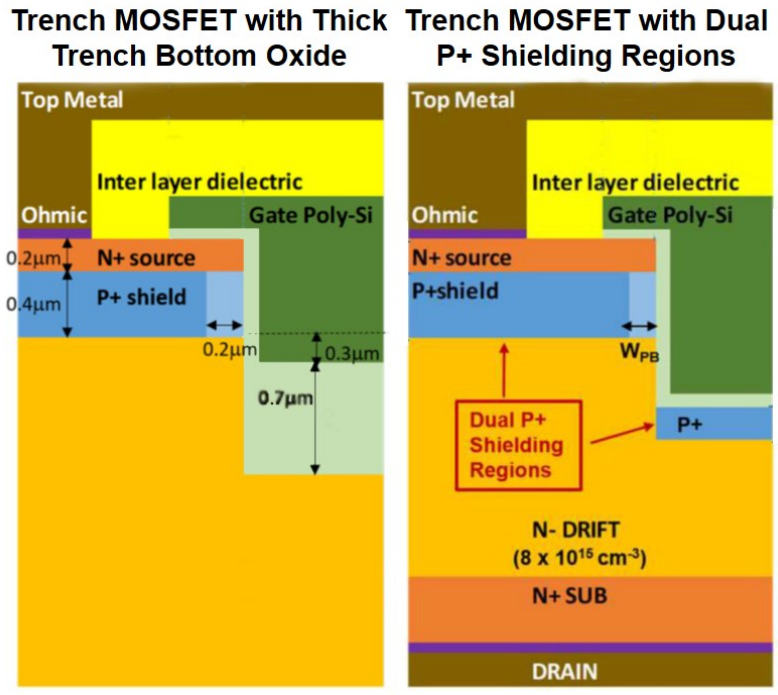
1.2kV SiC Shielded Trench Gate Power MOSFETs

1.2kV SiC Shielded Trench Gate Power MOSFETs

Power semiconductors have played a major role in improving the performance of power converters in all applications. Wide bandgap (WBG) semiconductors such as silicon carbide (SiC) offer several advantages over silicon, the material of choice for decades. In particular, they can operate at higher temperatures (thereby reducing cooling requirements) and are capable of higher power density—leading to smaller devices. However, as the technology of WBG materials advances, new challenges must be met.

With assistance from AMO through the PowerAmerica Consortium at North Carolina State University, the team at North Carolina State has been addressing improvements in performance for SiC power MOSFETs that can enhance the commercialization of "trench-gate" devices contrasted with commonly available "planar-gate" devices. Planar-gate silicon power MOSFETs were supplanted by trench-gate devices in the 1990s to reduce their on-state resistance and power losses. The same holds true for power MOSFETs based on SiC material to take advantage of the smaller cell pitch to achieve very low specific on-resistance. However, there is a serious problem of high electric field strength in the gate oxide that can produce failure of SiC devices.

The team at North Carolina State has combined a number of approaches to obtain a trench-gate SiC power MOSFET structure that has low specific on-resistance, high breakdown voltage while achieving low electric fields. At the time of writing, numerical simulations have been done to investigate the various trade-offs that are performed. (An example is shown below) Presently, fabrication of actual devices has been partially completed.



Cross-Sectional View of NC State's SiC Trench-Gate MOSFET structures: with Thick Trench Oxide (left) and with Dual-Shielding Regions (right)

Overview

- Developed by North Carolina State University, Raleigh, North Carolina.
- Development began in 2018.
- Simulations show excellent performance is possible, but device fabrication has not been completed.

Applications

A device based on this design could be used in high frequency switching converters with high breakdown voltages for a multitude of applications.

Capabilities

- Should lead to devices with higher breakdown voltages and lower on-resistance (and thus needing fewer devices for a given application).
- Creates new device structure with reduced gate oxide electric field to ensure reliable operation.

Benefits

Performance

The advantages of the new device structures created and analyzed in this work are:

1. Low specific on-resistance MOSFETs with reduced conduction losses in applications
2. High blocking voltage devices with reduced electric field in the gate oxide to ensure reliable operation.
3. Device with low gate-drain capacitance and charge to reduce switching losses for enabling high operating frequencies in applications.
4. Devices with reduced cost due to smaller specific on-resistance.
5. Devices that can be fabricated in a commercial foundry to accelerate manufacturing.

Contact Information:
Dr. Jayant Baliga
Email: bjbaliga@ncsu.edu
Phone: (919) 515-6169
North Carolina State University
ECE Dept., Monteith Research Center
Raleigh, NC 27695
Website: https://ece.ncsu.edu/

A Novel Unit Operation to Remove Hydrophobic Contaminants

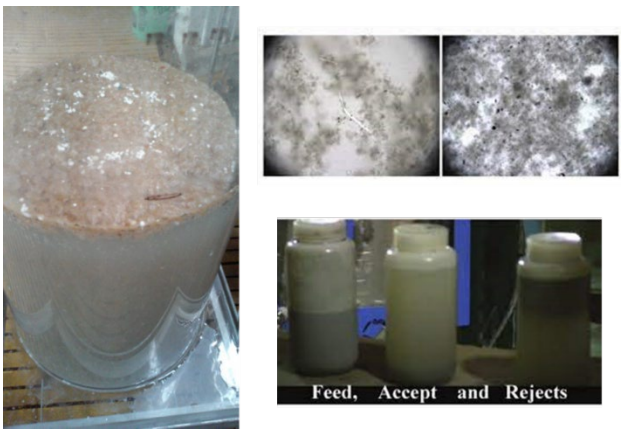
Sustainable Manufacturing – Flow of Materials through Industry **Emerging Technology**

Separation of Contaminants in Paper Recycling with Bubble Nucleation Process

Recycled paper is a potential cost-effective feed source for the papermaking industry. However, recycled paper contains pressure sensitive adhesives, which leave behind small particles in pulp after recycling. These particles, known as stickies, accumulate in the pulp white water and, after multiple water loops, eventually agglomerate and form deposits on papermaking machine wires and felts. These deposits interfere with paper machine operation by causing breaks and holes in paper boards and tissue, reducing overall product quality. Traditional methods to remove stickies are unable to remove deposits less than 100 microns in size without stopping machine production and using costly chemicals.

In 2015, Doshi & Associates, Inc., with assistance from the USDA Forest Products Laboratory and funding support from AMO, developed a Bubble Nucleation Separation (BNS) process designed to remove stickies from recycled paper in papermaking operations. BNS applies a vacuum to a slurry, causing dissolved gas bubbles to nucleate on hydrophobic particles and drag them to the surface for selective removal through a reject stream. Doshi & Associates constructed a 16-L batch unit to evaluate the effect of operating parameters on the removal of hydrophobic particles. The results from the batch unit test were used to design a continuous unit of the same size, as well as a pilot scale unit for laboratory testing.

By 2017, Doshi & Associates had constructed a 200-L unit to test BNS at pilot scale. Following promising results from tests at their own plant, the pilot unit was installed at a commercial paper recycling mill for a trial demonstration. The results from these trials showed that it was possible to remove a considerable amount of suspended solids from paper machine white water with less than 2% of the feed being sent to the reject stream. However, due to size differences between the pilot unit and the mill flow (50 L/min vs. 12000 L/min, respectively), it was not sufficient to determine whether a large-scale implementation of BNS would improve paper machine runnability. Currently, Doshi & Associates is seeking further opportunities to demonstrate BNS on a commercial scale.



Hydrophobic Contaminants form a brown stock mill water sample floating near the surface of the Bubble Nucleation Process Tube (Left); Microscopic images of accept and reject (Top right),samples from the mill trial (Bottom-right)

Overview

- Developed by Doshi & Associates, Inc.
- Development started in 2015
- Development finished in 2017
- Currently working to set up pilot mill trials in existing paper mills.

Applications

Can be used to remove hydrophobic contaminants such as stickies and dirt from white water in paper mills without the use of additional chemicals.

Capabilities

- Can remove hydrophobic particles from paper mill slurry at a recovery efficiency greater than 80% with paper feed sent to the reject stream at a rate of less than 2%.
- Can potentially reduce paper machine downtime by at least 1 hour/week.

Benefits

Environmental Benefits

BNS can remove stickies without the use of chemical solvents and reduce the water consumption needed compared to traditional methods.

Energy Savings

By removing stickies before deposits can agglomerate on paper machine equipment, BNS can potentially reduce downtime by at least 1 hour/week, saving up to 1.45 trillion BTU/year.

Cost Savings

Compared to traditional processes, BNS can both remove stickies without the use of additional chemicals or water treatment as well as reduce the volume of rejected contaminated paper products by improving recovery of recycled paper.

Contact Information:
Mahendra Doshi
Email: mahen@aol.com
Phone: (920) 731-9372
Doshi & Associates, Inc.
18 Woodbury Ct
Appleton, WI, 54913
Website: N/A

Additive Manufacturing of Polymer Based Bonded Magnets

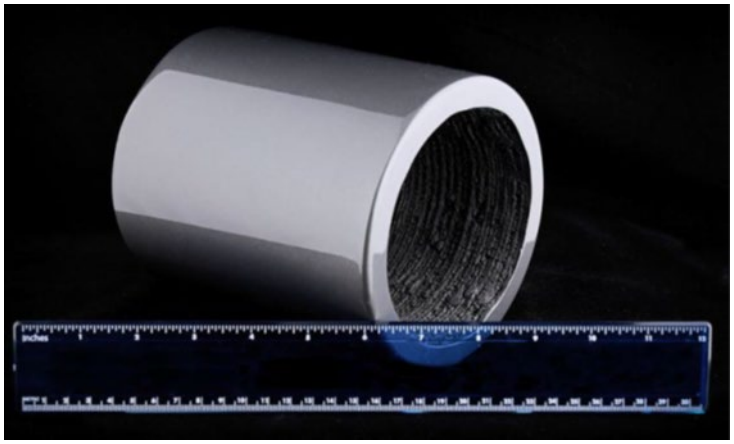
Critical Materials | **Commercial Technology**

Cost-Effective Production of Rare-Earth Composite Magnets

Permanent magnets are widely used for converting electrical to mechanical energy, mainly in motors and hard drives. However, permanent magnets consist of a large amount of rare-earth elements, which are limited in supply, making them very costly despite their prevalence. One strategy to mitigate the cost of permanent magnets is using additive manufacturing techniques to create bonded magnets. Bonded magnets are fabricated by first mixing magnet powder with a polymer binder. These powder-polymer bonds are then built, layer by layer, into a desired shape through a process such as injection molding or extrusion. Bonded magnets created through these processes are done with minimal waste and loss of critical materials and are flexible enough to enable innovative designs for motor magnets.

ORNL, with funding from AMO, tested the binder jet and big area additive manufacturing (BAAM) processes to provide a pathway for preparing near-net shape neodymium-iron-boron (NdFeB) bonded magnets for various magnetic applications. The binder jetting process first deposits the polymer binding agent onto the NdFeB powder. The bound powder is then coated with successive layers of powder and polymer until the desired shape is complete, where it is then cured in an oven followed by removal of excess powder, leaving the finished magnet. For the BAAM process, the starting composite pellets consisted of 65 volume percent isotropic NdFeB powder and 35 volume percent polyamide (nylon-12) as a binder. The pellets were melted, compounded with the binding agent via extrusion melt processing, enabling rapid fusing and solidifying to form the desired shape. It was found that both methods were able to successfully print magnets in the desired shapes, but BAAM offered a more effective pathway to large-scale industry production of bonded magnets with minimal cost and waste.

In 2017, Momentum Technologies licensed ORNL's 3D-printed magnet technology, and began construction to produce 3D-printed magnets made from recycled materials for use in electric vehicles, wind turbines, and high-speed rail. ORNL has continued to conduct studies to improve the properties of their bonded magnets, such as aligning anisotropic magnets post-production and testing the effects of binding the magnet powder to polyphenylene sulfide instead of nylon-12. Currently, ORNL is looking to license their 3D-printed magnet technology in other potential industries.



Isotropic, Nd-Fe-B bonded permanent magnet 3D-printed at DOE's Manufacturing Demonstration Facility at ORNL.

Overview

- Developed by ORNL
- Development began in 2015
- Development finished in 2016
- Technology licensed with Momentum Technologies in 2017

Applications

Can be used to produce composite magnets for use in electronic devices and clean energy technologies; including electric vehicle motors, wind turbines and other alternative energy equipment, medical image machines, and computer hard drives.

Capabilities

- Can produce composite bonded magnets with a density of 4.8 g/cm^3, an intrinsic coercivity H_{ci} = 8.65 kOe, remanence B_r = 5.07 kG, and an energy product $(BH)_{max}$ = 5.47 MGOe
- Can produce composite bonded magnets with an intrinsic coercivity Hci = 11.0 kOe, remanence Br = 5.07 kG, and an energy product $(BH)_{max}$ = 11.3 MGOe after post-alignment in a magnetic field of 20 kOe.

Benefits

Conservation of Critical Materials

Post-alignment after 3D printing can improve the strength of magnets without deformities, enabling the production of reduced amount of rare-earth materials in the magnets while enhancing magnetic properties.

Cost Savings

Can save money compared to traditional magnet producing methods by using additive manufacturing to conserve materials, avoid tooling, and operate faster than traditional injection methods.

Reduction of Waste

Can produce magnets by capturing and reusing materials through additive manufacturing, resulting in nearly zero waste.

Contact Information:
Parans Paranthaman
Email: paranthamanm@ornl.gov
Phone: (866) 574-5045
Oak Ridge National Laboratory
5200, 1 Bethel Valley Rd.
Oak Ridge, TN, 37830
Website: https://www.ornl.gov/

Advanced, Energy-Efficient Hybrid Membrane System for Industrial Water Reuse

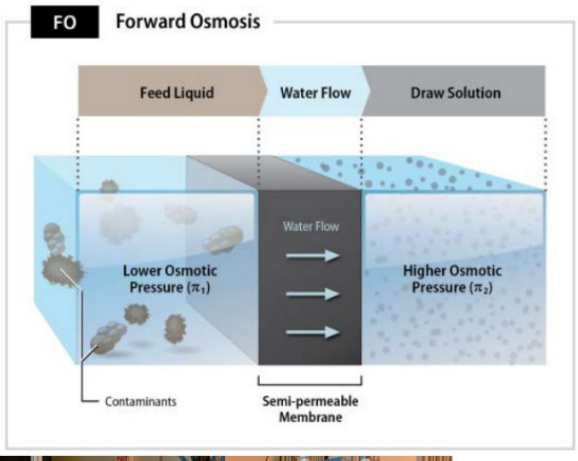
Sustainable Manufacturing **Emerging Technology**

Hybrid Membrane System allows for industrial water reuse at high TDS concentration

The United States relies heavily on water for industrial use and only a minimal amount of water is reused due to high costs. Water reuse will become an important component of the ability of U.S. manufacturing to move toward sustainability in the future as population growth and other factors stress water availability. Reverse Osmosis is the current state-of-the-art for manufacturers that wish to reuse water. However, RO requires pre-treatment of industrial wastewater, and the oils and dissolved solids can foul the membrane. In addition, this process is energy intensive as it requires forcing water through the membrane.

RTI International, in partnership with Duke University and Veolia Water Solution, and with assistance from AMO, has developed a forward osmosis (FO) system powered with waste heat that can provide water quality comparable to current RO systems. The system is capable of producing clean water when the feed water TDS levels exceed 60,000 ppm. The system combines forward osmosis with membrane distillation technology. The system uses a salt "draw" solution on the permeate side of the membrane to remove organic content. The water is then evaporated through heating from industrial waste heat and collected through condensation.

RTI International has demonstrated their FO-MD technology at laboratory, bench, and pilot scales that allow concentration at least 2.5 times higher than the TDS levels that RO can achieve. Membranes that are suitable for full scale plant applications are not currently available, and this technology will need further development before commercialization is possible. RTI currently operates a mobile pilot-scale system with a production capacity of 500 gallons per day and is seeking to demonstrate large scale industrial end use.





RTI International's Hybrid Membrane System

Overview

- Developed by RTI International beginning in 2012.
- Currently operating a mobile, pilot-scale project.
- Full Scale Commercialization will require improvements in membrane technology and more data from pilot-plant studies.

Applications

Can be used treating industrial wastewater with high total dissolved solids to produce water that is comparable to distilled water and suitable for direct reuse.

Capabilities

- Ability to handle feed water higher than 60,000 TDS without expensive pretreatment or thermal evaporation
- Beneficial use of industrial waste heat
- Broadly applicable to many industries

Benefits

Energy Savings

RTI's FO system uses industrial waste heat that could lower electricity costs by >90% relative to RO

Water Reuse

Reuse of high-TDS wastewater will allow for up to 90% reduction in wastewater discharge volumes

Reduced Costs

Reduction in water treatment costs by 20% or more

Environment

RTI's RO technology can potentially enable U.S. manufacturing to become more water sustainable and reduce carbon emissions associated with wastewater treatment by >90%. In addition, it could allow recovery of deep aquifer brine previously regarded as waste.

Contact Information:
Zachary Hendren
Email: zhendren@rti.org
Phone: (919) 541-6000
RTI International
3040 East Cornwallis Rd
Research Triangle Park, NC 27709
Website: https://www.rti.org

Advanced Ice-Thermal Storage

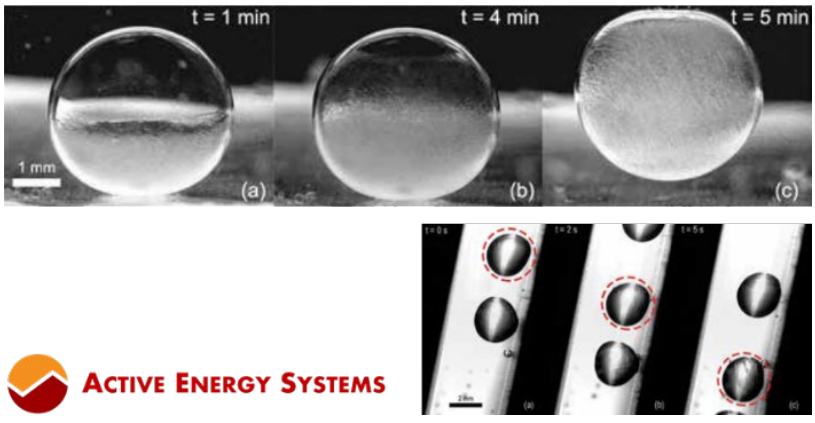
Direct Thermal Energy Conversion Materials, Devices and Systems | **Emerging Technology**

High Efficiency Heat Exchanger for Ice Thermal Energy Storage Systems

Cost-effective storage of energy is imperative for achieving a sustainable future. One method that can help achieve this is ice thermal energy storage. This process uses ice produced from a heat exchanger to provide cooling for buildings during warmer hours of the day, avoiding the use of chilling systems during peak operation hours. However, ice thermal energy storage technology has large upfront costs, mostly due to the cooling coil in the heat exchanger used to produce the ice. Ice-on-coil heat exchangers grow ice radially outward from the coil's cooling surface. As the ice grows, the thermal resistance between the ice and the coil surface increases, requiring more energy to produce additional ice as it adheres to the surface of the coil. Eliminating ice buildup would allow for the reduction of the size of the coil and significantly lower the cost of ice thermal energy storage systems.

In 2016, Active Energy Systems began development on a pumped thermal energy storage system to harness low-temperature waste heat to produce electricity as part of the Innovation Crossroads program. However, a discovery made during development in 2018 led to a shift in focus to ice thermal storage, leading to the development of an icephobic heat exchange (IHEX) system. Having frozen water droplets passively shed from the coil surface to avoid ice buildup can prevent the thermal resistance from increasing. To prevent droplets from adhering to the surface of the coil, the coil was completely coated with polytetrafluoroethylene (PTFE). Active Energy Systems used their own phase change material (PCM), a mixture of water and an ice nucleating protein that freezes more easily than water to test the adherence of frozen droplets to the IHEX's cooling coil surface.

In 2019, Active Energy Systems received SBIR funding from NSF to improve on the fundamentals of IHEX, optimizing plate and tube-based cooling coil geometries as well as the formula of the oil coating to achieve repeatable ice removal. Results from these studies would be used for the development and demonstration of a bench-scale prototype by 2020. Currently, Active Energy Systems plans to bring this technology to pilot-scale by 2022, followed with commercialization through partner companies by 2023.



Active Energy Systems's frozen PCM drop demonstrating low adhesion with a PTFE-coated surface in a silicone oil bath (top) and PCM droplets sliding down a PTFE-coated aluminum plate during the nucleation process (right)

Overview

- Developed by Active Energy Systems
- Development on pumped thermal energy storage began in 2016
- Shifted development to ice thermal energy storage in 2018
- NSF Funding received in 2019
- Plans to achieve pilot-scale production by 2022

Applications

Can provide cost-effective air conditioning for building cooling by shifting cooling loads to off-peak hours when electricity is less expensive.

Capabilities

- Can freeze a 50 µL drop of water with an average heat transfer coefficient of 520 $\pm$ 60 W/(m^{2}K)
- Can operate with a maximum adhesion stress of 5.21 Pa.

Benefits

Cost Savings

The IHEX can maintain a constant heat transfer coefficient over the duration of the freezing process, reducing the required surface area of the cooling coil to make ice, thus reducing overall costs.

Increased Energy Efficiency

Can provide an estimated 15% improvement in energy efficiency upon existing technology through elimination of the heat exchange effect due to ice buildup.

Peak Power Reduction

Can shift peak energy cooling loads from costly peak hours to off-peak hours when electricity is less expensive.

Contact Information:
Dr. Mitchell Ishmael
Email: mitch@activeenergysystems.com
Phone: (865) 257-4742
Active Energy Systems
11020 Solway School Rd.
Knoxville, TN 37931
Website: http://www.activeenergysystems.com

Advanced Manufacturing of High Performance Superconductor Wires for Next Generation Electric Machines

High Performance Superconductors **Emerging Technology**

Manufacturing Process Reduces Fabrication Cost and Minimizes Defects

Superconducting materials have high application potential for advanced electrical motor systems. High Temperature Superconductors (HTS) are being manufactured as wires for advanced motor systems and can provide benefits including improved performance as well as reduced size and weight of the motor. Rare-earth barium-copper-oxide (REBCO) HTS wires are expected to have greater improved performance and reduced overall wire costs based on the critical current at cryogenic operating conditions. But conventional processes used to manufacture REBCO HTS wires are expensive, costing ten times that of copper wire.

University of Houston, with assistance from SuperPower, E2P Solutions, and TECO-Westinghouse, as well as funding from AMO through the NGEM program, developed a method to reduce the fabrication cost of REBCO HTS wires through improved precursor-to-film conversion efficiency and improved critical current value of the wire at a temperature of 65 K. The critical current was increased by increasing the film thickness from 1.5 to 4 μm, but increasing the film thickness increased the density of nanoscale defects, and it was found that the existing Metal Organic Chemical Vapor Deposition (MOCVD) reactor was unable to achieve the performance targets. An advanced MOCVD reactor with parameters derived from modeling was designed and built, allowing for uniform temperature control and more stable precursor flow. An in-line 2D X-Ray Diffraction (XRD) system was also installed after the MOCVD for real-time verification of nanoscale defect growth in the film.

In 2019, University of Houston optimized their parameters of rare-earth and Zr content to reach their critical current goal of 1440 A/cm in 4 μm length films with minimal nanoscale defects. These parameters were used to design and build a pilot-scale system to scale up manufacturing of REBCO HTS wires to up to 50 m in length. Currently, there are plans to commercialize enhanced, low-cost wire manufacturing technology through SuperPower and American Supermagnetics, and superconducting motors made using REBCO HTS wires produced by TECO-Westinghouse by 2023.



University of Houston's pilot-scale reel-to-reel advanced MOCVD system with integrated in-line 2D-XRD for real-time monitoring of tape quality (center) and symmetric tape round wire bent to 30 mm diameter with copper connectors (right)

Overview

- Developed by University of Houston
- Development began in 2017
- Pilot-scaling of wire production began in 2019
- Plans to commercialize technology by 2023

Applications

Can be used for production of motors and generators that have restrictions to their size and/or weight, such as airborne generators for electric aircraft, propulsion motors, superconducting magnetic energy storage, fusion, and wind generators.

Capabilities

- Can achieve a minimum critical current value from 1440 A/cm to 1850 A/cm at operating conditions of 65 K, 0.25 T.
- Can achieve 45% precursor to film conversion efficiency with the Advanced MOCVD reactor up from the former MOCVD reactor conversion efficiency of 15%.
- Can create 4 μm thick films with less than 3% a-axis grains and continuous BZO nanocolumns.

Benefits

Increased machine efficiency

Can achieve machine efficiency to approximately 99.9%, which is a 2% improvement over existing technologies, depending on the target motor.

Energy Savings

Can potentially save more than 6250 GWh on electrical costs annually in the industrial motor industry.

Return on investment time reduced

Can achieve a breakeven ROI in less than two years compared to the seven years it takes for conventional wires.

Contact Information:
Venkat Selvamanickham
Email: selva@uh.edu
Phone: (713) 743-4044
University of Houston
Texas Center for Superconductivity
Office EGRI N237
Houston, Texas 77204
Website: https://uh.edu/uh-research/asmi/

Advances in Power Integrated Circuits for 600 Volt SiC

Wide Bandgap Semiconductors **Emerging Technology**

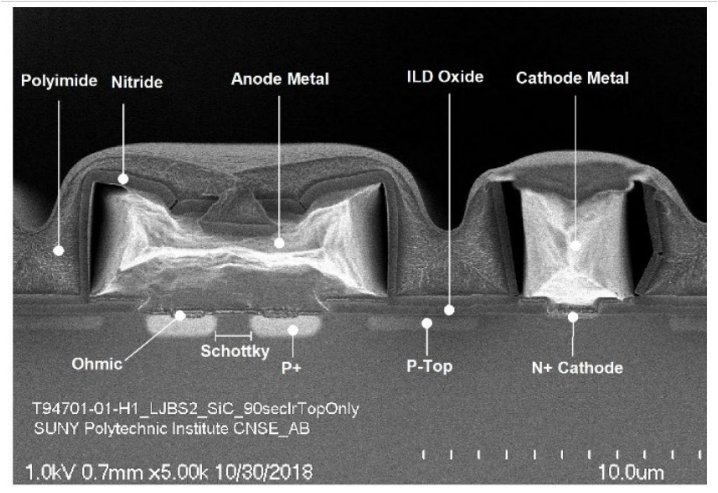
Innovating Wide Band Gap SiC Power Integrated Circuits

Power semiconductors have played a major role in improving the performance of power converters in all applications. To date, most of them have been built using silicon. The technology is well developed. Wide bandgap semiconductor, and in particular silicon carbide (SiC) offer several advantages over Si. In particular, they can operate at higher temperatures (thereby reducing cooling requirements) and are capable of higher power density—leading to smaller devices. However, the technology is not as advanced as for Si. The SUNY work was aimed at advancing the field.

The design of a power integrated circuit (PIC), which may require high voltages to be applied, and high currents to pass through, is a matter of trading off improvements in some aspect of the circuitry against some other aspect. With SiC, the tradeoffs are extremely challenging, including, as they do, aspects of the production process as well as the performance of the final circuit.

Some of these interacting factors have been addressed by the team at the State University of New York Polytechnic Institute, in Albany New York and X-fab, with assistance from AMO through the PowerAmerica Consortium at North Carolina State University. In this work they have developed a SiC lateral MOSFET and a novel SiC lateral Schottky diode.

In semiconductor processing, the words vertical and lateral have their ordinary meaning, but they have very different implications for the processing. In a lateral diode, the anode and cathode are side-by side in a well created in a single layer, and the metallization is over the top. In a vertical diode, each of those elements is a separate layer, each on top of the one underneath. The connections to the anode and cathode are on different layers, complicating interconnection and resulting in longer "wiring." The processing for the lateral diode is much simpler. In fact, the advantage is so great that lateral components are regarded as an essential prerequisite for SiC to realize its full potential.



Cross-section SEM view of a lateral JBS (Junction Barrier Schottky) diode fabricated for SUNY at X-FAB, Lubbock, TX

Overview

- Developed by State University of New York Polytechnic Institute, Albany New York.
- Development began in 2016.
- Several advances made in SiC Power Integrated Circuits have been demonstrated.

Applications

Basic-level advances leading to low-cost and efficient devices with applicability across the range of lower-voltage power conversion and motor control applications, such as power converters and automobiles

Capabilities

- Provides improved performance over silicon-based technology
- Achieves greater power density (allowing smaller size for a given power level)
- Operates with high temperature at the semiconductor level, allowing simplified cooling

Benefits

Process-flow simplified

Power ICs based on silicon carbide are competitive with those using silicon, and have considerable remaining potential. A system that allowed for certain lateral elements to be implemented using the same process flow already developed is an important step toward realizing that potential

Straightforward Integration

Availability of lateral diodes and lateral MOSFETs on a power integrated circuit allows straightforward integration of Schottky clamping diodes and of control circuitry.

Reduced unwanted interactions

Good interconnections with control circuitry in particular helps cut down on unwanted interactions. Rapid switching of large currents at large voltages has the potential for electromagnetic coupling between the switched circuit and the control (input) circuit in a small IC. The better connection possibilities aid designing these effects out.

Contact Information:
Dr. Woongje Sung
Email: WSung@sunypoly.edu
Phone: (518) 956-7197
SUNY Polytechnic Institute
Office NFE 4334
257 Fuller Rd, Albany, NY 12203
Website: https://sunypoly.edu/research/woongje-

ARES - Advanced Reciprocating Engine System

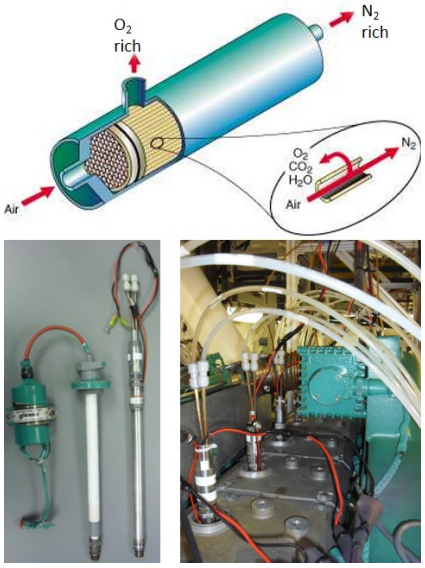
Energy Systems - Electric Power Generation **Emerging Technology**

Laser Ignition and Air Separation Membrane Reduce NOx emissions and increase engine efficiency

Distributed energy systems can lower operating costs and enable energy independence for US manufacturers. Per recent estimates from the U.S. Department of Energy (DOE), more than 10,000 stationary reciprocating engines fueled by natural gas are already deployed in various parts of the United States for distributed power generation. For these stationary engines, natural gas is the fuel of choice on account of its ready availability and clean burning nature. Natural Gas-reciprocating engine powered distributed energy systems offer high-efficiency with low capital costs and reduced carbon emissions. However, there are concerns with high nitrogen oxide (NO_x) emissions, which tend to increase with engine efficiency. Argonne National Laboratory (ANL) is working to offset the NOx emissions – engine efficiency trade off by developing innovative approaches.

ANL, with assistance from AMO has demonstrated the use of air separation membranes with engines. These polymeric membranes coated with special materials enable separation of air to provide a nitrogen rich air stream. Such a stream when used as combustion air leads to 70% reduction of NOx emissions with negligible increase in parasitic power requirements.

In parallel, Argonne has developed a laser ignition system that provides a vastly improved performance in extending lean-burn capability, and improved ignition at higher pressures. The performance of these igniters was demonstrated on a 6-cylinder Cummins engine to achieve 3% point improvement in efficiency. Also, tests show that these igniters are capable of extending service life up to 6000 hrs. in the field. In 2019, ANL patented the laser igniter system, now assigned to U.S. Department of Energy. The technology is being discussed with natural gas engine manufacturers and commercialization is expected within the next few years.



ANL'sNOx Air Separation Membrane (Top) and Laser Ignition Modules and Engine Installation (LHS)

Overview

- Developed by Argonne National Laboratory.
- Tested on several different engine systems
- Commercialization potential with existing engine manufacturers

Applications

Can be used with natural gas-powered engines to improve efficiency and/or reduced NO_x emissions in distributed energy systems.

Capabilities

- Provides laser ignition in natural gas-powered reciprocating engine systems.
- Allows for lean operation with reduced knocking and support for lower quality fuels
- Air separation membranes reduce NO_x emissions and are compatible with existing systems

Benefits

Flexibility

Existing engines can be retrofitted with air separation membranes with no major hardware modifications required.

Efficiency

Laser ignition system increases efficiency up to 3% compared to conventional spark ignition.

Maintenance Costs

Air separation membranes do not introduce contaminants into the engine, reducing maintenance costs.

NO_x Emissions

Laser ignition can reduce NO_x emissions by 60-70% compared to spark ignition.

Contact Information:
Sreenath Gupta, Ph.D.
Email: sgupta@anl.gov
Phone: (630) 252-6089
Argonne National Laboratory.
9700 South Cass Ave,
Argonne, IL, 60439
Website: https://www.anl.gov/es

Atomically Precise Manufacturing for 2D-Designed Materials

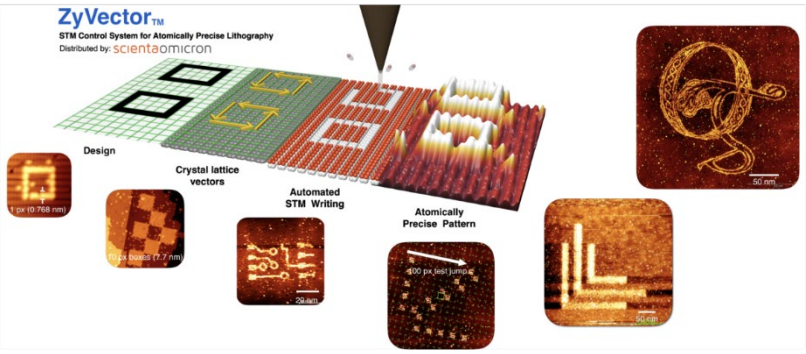
Advanced Materials Manufacturing | **Commercial Technology**

Manufacturing and Testing of Atomically Precise Materials and Devices

The field of computing is constantly evolving, with recent developments being directed towards the field of quantum technology, in which computers constructed on a microscopic scale can be used to solve difficult problems. Using atomically precise manufacturing is particularly important in quantum technology where quantized energy levels and quantum tunneling transport mechanisms are extremely sensitive to atomic scale dimensions, e.g. single atomic layer or atom. Electron Beam Lithography or e-beam lithography (EBL), the current leading manufacturing technology at this scale, does not have sufficient precision for quantum devices.

Zyvex Labs, in cooperation with NIST and 3D Epitaxial Technologies (3DET), with support from AMO, developed software compatible with their product ZyVector, a control system for dopant placement on atomic-scale quantum devices. This software innovates on the method of Hydrogen Depassivation Lithography (HDL), a method that uses a Scanning Tunneling Microscope (STM) to inject electrons into surface chemical bonds, causing them to break. This specifically allows for the release of hydrogen atoms from a silicon surface, and the creation of patterns of exposed silicon dangling bonds (immobilized free radicals) on a 2D plane which can then be used to attach new atoms. This software is able to automate the process of atomically-precise manufacturing, create uniform arrays of dopants, all placed with atomic precision (± 0.4 nm) allowing development of devices using these arrays.

Zyvex Labs is currently working to improve their nanoscale materials research, with ZyVector currently available as software, hardware components are currently in development. Zyvex anticipates using the advancements from ZyVector to further develop the HDL process to fully automate the dopant placement, and expand into new avenues for atomically-precise materials manufacturing.



Zyvex Lab's Zyvector STM Control System process for Atomically Precise Lithography

Overview

- Developed by Zyvex Labs LLC.
- Commercialized in 2019.

Applications

Can be used to manufacture quantum materials and devices, e.g. quantum computing.

Capabilities

- Can construct uniform, precise circuits as small as one square micron (1 μm^2) in size.
- Automated manufacturing processes enables atomically precise dopant placement.

Benefits

Precision

Produces consistent materials and devices using piezo actuators to reduce the effects of creep and hysteresis positioning errors during dopant placement.

Contact Information:
James H. G. Owen
Email: jowen@zyvexlabs.com
Phone: (972) 235-7881
Zyvex Labs LLC
1301 N. Plano Rd.
Richardson, TX 75081
Website: https://www.zyvexlabs.com/

Buzzcell™: Fuel Cell-Based Power Solutions Running on Renewable Fuels

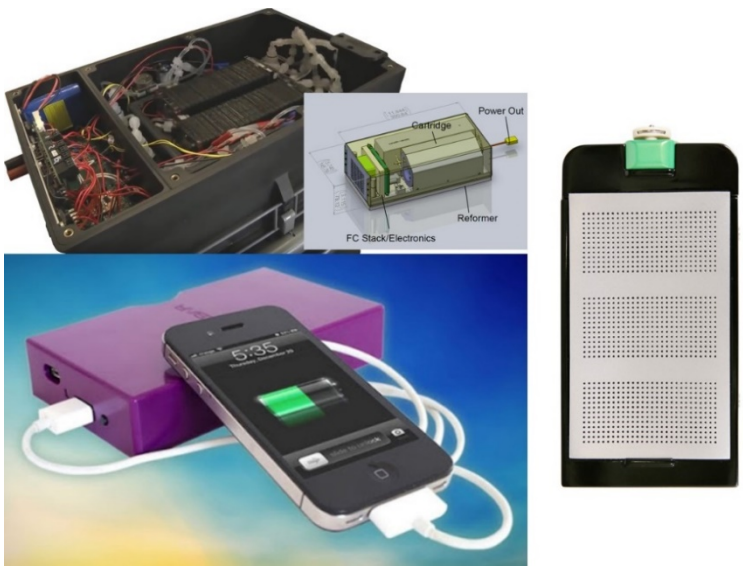
Other Industries **Commercial**

Formic Acid Fuel Cell Offers Off-Grid Energy Source

In an effort to reduce carbon emissions, many domestic industries are exploring new technologies to both improve performance and drive down emissions. Hydrogen fuel cells have received a large amount of interest as an environmentally friendly method of producing power for mobile or off-grid applications. However, the hydrogen fuel used in these applications requires large investments in infrastructure for generation, storage, and transportation. These infrastructure investments have led to the slow adoption of hydrogen technologies. A method of hydrogen generation that removed these costly investments could help reduce domestic emissions and promote the adoption of clean hydrogen technologies.

Neah Power Systems, Inc., with assistance from AMO, has developed the BuzzCell™ and Formira HOD® (Hydrogen-on-Demand). BuzzCell is the new generation of the Formira HOD and offers a smaller form factor than its predecessor. The system is powered by formic acid rather than compressed hydrogen and offers up to 417Wh/kg.[1] Formic acid is commonly used as a preservative and antiseptic, is non-flammable at 85% concentration, and is stored as a liquid. The BuzzCell combines a fuel cartridge, reformer, and fuel cell stack into a single conveniently packaged unit. Each unit offers up to 25 W per stack but the modular design allows expansion to provide more power. For site-specific applications that require more flexibility, the system configuration can be customized per customer specifications.[2]

Neah Power Systems has included its BuzzCell with the new BuzzBar Suite™ the BuzzBar Suite combines solar, fuel cell, and battery power options to give users a variety of options depending on their needs.[3]



Neah Power Systems' Formira HOD™ and Buzzcell™ Technologies

Overview

- Developed by Tekion, Inc.. Acquired by Neah Power Systems, Inc. in 2013.
- Commercialized in 2016.

Applications

Can be used as a portable power source for electronic devices.

Capabilities

- Offers sustainable off-grid power.
- Provides up to 25 W of continuous power from a single stack.
- Offers scalable format for increased power applications.

Benefits

Cost Savings

Reduces the cost of off-grid hydrogen use by eliminating the cost of hydrogen storage infrastructure.

Environment

Allow for mobile production of electricity through a carbon neutral process.

Storage

Enables on-site production of hydrogen using a non-flammable liquid fuel rather than the use of compressed hydrogen from tanks.

Contact Information:
Dr. Chris D'Couto
Email: Chris.dcouto@xnrgi.com
Phone: (425) 272-2703ye
Neah Power Systems, Inc.
22722 29th Avenue SE, Ste. 100
Bothell, WA 98021
Website: http://xnrgi.com/

[1] For more information: "Formic Acid Reformer", Neah Power Systems, Inc., September 2016
[2] For more information: Disruptive solutions for off-grid energy.
[3] For more information: "BuzzBar Recharging Suite", Neah Power Systems, Inc.

Catalysts for Electrochemical Conversion of CO_2

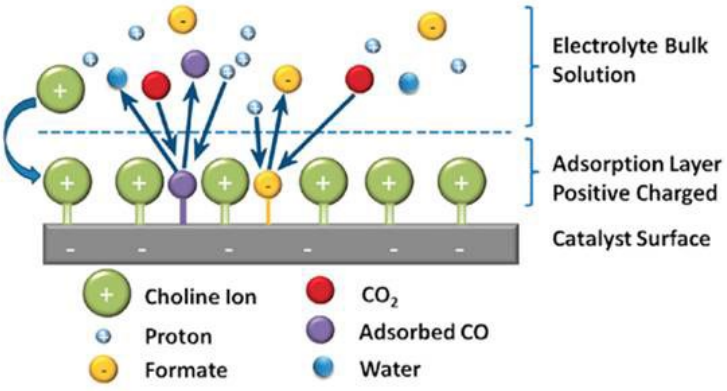
Chemicals | **Commercial Technology**

Electrochemical Conversion of CO_2 for Producing High-value Chemicals and Fuels

In the United States, approximately 80% of the energy consumed is from fossil fuels.[5] Recent research into alternative energy sources has focused on searching for ways to harness the energy in sunlight to generate energy-rich chemical fuels, such as hydrogen gas, methane, and gasoline. This has been successfully demonstrated but the means for doing so have been inefficient and expensive[6].

Dioxide Materials, Inc., in collaboration with 3M, with assistance from AMO, in the form of STTR and SBIR grants, has developed processes and materials for the electrochemical conversion of CO_2 into high value chemicals. Dioxide Materials' approach for converting carbon dioxide (CO_2) into carbon monoxide (CO), the first step to making a hydrocarbon fuel, is more energy efficient. Electrochemical conversion of CO_2 requires application of a large electrical voltage and is inefficient and uses more energy to produce CO than can be stored chemically. Dioxide Materials' process uses a solvent, called an ionic liquid, during the electrochemical conversion reducing the applied voltage approximately 10-fold. This is followed by 3M's electrochemical process for creating hydrogen, resulting in a mixture of CO and H_2 known as syngas, which can be used to produce gasoline.

Dioxide Materials' process could enable a new chemical value chain using carbon dioxide feedstock and renewable energy (instead of oil and gas) to obtain high value fuels and chemicals. By using waste carbon dioxide from power plants as feedstock to produce gasoline, diesel fuel, jet fuel, and industrial chemicals carbon emissions would be significantly reduced as a result. The long-term goal is to build a mini-pilot plant to produce 1 gal/day of renewable fuel, followed by building larger CO_2 recycling facilities to increase production.



Dioxide Materials Catalyst

Overview

- Developed by Dioxide Materials, Inc. in collaboration with 3M.
- Commercialized in 2017.
- Continuing development of CO_2 conversion to high value fuels and allow for storage of this renewable energy when produced.

Applications

Can be used to convert CO_2 into high-value chemicals, fuel (e.g. syngas) or for energy storage.

Capabilities

- Achieves CO_2 conversion at >97% selectivity and >80% overall energy efficiency.
- Achieves a 10-fold reduction in overpotential, resulting in a 2-fold reduction in voltage for CO_2 electrochemical conversion.
- Enables the potential of converting CO2 and water into syngas, which is then converted into high value chemicals such as gasoline, diesel fuel, jet fuel and industrial chemicals.
- Allows use of renewable energy sources as an alternative to fossil fuels.

Benefits

Cost Savings

Reduces the cost of CO_2 electrochemical conversion by 3-fold by using an ionic liquid solvent that reduces the required voltage.

Environment

Reduces use of fossil fuels and carbon emissions, providing fuel derived from renewable, CO_2-free energy sources.

Contact Information:
Rich Masel
Email: rich.masel@dioxidematerials.com
Phone: (217) 239-1400
Dioxide Materials Inc.
3998 FAU Boulevard #300
Boca Raton, FL, 33431
Website: dioxidematerials.com

[5] See EIA website: https://www.eia.gov/state/seds/data.php?incfile=/state/seds/sep_sum/html/sum_btu_1.html&sid=US

[6] Rosen, et al., "Ionic Liquid-Mediated Selective Conversion of CO2 to CO at Low Overpotentials, http://www.sciencemag.org/content/334/6056/643.full.html

Ce – Al Alloy

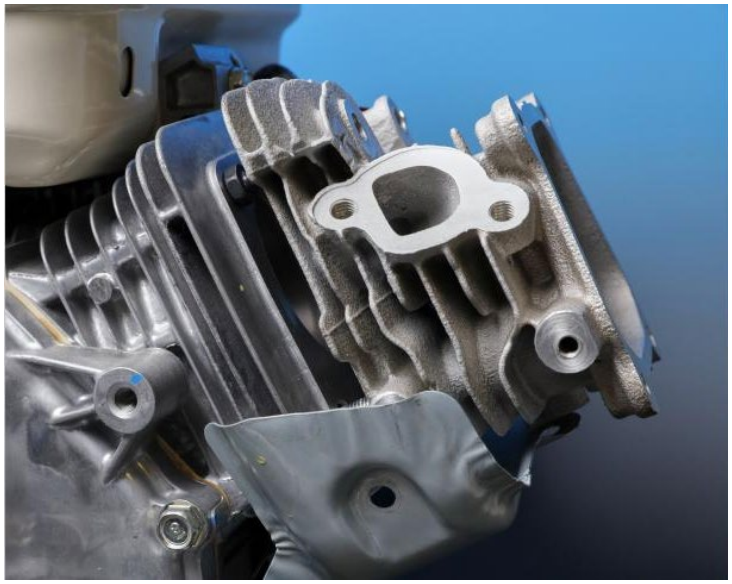
Process Intensification **Emerging Technology**

Aluminum Alloy Improves Performance Characteristics and Reduces Weight

Developments in lightweighting and the current drive toward improving energy efficiency are increasing the need for new materials that can satisfy the growing requirements of the advanced manufacturing sector. In many cases, materials exist which could provide a solution to current needs but do not universally meet performance goals. Development of a new material that is both light weight and durable would provide the means for domestic manufacturers to increase performance while reducing costs.

ORNL, with assistance from AMO, through the Critical Materials Institute, and a team of industry partners, has developed a new Cerium-Aluminum (Ce-Al) alloy that can fill the missing role of a robust high performance aluminum substitute. The new alloy offers improved casting characteristics over conventional alloys and can even reduce or eliminate the need for heat treatment in some cases.[7] In addition to this, the alloy demonstrates mechanical characteristics that are up to 30% better than other Al alloys.[8] This improvement comes without significant increase in density, making the Ce-Al alloy suitable for lightweighting applications.

While the material offers impressive performance characteristics, it also offers further economic benefits. The cerium used in the alloy is a waste product of the rare earth metals production sector making it less expensive than other alloying materials. Additionally, use of the Ce-Al alloy can reduce energy use during the manufacturing process by up to 60%.[9] ORNL has also demonstrated that the alloy is suitable for use with 3D printed molds due to its above average castability, which may lead to further cost reductions for manufacturers. Eck Industries Inc. has an exclusive license to the Ce-Al alloy and is currently producing high temperature engine cylinder heads.



Eck Cylinder Head

Overview

- Developed by ORNL, Ames Laboratory, Lawrence Livermore National Laboratory, Eck Industries Inc.
- Commercialized in 2016 by Eck Industries, Inc.

Applications

Can be used in processes that benefit from high strength aluminum parts that perform well in corrosive or high temperature environments.

Capabilities

- Eliminates the need for heat treatment of cast parts.
- Reduces the energy required by the casting process by up to 60% compared to traditional alloys.
- Offers stable performance at temperatures as high as 500°C.

Benefits

Cost Savings

Reduces fabrication cost of aluminum parts by reducing the need for heat treating machining.

Durability

Provides high strength alternative for corrosive environments.

Flexibility

Usable in 3d printed molds.

Contact Information:
Dr. Orlando Rios
Email: rioso@ornl.gov
Phone: (865) 574-3747
Oak Ridge National Laboratory
1 Bethel Valley Rd
Oak Ridge, TN 37830
Website: http://www.ornl.gov

[7] For more information: New alloy promises to boost rare earth production while improving energy efficiency of engines.
[8] For more information: Castable High-Temperature Ce-Modified Al Alloys.
[9] For more information see: Eck Industries exclusively licenses cerium-aluminum alloy co-developed by ORNL.

Cerahelix: High Flux Ti Nanofiltration Membrane for Efficient Processing of Bioproducts

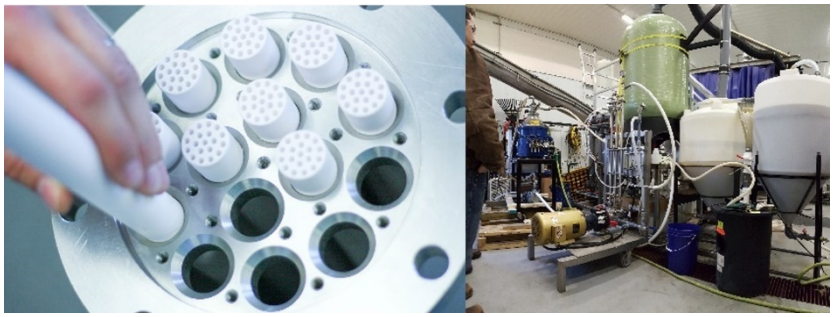
Other Materials | **Commercial Technology**

DNA Templated Membrane Operates in Harsh Conditions

Membranes are becoming increasingly used in many U.S. industries ranging from water purification to bioproduct processing. Ceramic membranes have enjoyed widespread acceptance in chemically intensive industries due to their thermal and chemical resistance. While ceramic membranes offer improved durability, they suffer from low reproducibility which restricts pore size to >1000 Dalton (1 Dalton = $^1/_{12}$ carbon-12 atom). Producing ceramic membranes is currently done by sintering together ceramic membrane particles which limits porosity and contributes to low reproducibility. Another method of production which yields robust and reproducible membranes would be useful for enabling the low cost and energy efficient processing of bioproducts.

Cerahelix, Inc., with assistance from AMO, in the form of SBIR grants, has developed TiO_2 and ZrO_2 mixed oxide ceramic membranes using DNA templates. Self-orienting DNA, which orients into domains of hexagonal-phase liquid crystalline order, has been used to produce linear series of continuous pores to facilitate fast transport of permeates. The hydrophilic nature of the membrane material further supports specialized separations by allowing separation based on size, chemical properties, and charge-charge interactions. Use of hydrophilic materials also makes Cerahelix's membranes resistant to fouling from organic materials, as well as allows for purification of the water, which can then be recycled or safely returned to the environment. The combination of flexible selectivity and fouling resistance allows the DNA –templated membrane to be used under harsh conditions including low ph. and elevated temperature environments.

With additional funding provided through the RAPID institute, Cerahelix has further developed its membrane, adapting to titania chemistry to leverage its increased chemical and hydrothermal resistance compared to silica. In Pilot-scale filters that could filter up to 1000 gallons per day were tested and commercialized in 2017, and those have been scaled up to filter 10k-100k gallons in 2019. Current projections estimate that by using these tubes in place of commercial evaporators, if 600k gallons of water could be filtered per day, this could save up to 1200 tons of carbon spent per year, along with recovering 90% of water in single stage recovery.



Cerahelix's DNA Templated Membranes (left) and Test Platform (right).

Overview

- Developed by Cerahelix, Inc.
- Commercialized in 2017.
- Started with pilot scale filters that filtered 1000 gallons per day, currently has developed industrial scale filters that can filter 10k-100k gallons per day.

Applications

Can be used remove dissolved contaminants from chemical solutions in harsh conditions, including high temperature, low pH, and high viscosity.

Capabilities

- Tolerates pH in 2-10 range.
- Allows operation at > 70ºC.
- Achieves 35% porosity.
- Can be cleaned with citric acid, taking 20 minutes for every 24 hours of use; which then can be flushed down the drain or recycled.

Benefits

Efficiency

Improves high-fouling separation processes by offering a fouling resistant membrane option.

Productivity

Enables high-volume production by minimizing flux losses due to fouling and improving process selectivity and transport rates.

Environmental Conservation

Enables conservation of water through purification, allowing water to be recycled or returned to the environment.

Contact Information:
Dr. Susan MacKay
Email: smackay@cerahelix.com
Phone: 1-800-604-0697 ext. 700
Cerahelix, Inc.
20 Godfrey Drive
Orono, ME 04473
Website: http://www.cerahelix.com

CF8C-Plus Cast Austenitic Steels

Steel **Commercial Technology**

Steels for Engine Casings, Naval Propellers, and Piping for Energy Applications

CF8C-Plus is a new grade of heat- and corrosion-resistant cast austenitic stainless steel. This material was originally developed to be a cost-effective material alternative to high silicon and molybdenum cast iron, meet the performance demands, and improve durability and reliability of advanced diesel engines. The material won a 2003 R&D 100 award and the first commercial application by Caterpillar occurred in 2006.

Oak Ridge National Laboratory, with AMO assistance, is investigating new applications of the CF8C-Plus alloy. Cast stainless steels such as CF8C have some desired properties but lack others. CF8C-Plus, contains additional manganese and nitrogen, and an adjustment to the CF8C alloy composition. The new alloying additions enhance the formation and stability of a nanoscale dispersion of niobium carbides and nitrides, which provide creep strength to CF8C-Plus at temperatures as high as 800ºC. The new material is more castable, and a low-cost, high-performance alternative to conventional cast steels. CF8C-Plus' superior high-temperature mechanical properties which include tensile strength and ductility, creep resistance, fatigue behavior, and aging resistance relative to the standard grade of CF8C cast stainless steel.

ORNL has successfully applied CF8C-Plus cast steels to a variety of applications including being used as a turbine casing for the Mercury 50 engine at the 29 Palms Marine base in California. It also has been used to make propellers on small ships operating at the U. S. Naval Academy with the potential to be increased in scale for larger ships and is in development for turbocharger applications by Tier 1 automotive suppliers, and in extruded main line steam piping for fossil energy power applications.

Additionally, CF8C-Plus cast steels have also been qualified for an ASME Boiler and Pressure Vessel code case for applications to 427°C (800°F) and an application is in progress in ASME Sections I and B31.1 for applications to 816°C (1500°F) and in ASME Section II.



CF8C-Plus Compared to Cast Iron in High Temperature Application

Overview

- Developed by ORNL in collaboration with Caterpillar, Inc.
- Commercialized in 2006.
- Continued operations include CF8C-Plus turbine casing on the Mercury 50 engine at the 29 Palms Marine base in California, propellers on ships operating at the Naval Academy, development for turbocharger applications by Tier 1 automotive suppliers, and extruded main line steam piping for fossil energy power applications.

Applications

Can be used in steel casting applications which require a durable, high-temperature, high-strength and weldable stainless steel.

Capabilities

- Provides high-temperature strength in the 650–800ºC range.
- Provides good castability for ease of air-casting large or small components.
- Provides creep strength comparable to nickel-based superalloys.
- Approved by ASTM as a heat resistant alloy, HG10MnN

Benefits

Cost Savings

Low-cost, weldable austenitic grade steel that eliminates the need for post-casting processes e.g., heat treatment.

Durability

Alloy's composition and structure have higher resistance to fatigue and age-induced failure when compared to standard grade CF8C stainless steel.

Contact Information:
Bruce Pint
Email: pintba@ornl.gov
Phone: (865) 576-2897
Oak Ridge National Laboratory
P.O. Box 2008
Oak Ridge, TN 37831
Website: ornl.gov

DB-LN Series Burner: Fuel-Flexible Combustion System for Refinery and Chemical Plant Process Heaters

Chemicals **Commercial Technology**

Fuel-Flexible Burner Offers Low-Emission Performance At Reduced Cost

The industrial sector utilizes heat sources for a variety of applications in day-to-day processes. Generally, these sources are fired with natural gas and uninterrupted performance is necessary to ensure continued plant operation. Extended use periods require burners to be durable to avoid down time, and often mean that low-emission burners are desirable to control plant emissions. Some units can suffer from complications ranging from structural support issues to variable or unpredictable flame lengths. The resulting heating balance issues or structural sagging can result in costly down times.

etaPartners, with assistance from AMO, has developed a low NOx fuel-flexible burner to address industrial needs. The DB-LN series burner is available through Zeeco, Inc. and offers low-emission performance while using a variety of low-cost opportunity (waste or by-product) fuels. The duct burner is designed to use Zeeco, Inc.'s burner management system to provide seamless integration into existing plant systems but can be installed as a standalone if necessary.[1] Each system is designed using extensive computational fluid dynamic (CFD) and physical modeling to optimize performance, ensure balanced heating, and improve product life.

Further durability improvements are identified during each site-specific design process and are implemented during installation. The standard DB-LN burner includes self-supporting elements to minimize the risk of sagging and eliminate the need for mid span supports. The duct design balances flame patterns and produces predictable flame lengths to improve overall performance. DB-LN burners provide robust heating capabilities and are backed by round the clock support by Zeeco, Inc.[2]



Zeeco's DB-LN Series Burner

Overview

- Developed by etaPartners LLC. Available through Zeeco, Inc.
- Commercialized in 2016.

Applications

Can be used to provide low-emission, supplemental firing for industrial applications.

Capabilities

- Reduces emissions through controlled fuel mixing in combustion zones.
- Allows manufacturers to operate using a variety of opportunity fuels.
- Offers turnkey installation, round the clock startup capability, and easy initial setup using Zeeco's burner management system.

Benefits

Cost Savings

Reduces operating cost by enabling the use of low-cost opportunity fuels.

Durability

Provides robust performance by selecting design materials on a per installation basis.

Efficiency

Offers improved performance by implementing both physical airflow and CFD modeling in the design process.

Contact Information:
Seth Marty
Email: Seth_Marty@zeeco.com
Phone: (918) 893-8126
Zeeco, Inc.
22151 East 91st Street
Broken Arrow, OK 74014
Website: https://www.zeeco.com/

[1] For more information: Low-NOx Duct Burners.

[2] For more information: Duct Burners.

Design, Fabrication, and Vehicular Testing of 200kW 1050VDC Bus SiC Dual Inverter for Heavy-Duty Vehicles

Wide Bandgap Semiconductors **Emerging Technology**

Innovating Wide Band Gap SiC Inverters for Heavy-Duty Vehicles

Better fuel efficiency in heavy-duty off-highway vehicles can go a long way towards reducing overall operating costs in the construction and mining industries. One potential solution to achieve these goals is a variable-speed electric drive system, made possible by wide bandgap (WBG) power devices. For example, a fixed-speed diesel motor and an inverter combined with a variable-speed drive offers many benefits. Vehicle efficiency is improved, leading to fuel savings and noise levels inside the vehicle and outside are reduced. An inverter based on WBG technology is smaller in size and weight, and operates at higher coolant temperature.

John Deere Electronic Solutions, with assistance from AMO through the PowerAmerica Consortium at North Carolina State University and support from NREL, has developed an inverter designed for heavy-duty vehicles. The inverter, rated at 200 kW (270 HP), with a 1050 VDC bus, uses SiC wide-bandgap MOSFETs. The 1st generation Gen-0 SiC inverter uses JDES' own Insulated Gate Bipolar Transistor (IGBT) PD400 inverter retrofitted with 1700 V 400 ADC SiC power modules. The SiC module allows a higher coolant (45°C) than allowed by silicon IGBT technology. Full power operation is possible on even the hottest days without compromising reliability. A second-generation (Gen-2) SiC inverter has a four times power density increase (43 kW/L).

In 2017, the first-generation (Gen-1) SiC dual inverter was successfully demonstrated in the JD 644K Hybrid Loader and has since operated for over 100 hours. The Gen-2 SiC inverter has been tested in JDES's power electronics lab by simulating 644K Hybrid Loader drive profile condition in a back-to-back motor dynamometer. Over 3,500 hours of high temperature SiC power electronics test data indicates that the Gen-2 SiC inverter offers an additional 3% in fuel savings over the original IGBT inverter. It is estimated that the Gen-2 SiC inverter in the hybrid loader could offer up to 25% fuel savings compared to a conventional (non-electrified) drivetrain. JDES has plans to commercialize a SiC inverter within the next two to five years. There is interest from early adopters of SiC inverter technology, but as SiC MOSFET inverters currently cost about three times as much as an IGBT inverter, there are cost barriers that are still prohibiting the widespread adoption of this technology.



John Deere's Gen-2 SiC Dual Inverter and 644K Hybrid Loader

Overview

- Developed by John Deere Electronic Solutions and NREL.
- Development began in 2015.
- Gen-1 SiC dual inverter successfully demonstrated in JD 644K Hybrid Loader in Q2 2017.

Applications

Can be used for developing vehicle traction systems for mining/agriculture vehicles, heavy-duty off-road vehicles, and heavy duty on-road vehicles

Capabilities

- Provides improved performance over heavy-duty vehicles equipped with conventional IGBT inverters.
- Achieves a power density greater than 40 kW/L.
- Operates with high-temperature (115 °C) coolant

Benefits

Energy Savings

SiC inverter-based drivetrain in JD 644K Hybrid Loader may save ~3% fuel compared to current Silicon IGBT- based drivetrain. Due to SiC dual inverter-led improvements in efficiency, vehicle fleet owners will experience lower daily operating costs and will require less frequent refueling.

Fuel Savings

The hybrid loader with the SiC Dual Inverter has potential to offer ~3% fuel savings as compared to a conventional John Deere 644K Hybrid Loader manufactured using Si IGBT inverter.

Wider range of Operating Conditions

WBG technology allows higher operating temperatures on the semiconductors, and hence higher coolant temperatures. This allows use of engine coolant system.

Contact Information:
Dr. Brij Singh
Email: SinghBrijN@JohnDeere.com
Phone: (701) – 552-8516
John Deere Electronic Solutions
4101 19th Ave North
Fargo, ND, 58102
Website: www.deere.com/en/

Directed Green Liquor Utilization (D-GLU) Pulping

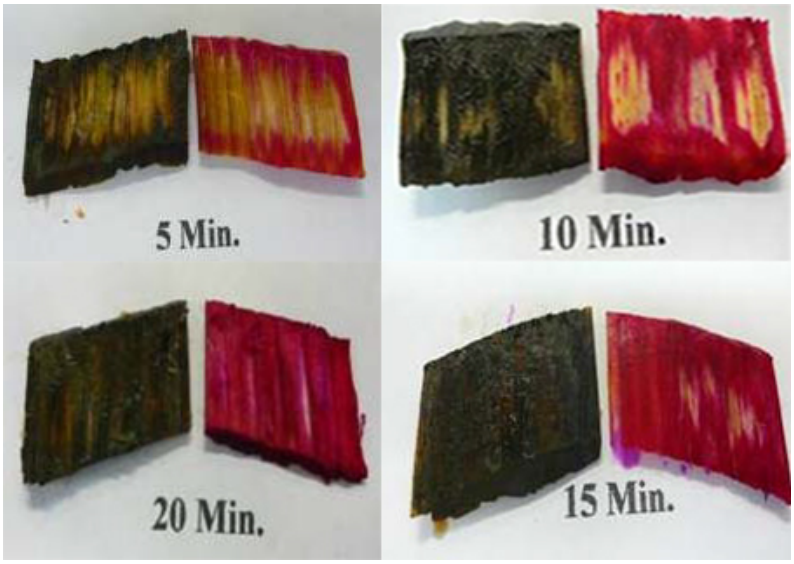
Sustainable Manufacturing **Commercial Technology**

Process Recovers Green Liquors From Mill for Reuse

To reduce environmental impacts and maximize performance, the pulp and paper industry is seeking opportunities to optimize their pulping operations. This objective can often require large capital investments that can deter domestic producers from selecting newer technologies. Process improvements that have minimal capital investments while offering improvements to the pulping process could improve the efficiency of domestic pulp and paper mills, reduce emissions, and save energy.

North Carolina State University (NCSU), with assistance from AMO and collaborators, has developed Directed Green Liquor Utilization (D-GLU) Pulping. D-GLU is a modification to the standard pulping process that recovers green liquor from the causticizing step and redirects it to the digester. This step reuses up to 30% of the green liquor used in causticizing and can be implemented with minimal changes to the existing setup. The design requires no addition tanks or specialized equipment, a single pumping system, and a low-pressure injector into the upper digester.[1]

In addition to offering compelling benefits with relatively small retrofit requirements, D-GLU can increase pulp yield and fiber strength. The system can also increase yields by increasing dryer uptime compared to conventional mills. The increase in production is accompanied by a reduction in natural gas use by up to 10% per air-dried metric ton of pulp and a 4k ton/yr reduction in CO_2 generation. The D-GLU system is available for license from NCSU.



Chemical Penetration Profile of Southern Softwood

Overview

- Developed by North Carolina State University, Georgia Institute of Technology, MeadWestvaco.
- Commercialized through licensing agreement in 2016.

Applications

Can be used in the kraft mill pulping process.

Capabilities

- Reduces energy used by kraft mills by up to 30%.
- Increases fiber strength.
- Reduces digester alkali demand by up to 50%.[2]

Benefits

Cost Savings

Reduces energy cost by offsetting local utility power loads.

Efficiency

System is easily transported and easily retrofits into existing plant infrastructure or new installations.

Quality

System is self-contained, fuel-free, and emissions-free.

Contact Information:
Dr. Lucian Lucia
Email: lalucia@NCSU.edu
Phone: (919) 515-7707
North Carolina State University
3108 Robertson Hall, Box 8005 & 8204
Raleigh, NC 27695
Website: https://www.ncsu.edu/

[1] For more information: Highly Energy Efficient D-GLU (Directed Green liquor Utilization) Pulping

[2] For more information: Highly Energy Efficient D-GLU (Directed Green liquor Utilization Pulping) - DOE/EE-0473, May 2011

Direct Process for Wire Production from Sulfide Concentrates

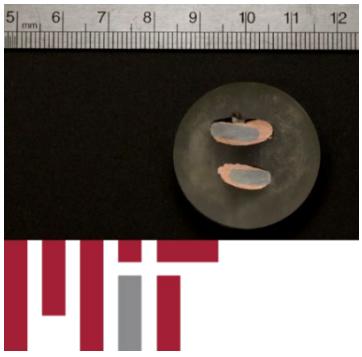
Sustainable Manufacturing **Emerging Technology**

Wire Production Directly from Ore Recovers Valuable Metals and Avoids Harmful Intermediates

Copper (Cu) and its byproducts are essential to modern life as part of critical components in consumer electronics and other advanced materials. Nearly half of the copper used in wires and electrical applications is derived from chalcopyrite ($CuFeS_2$), a sulfide contained in copper ore. The traditional smelting process requires pyrometallurgy to transform copper iron sulfides which are oxidized to remove iron oxide and sulfur dioxide (SO_2), producing liquid copper. However, SO_2 gas cannot be released to the environment, typically requiring several reactors upstream and downstream to safely remove the gas to be transformed into sulfuric acid. Typically, a semi-finished solid copper product is then shipped to manufacturers outside of the smelter who in turn re-smelt the copper to produce wire or other end products. The current supply chain from mining to wire production is highly energy intensive, and with the demand for copper wire anticipated to grow worldwide, is expected to be very costly as energy resource demands increase and the purity of copper ores decreases.

MIT has developed a new process that uses electrolysis, changing the chemical basis of copper extraction, enabling a direct liquid-to-wire extrusion/melt spinning process. With assistance from AMO, MIT has reproduced this process, which was previously tested on synthetic feedstock, to work with natural materials provided by partner companies. This allows the production of copper products directly from ore along with the recovery of valuable metals, including Fe, and elements, all while avoiding the extra steps needed to remove hazardous byproducts by capturing sulfur in its elemental form (S2), which does not require special handling or transportation procedures. This development effort brings core reactor technology to a size ready for pilot-scale implementation.

In 2018, MIT finished the initial pilot-scale design work and began work on a production-scale direct process which is expected to be completed in three years. The production-scale work will demonstrate a 1 tpa reactor for Fe, Cu, and S production by January 2021, as well as completion of plans to create a 100 tpa demonstration for industrial sites after that. Process and cost models from this work suggest commercial scale is around 20,000 tpa, which would consist in a facility of two to ten reactors at scale. In the development of the copper route, a new process based on sulfur chemistry has been discovered and a new reactor built to separate rare earth materials, nickel, cobalt, and lithium from ore.



Sample of pure copper deposited on an iron electrode after extraction through MIT's electrochemical process.

Overview

- Developed by MIT
- Development began in 2013
- Initial work finished in 2018
- Feasibility tested on concentrate from Freeport McMoRan Inc. and Chile
- Scaling up began in 2018, expected to last through January 2021.
- Expected to reach large-scale production during 2022.

Applications

Can be used to provide copper wire for various applications including renewable energy and electric vehicles.

Capabilities

- Extracts and separates 1 unit worth of iron from 1 unit worth of copper from natural materials.
- Can extract elemental sulfur which can be used to produce fertilizer, remote sulfuric acid, and generate electricity.
- Can separate rare earth materials, nickel, cobalt, and lithium from ore.

Benefits

Cost Savings

Enables a reduction in production costs of copper by around 20%.

Energy Efficiency

Reduces energy consumption for copper production by up to 20%.

Improved Product Quality

Increases purity of the liquid copper product while avoiding producing harmful SO_2 gas as an intermediate.

Ore Compatibility

Enables better handling of impurities from copper concentrates such as arsenic.

Contact Information:
Dr. Antoine Allanore
Email: allanore@mit.edu
Phone: (617)-452-2758
Massachusetts Institute of Technology
77 Massachusetts Avenue
Cambridge, MA, 02139
Website: https://www.mit.edu/

FLAAT Growth Technology for GaN on 6 inch Sapphire with No Wafer Bow

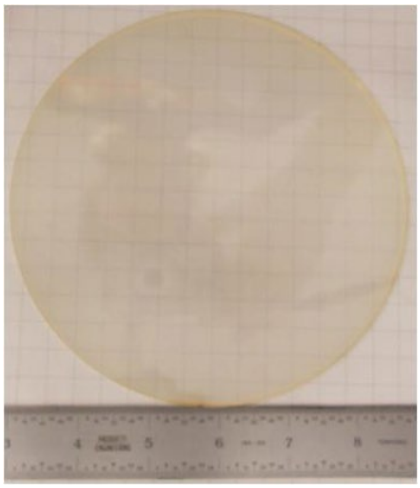
Wide Bandgap Semiconductors **Commercial Technology**

Modeling and Control System Improves Manufacturing Yield

Modern wafer production techniques suffer from limitations due to wafer bow experienced during several stages of the manufacturing process. Wafer bow can lead to non-uniformity on the wafer surface, causing emission wavelength issues. Additionally, wafer bow contributes to impurity incorporation and surface roughness, a common issue with many LEDs. Current techniques often implement the use of curved wafer platters, which attempt to match expected wafer bow, or necessitate complicated growth recipes. These solutions are somewhat effective but not optimal as they limit growers to an inflexible growth procedure and stifle innovation.

To address these issues Kyma Technologies, Inc., with assistance from AMO, has developed the MaxFLAAT™ (Flat Layers At All Temperatures) Gallium Nitride (GaN) template. The MaxFLAAT template provides a low-cost native GaN substrate to remove the problems associated with heteroepitaxial growth. Removal of these issues allows for wafer growth with minimal bow and reduces the cost involved with producing large area LEDs. As a result of minimized bow, FLAAT users can realize up to a 75% reduction in production cycle times. FLAAT templates can eliminate the need for the clean, nucleation, recovery, and buffer process steps for further reductions in process time. Using hydride vapour phase epitaxyHVPE growth, FLAAT templates can be produced with 15µm GaN deposits on both sides in under two hours.[1]

In addition to offering favorable growth characteristics, MaxFLAAT templates allow manufacturers to eliminate the Metal Organic Chemical Vapor Phase Deposition (MOCVP) process as well as reduce raw material costs. The HVPE based epitaxy of MaxFLAAT templates allows manufacturers to replace metalorganic gallium sources with metal gallium, potentially reducing ammonia use by up to 90%.



Kyma Technologies' FLAAT GaN Substrate

Overview

- Developed by Kyma Technologies, Inc.
- Commercialized in 2016.

Applications

Can be used as a template to produce flat LEDs.

Capabilities

- Produces epi-ready quality films.
- Achieves minimal wafer bow.
- Reduces cost of producing large area LEDs.

Benefits

Cost Savings

Reduces costs by minimizing wafer bow, wavelength binning, and polishing difficulties.

Efficiency

Optimizes wafer production by removing heteroepitaxial growth issues.

Productivity

Enables high-volume production by reducing cycle times.

Contact Information:
Barry Freifeld
Email: BMFreifeld@lbl.gov
Phone: (510) 486-4381
Lawrence Berkeley National Laboratory
1 Cyclotron Road MS 74R316C
Berkeley, CA 94720
Website: http://www.lbl.gov

[1] For more information: Large-area bow-free n+ GaN templates by HVPE for LEDs.

Flash Processed Steel for Automotive Applications

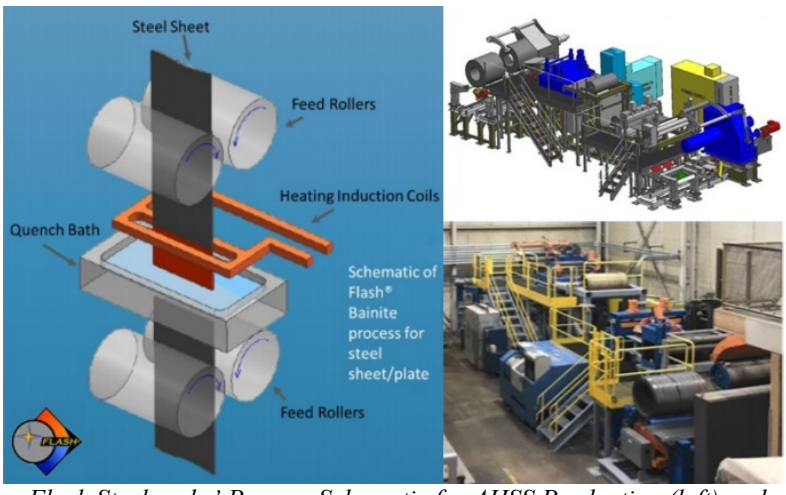
Advanced Materials Manufacturing **Emerging Technology**

Heat Treating Process Produces Low-Cost, High-Strength Weldable Steel

An established goal for the U.S. Department of Energy is to reduce vehicle weight with lightweight, high-strength steel in order to improve fuel efficiency. However, most methods to produce advanced high-strength steel (AHSS) use costly materials and time-consuming thermal processes. Additionally, this expensive AHSS has several workability issues which can require significant retooling of automotive factories.

Flash Steelworks, Inc., with assistance from AMO, in the form of SBIR grants, has developed an innovative and cost-effective continuous process to turn commercial off-the-shelf steel into AHSS in less than 10 seconds. In comparison, traditional steel processing requires high temperature exposure for several minutes to hours. Flash processing uses electromagnetic inductive heating to quickly and uniformly heat the steel to over 1000∞C then rapidly reduce the temperature with a water quench step. This rapid thermal process not only uses less energy than traditional processes, but also forms highly complex, heterogeneous steel that is cold-formable, weldable, and extremely strong, at 1100 to 2100 MPa. Flash processed steel's strength and durability properties and lower production costs make it ideal for many manufacturing applications. Flash processed steel supports lightweighting initiatives, since its high strength allows the use of less steel, which in turn can increase energy savings. For example, Flash Steelworks, Inc. estimates that Flash processed steel could reduce overall vehicle weight by 10% through individual component weight reductions of 30-50%. This weight reduction could save approximately 19.3 BTUs of energy over the lifetime of the vehicle through increased fuel economy.

Flash Steelworks, Inc. is currently constructing a pilot line using a Phase III SBIR grant to study and address scale-up issues. Flash processed steel is also being used for armor plating for Department of Defense vehicles, providing increased protection of vehicles with lightweight steel.



Flash Steelworks' Process Schematic for AHSS Production (left) and Flash Processing 10 Ton Coil-to Coil Facility Operation (right)

Overview

- Developed by Flash Steelworks, Inc. in 2014.
- Flash Steelworks is currently working on the completion of a full production line using a Phase III SBIR grant.
- 14 patents issued across 9 countries

Applications

Flash processed advanced high-strength steel can be used in automobiles, agricultural machinery, heavy equipment, and rail, ship and defense systems to replace heavy steel components.

Capabilities

- Uses a <10 second thermal process to produce advanced high strength steel using commercial off-the-shelf steel.
- Produces heterogeneous transformation microstructures that are cold-formable, easily weldable, and suited to fabricate automotive parts.
- Flash processed steel quality and performance characteristics are superior to aluminum and titanium for many structural parts.
- Can process 5-ton steel coils and produce steel plates up to 4ft x 12ft.

Benefits

Cost Effective

Flash Processing uses inexpensive inputs and processing to produce cost-effective high-strength steel. In comparison to steel used by major automotive manufacturers, Flash Steelworks has achieved up to 25-50% in cost reductions.

Energy Savings

Flash processing uses approximately 40% less energy than traditional processes when processing efficiency and using less steel is considered.

Lightweighting Compatible

Flash processed steel could save over 100 pounds of vehicle weight per car.

Contact Information:
Gary Cola
Email: Gary.Cola@flashsteelworks.com
Phone: (586)864-9001
Flash Steelworks, Inc.
11825 29 Mile Rd.
Washington, MI 48095
Website: http://www.flashbainite.com

Flexible Carbon Conductors for Motors and Generators

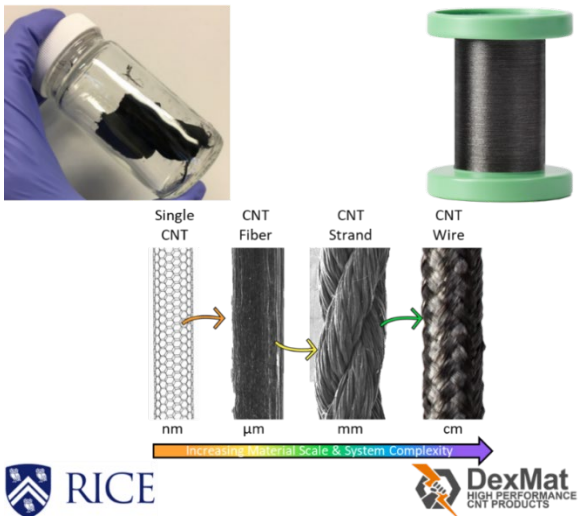
Wide Bandgap Semiconductors **Emerging Technology**

Enabling Increased Motor Efficiency Using Carbon Nanotube Technology

Motors are a near-ubiquitous technology used throughout American industries. Through their usefulness in HVAC cooling and material transport, motors account for most of the electricity spent in the U.S. manufacturing sector. The material properties of carbon nanotubes (CNTs) have shown promise for use in improving motor performance. The low weight, high strength, and improved electrical and thermal conductivities of CNTs make them an ideal candidate for conductor winding materials over traditional choices such as copper and aluminum. However, while the properties of CNTs have been demonstrated at the molecular scale, they still need to be tested and optimized at larger scales before they can be widely utilized for commercial applications.

Rice University, with assistance from AMO, has demonstrated the production of CNT fibers suitable as winding material for electrical motors at a laboratory scale. Working in cooperation with University of Maryland and DexMat, a Houston-based startup that focuses on the industrial production of CNT fibers, Rice University has characterized and optimized a process for CNT synthesis and fiber spinning. Synthesis reactors at Rice University and University of Maryland were used to first develop and optimize CNT properties to produce high quality CNTs, and then spinning and braiding machines at Rice University and DexMat were used to braid the optimized CNTs into fibers and wires suitable for motor winding material. Starting from single CNT filaments with an electrical conductivity of around 0.5 MS/m, CNT wires are currently comprised of two hundred filaments with a total electrical conductivity greater than 10 MS/m.

In 2020, DexMat has released a product line called Galvorn, a series of CNT conductor fiber products developed through Rice University's process. Fiber production has reached a continuous coating process at laboratory scale with further research focusing on CNT fiber conductivity modeling and continued efforts to scale up the process to commercial production.



CNTs developed by Rice University (Left), and DexMat's Galvorn CNT Yarn Product (Middle and Right).

Overview

- Developed by Rice University beginning in 2001.
- Next Generation Electric Machines (NGEM) funding provided in 2017.
- Products commercialized for R&D sales with DexMat by 2020.

Applications

Can be used to produce create CNT wires for motors used various applications across the industrial sector, including pumps, fans, compressed air, materials handling and process, and compressors in industrial facility HVAC systems.

Capabilities

- Can manufacture neat CNT fibers to yarns > 500 µm in diameter with conductivity greater than 10 MS/m without chemical doping.
- DexMat's Galvorn CNT Yarn/Wire/Rope product has a conductivity ranging from 3-10 MS/m, with a strength of 400-2800 MPa.
- DexMat's Galvorn CNT Tape/Film product has a conductivity ranging from 2-6 MS/m, with a strength of 200-600 MPa.

Benefits

Improved Conductivity

Can manufacture CNT fibers with conductivity greater than 10 MS/m without doping. The addition of a mixed halide dopant to CNT fibers can result in CNT fiber conductivity higher than 16 MS/m.

Improved Energy Efficiency

Compared to copper and aluminum, CNTs are lighter in weight, have increased electrical and thermal conductivity, and have high flex fatigue resistance and corrosion resistance, all of which contributes to lightweight, longer-lasting motors, improving energy efficiency.

Contact Information:
Dr. Matteo Pasquali
Email: mp@rice.edu
Phone: (713)-348-5830
Rice University
6100 Main St.
Houston, TX, 77005
Website: https://www.rice.edu/

Flexible Hybrid Friction Stir Joining Technology

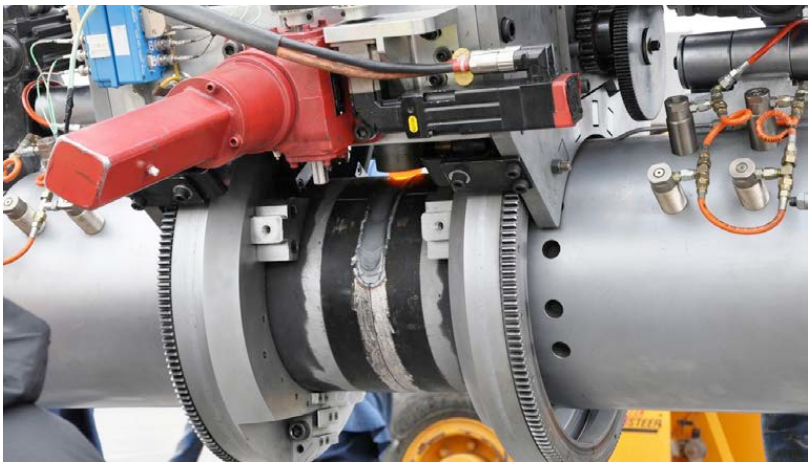
Process Intensification **Commercial Technology**

Environmentally Friendly Welding Technique Reduces Energy Use and Operating Cost

Growth in the advanced manufacturing industry is leading to technology developments that require the use of high strength materials including the use of steels. Steels used in these manufacturing processes are often joined through arc welding or other conventional welding methods. While these techniques are flexible and provide robust products, they are energy intensive and time consuming. A new method of joining steels and other metals that reduces energy use and increases manufacturing speed could foster growth in the domestic manufacturing sector and contribute to the adoption of energy efficient manufacturing techniques.

Oak Ridge National Laboratory (ORNL), with assistance from AMO and industry partners, has developed an improved friction stir welding (FSW) process that can address the shortcomings of more conventional joining procedures while offering the flexibility and robustness that is generally associated with these methods. ORNL has constructed a FSW system that improves upon older FSW techniques by offering the flexibility to be used on site as well as offering the capability of joining high thickness steel parts. The process allows the welding of large diameter steel pipes without internal supports and represents an advancement toward making high durability offshore pipelines. The welds generated by ORNL's FSW platform have shown a consistent ability to pass inspections using API 1104 guidelines with visual, radiographic, bend, and nick break tests.[1]

MegaStir Technologies offers the ORNL developed FSW technology as its N2W Nonweldable to Weldable process. The N2W process is available for mining, oil, gas, and construction support activities. MegaStir offers FSW contract services as well as feasibility studies.[2]



On Site FSW of a 12" Diameter and 3/8" Wall Steel Pipe

Overview

- Developed by ORNL in partnership with MegaStir Technologies LLC and ExxonMobil Upstream Research Company.
- Commercialized in 2016.

Applications

Can be used in the aerospace, automotive, chemicals, oil and gas, power generation, and shipbuilding sectors to improve fabrication techniques.

Capabilities

- Reduces energy use by over 90% compared to traditional arc welding.
- Reduces capital cost investment by 60% compared to equivalent resistance spot welding systems.
- Eliminates the loss of alloying elements at the weld location and maintains excellent corrosion characteristics at that joint area.

Benefits

Cost Savings

Reduces materials needed to complete a weld and capable of performing a single pass weld on high thickness pipes.

Environment

Eliminates emissions from the welding process through solid-state operation.

Quality

Produces welds with low distortion and good dimensional stability.

Contact Information:
Zhili Feng
Email: fengz@ornl.gov
Phone: (865) 576-3797
Oak Ridge National Laboratory
1 Bethel Valley Rd
Oak Ridge, TN 37830
Website: http://www.ornl.gov

[1] For more information: Flexible Friction Stir Joining Technology
[2] For more information: N2W Nonweldable to Weldable

Foundry Process Kit for 1.2kV SiC Power MOSFETs and JBS Rectifiers

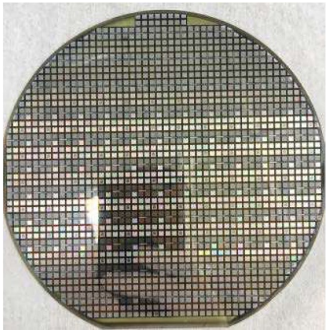
Wide Bandgap Semiconductors **Emerging Technology**

Process Kit Developed for more Accessible Market Adoption of SiC Power Devices

For decades, electronics have used silicon-based power devices but recently companies have started switching to silicon carbide (SiC) power devices, which can run at higher temperatures and frequencies than silicon devices. This allows companies to make smaller, lighter electronic products with higher performance than their traditional silicon counterparts. However, silicon devices are cheaper and easier to make than SiC devices and companies that have developed manufacturing processes for creating SiC power devices have kept their processes proprietary. This makes it difficult for other companies to enter the field, therefore limiting the participation in the market and keeping the cost of SiC devices high.

In 2015, North Carolina State University (NCSU), with assistance from AMO through the PowerAmerica Consortium at North Carolina State University, began development of PRESiCE™, a process that can be licensed, for manufacturing SiC devices, including power metal-oxide semiconductor field-effect transistors (MOSFETs), junction-barrier-controlled Schottky (JBS) rectifiers, and JBSFETs. Using PRESiCE™, companies can now have an affordable method to fabricate their own SiC devices, without having to design and qualify such a process themselves, allowing for easier market penetration. The PRESiCE™ team worked with X-Fab, using their foundry in Lubbock, TX, to implement and qualify the manufacturing process, demonstrating the high yield and tight statistical distribution of electrical properties for SiC power devices necessary to make them attractive to industry. In 2017, it was estimated that SiC power devices cost five times as much as silicon-based power devices. Through licensing PRESiCE™, NCSU hopes to reduce the cost of SiC devices down to one-and-a-half times that of silicon.

In 2018, NCSU completed qualifying the PRESiCE™ process. NCSU has licensed the technology for commercialization to one company and is in talks with others. In addition to their work on PRESiCE™, NCSU continues work on developing SiC power MOSFET technology with enhanced electrical performance.



SiC Power Device Wafer produced using NCSU's PRESiCE™ process

Overview

- Developed by North Carolina State University in 2015-2017.
- PRESiCE™ process was qualified at X-Fab Facility in 2016-2017.
- Licensed for commercialization in 2018.

Applications

Can be used to manufacture SiC power devices by semiconductor companies without a qualified process, to expand the availability of commercial low-cost products.

Capabilities

- Provides a process for creating 1.2 kV rated 4H-SiC power devices, including MOSFETs, JBS rectifiers, and JBSFETs, which can be produced in the X-Fab foundry.
- Achieves wafer fabrication process yield greater than 95%.
- Enables SiC manufacturing expansion through licensing SiC fabrication process.

Benefits

Cost Savings

Integration of JBS fly-back rectifier into the power MOSFET structure creates the power JBSFET, saving ~40% chip area and reducing the package count in half.

Energy Efficiency

As more companies enter the market with their own products, the cost of SiC power devices will be reduced expanding the market.

Contact Information:
Jay Baliga
Email: bjbaliga@ncsu.edu
Phone: (919)-515-6169
North Carolina State University
Raleigh, NC, 27695
Website: https://www.ncsu.edu

High-Octane Fuel-Stocks via Engineered Solid-Acid Catalysts

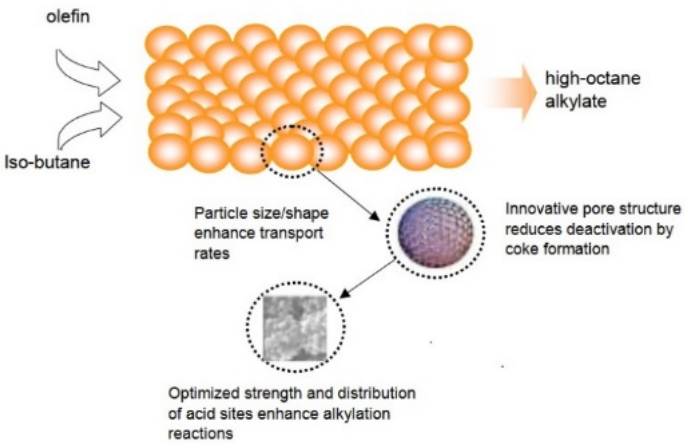
Chemicals **Commercial Technology**

Solid-Acid Technology Produces Ultra-Clean Fuels and Reduces Emissions

Current trends in environmental stewardship have made production of clean transportation fuels increasingly important. Demand for these green fuels is predicated on not only clean production and use methods, but also on the performance characteristics of the fuel. As a result, refiners could be left with no choice but to retrofit their older refinery systems to keep up with demand. A new distillation technology that addresses this issue could reduce the cost of the retrofit process and foster early adoption of clean fuel production methods.

Exelus, Inc., with assistance from AMO in the form of SBIR grants, has developed an engineered distillation catalyst that allows for the energy efficient production of green fuels. The solid catalyst has been designed to make retrofitting as simple as possible, both pellet shape and size are controlled to maximize the flexibility of the catalyst. The pellet's shape maximizes the mass transport rate into and out of the pellet, which reduces the restrictions on applicable system designs as well as the cost of implementation. Exelus has also optimized surface reaction characteristics of the catalyst to ensure that large coke molecules leave the catalyst pores as quickly as possible. This reduces catalyst deactivation resulting from pore blockage and extends catalyst life. To further promote conversion efficiency and long catalyst life, Exelus has optimized the strength and distribution of active catalyst sites to promote alkylation over coke formation.

Exelus' solid-acid catalyst is currently marketed under the ExSact and M2Alk product names and used for light olefin (ExSact) and methanol(M2Alk) conversion to high-octane gasoline blend-stock. [1,2] ExSact is currently in use by industry partners as part of their high-octane fuel generation systems. Exelus won the 2016 Tibbets award for their work on these catalysts.



Exelus, Inc.'s ExSact Solid-Acid Catalyst Design

Overview

- Developed by Exelus, Inc.
- Commercialized in 2016.

Applications

Can be used to improve efficiency in liquid-acid alkylation technologies or olefin polymerization units.

Capabilities

- Produces high-octane alkylate.
- Lowers energy consumption.
- Reduces capital investment costs.
- Easily retrofitted into existing refineries.

Benefits

Emissions Reductions

Reduces sulfur dioxide emissions.

Resilience

Resists poisoning from many common catalyst poisons including mercaptans, diolefins, and oxygenates.[1]

Waste Reduction

Improved product selectivity leads to reduction in raw material consumption and less waste.

Contact Information:
Mitrajit Mukherjee
Email: mmukherjee@exelusinc.com
Phone: (862) 210-8924
Exelus, Inc.
264 Passaic Avenue
Fairfield, NJ 07004
Website: http://www.exelusinc.com/

[1] For more information: ExSact.
[2] For more information: M2Alk.

High Performance Solar PV String and Micro Inverters with SiC and GaN Devices

Wide Bandgap Semiconductors **Emerging Technology**

Innovating Wide Band Gap SiC and GaN micro Inverters

Power semiconductors have played a major role in improving the performance of power converters in all applications. To date, most of them have been built using silicon. The technology is well developed. Wide bandgap semiconductors offer several advantages over Si. In particular, they can operate at higher temperatures (thereby reducing cooling requirements) and are capable of higher power density—leading to smaller devices. However, the technology is not as advanced as for Si. The ASU work was aimed at advancing the field of small, efficient, inverters.

Inverters for PV array use are required to be efficient over a range of voltages and currents. For a given array, the voltage is dependent on the temperature, and the available current on the amount of sun, the insolation. Since these parameters vary when a system is in use, the efficiency is specified as a weighted value over a range of conditions fixed to give a representative number. (It is known as the CEC efficiency because the California Energy Commission has approved the method.) A typical inverter CEC-efficiency is 96%.

The group at Arizona state University, with assistance from AMO through the PowerAmerica Consortium at North Carolina State University, has developed a string inverter that demonstrates a CEC efficiency of 98%. The work has involved the development of several new topologies for the inverters.

A challenge in the design of a transformerless single-phase PV inverter is the presence of switching-frequency capacitive ground current through the PV array. An additional challenge is that there is a ripple voltage on the dc side at twice power-frequency that should be kept small. The solution of these challenges involves trading off various design parameters. The solutions obtained by the project allowed the inverter to use relatively small-value capacitors, and eliminate the reliability risk associated with electrolytics by using film capacitors.

Three prototypes of string- and micro-inverters have been made, verifying efficiency and power density performance. Three patents have been applied for.



Hardware Prototype for GaN Based Transformerless Microinverter Power Board (left) and Control Board (right)

Overview

- Developed by Arizona State University, Tempe, Arizona.
- Development began in 2015.
- Several advances made in wide bandgap PV inverters and micro-inverters have been demonstrated.

Applications

Both PV inverters and micro-inverters have applications in renewable generation and transport sectors

Capabilities

- Enables significant increase in switching frequency leading to a factor of 5 improvement in power density over silicon-based technology
- Enables the use of film capacitors instead of electrolytics, a reliability improvement
- Can operates with high temperature at the semiconductor level, allowing simplified cooling

Benefits

Smaller Converters

Some applications, such as roof-top PV inverters, can take advantage of the improved size and weight aspects of the inverters developed.

More Reliable Electronics

Smaller-value capacitors can be used with these designs. That enables film capacitors instead of electrolytics. Film capacitors are efficient and more reliable.

Reduced Unwanted Interactions

The topologies allow for mitigation of the stray high-frequency ground currents coming via the stray capacitance of the PV array.

Contact Information:
Dr. Raja Ayyanar
Email: rayyanar@asu.edu
Phone: (480) 727-7307
Arizona State University
Electrical, Computer and Energy Engineering
Goldwater Center 208,
650 E. Tyler Mall,
Tempe AZ 85287
Website: https://ecee.engineering.asu.edu/

High Power Industrial Ultraviolet Curing System

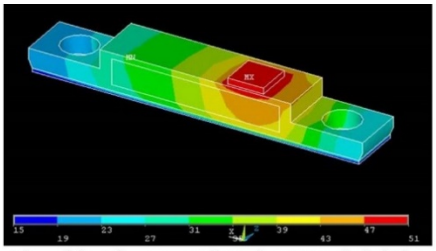
Wide Bandgap Semiconductors **Emerging Technology**

LED-UV Curing System Reduces Energy Consumption and Emissions

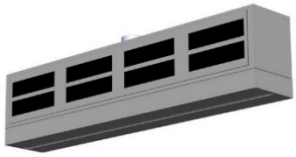
Traditional coating processes involving solvent based ink, adhesives and protective coatings such as sealants and paint typically involve either an air or oven drying step resulting in the emission of volatile organic compounds (VOCs). Adopting UV curing technology and chemistry can reduce VOC emissions as the curing mechanism involves polymerization versus evaporation. However, mercury lamps have been used as UV sources bringing different challenges to the process e.g. ozone emissions and logistics of operating a controllable exposure process step. Recent developments in high power LED technologies has resulted in the research and development of LED based UV sources.

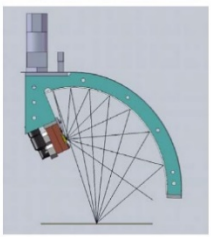
SolidUV Inc., with assistance from AMO, has developed a UV-LED industrial curing system for inks, adhesives, coatings and other applications such as disinfection/purification. SolidUV designed and developed UV LED devices, design patented in 2019, that could be used as a replacement for mercury (Hg) lamps that are currently used in industrial curing applications. The development work resulted in a new water cooled, high power, large area chip UV LED package design. SolidUV subsequently designed the associated optics, e.g. reflector/light guide optimized for their UV LED modules to create very high irradiance curing systems with a large working distances (distance between the lamp and the UV material to be cured).

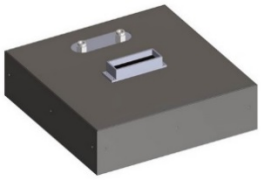
In 2014, SolidUV Inc. licensed its IP and manufacturing designs to PlayNitride, Inc. , who have sold 25 systems, based on SolidUV's technology, into the global market (Pacific Rim). A UV sheet fed offset printing system design is currently being developed. Currently, SolidUV, Inc., is seeking additional licensing partners for its LED related intellectual property, and is evaluating becoming a value added reseller of PlayNitride systems in the Americas and EU markets.



Advanced thermal management designs keep LEDs cooler for higher power and long life (new patent pending technologies)







SOLIDUV, INC.
LED Curing Systems

SolidUV's UVLED Device, Custom Parabolic Optic and Sources

Overview

- Developed by SolidUV, Inc. in 2010.
- Currently licenscing UV-LED related IP, licensing partnership with PlayNitride, Inc.

Applications

Can be used in UV curing applications as a replacement for traditional Mercury UV lamp sources.

Capabilities

- Provides industrial curing in the UVA range 325-400 nm
- UV LED source has actual useable life of over 40,000 hours
- No lamp warm up time and adjustable output
- Customizable optics and power output to suit curing application

Benefits

Energy Savings

LED UV cure systems can save over 80% energy used in thermal curing and 50% energy savings using Hg UV Lamps

VOC Emissions

UV curing processes reduce VOC emissions by 70 - 85%

Flexibility

LEDUV curing systems can be highly customized to suit UV chemistry process and retrofittable into existing UV systems

Environment

UV LED curing systems compared to Hg Lamps operate cooler (no IR emission), produce no ozone (safer operation) and contain no mercury

Contact Information:
Robert Karlicek
Email: bkarlicek@soliduv.com
Phone: (888) 281-1887
SolidUV, Inc.
5 Southside Dr., Ste 11-170
Clifton Park, NY 12065
Website: http://www.soliduv.com

High Surface Area Inorganic Membrane for Process Water Removal

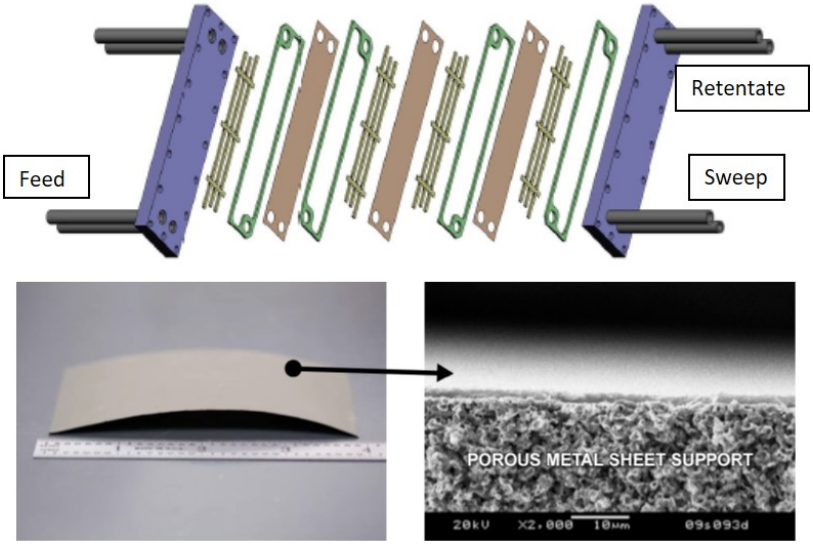
Chemicals **Commercial Technology**

New Material Leads to Energy Savings and Reduced Green House Gas Emissions

Energy consumption is the largest operational cost in ethanol plants. Economic competitiveness of existing corn-fed ethanol plants stands to substantially improve from a reduction in energy consumption. This energy efficient ethanol water separation technology would not only improve the cost competitiveness of existing corn-fed ethanol plants but also help with development of cellulosic ethanol plants in the future. Further, when used in the context of natural gas drying, this technology can result in significant energy savings and greenhouse gas reductions.

This membrane technology developed out of zeolite and ceramic oxide-type materials that allow permeation of water molecules while blocking all other molecules can be used in any distillation and extraction processes for separation of water from hydrocarbons or solvents (such as ethanol).

Developed by Pacific Northwest National Laboratory in collaboration with Pacific Ethanol Inc.,(licensed to Molecule Works, Inc.) and ADMA Products Inc. in 2015, this is a thin flat sheet water-selective molecular sieve membrane technology for separation of water from ethanol-enriched process streams. Molecular sieves, which are a special class of micro-porous materials, made of inexpensive precursors such as alumina and silicate—provide molecule-specific sieving functions. These micro-porous materials, also known as zeolite, have been widely used as catalysts and/or adsorbents in industry. Any distillation and extraction processes for separation of water from hydrocarbons or solvents (such as ethanol) could use this membrane technology. PNNL is currently investigating ways to scale-up membrane manufacturing, ethanol plant retrofitting and deployment as well commercialization of the technology.



PNNL's Small-Scale Membrane Module Design (top), 50µm-thick porous metal sheet (1µm pores) (left) and SEM photograph <2µm-thick layer of inter-grown zeolite crystals

Overview

- Developed by Pacific Northwest National Laboratory in collaboration with Pacific Ethanol Inc., licensed to Molecule Works, Inc. and ADMA Products, Inc. in 2015.
- Marketing efforts began in 2018 with first online sales in 2019.

Applications

- Dehydration of ethanol fuel and alcohols.
- Hot air dehumidification.

Capabilities

- Metal membrane thickness of 50-200µm with ultra-thin zeolite coating (<3µm).
- Zeolite coating provides high porosity (high surface area) with uniform pore structures at sub-micrometer.
- Provides high separation capacity in a compact footprint.
- Membrane is light, highly permeable, mechanically strong, flexible and stable in organic solvents and under heating.

Benefits

Energy Savings

Replacing ethanol distillation and adsorption processes with a membrane separation process could reduce energy consumption by more than 90%.

Manufacturability

The small thickness of the membranes allows manufacturing in sheet form through using a low-cost roll-to-roll production line.

Contact Information:
Wei Liu
Email: wei.liu@pnnl.gov
Phone: (509) 375-2524
Pacific Northwest National Laboratory
902 Battelle Blvd.
P.O. Box 999, MSIN K6-28
Richland, WA 99352
Website: http://www.pnnl.gov

High Voltage Electrolytes for Ultracapacitors

Energy Systems – Energy Storage **Emerging Technology**

High Voltage Electrolyte Lowers Cost and Size of Ultracapacitors

Ultracapacitor devices can be used to store energy with a more rapid charge and release time than lithium ion batteries. Battery packs for hybrid and electric vehicles typically require oversizing due to the high-power strain imposed by acceleration and regenerative braking. Using ultracapacitors in tandem with a lithium ion battery can reduce this need, dramatically improving the efficiency and range of electric vehicles and grid storage applications. However, despite the performance advantages granted from ultracapacitors they are not widely adopted because of their high cost and large size.

Eonix, with assistance from AMO through the LEEP Innovation Crossroads program at Oak Ridge National Laboratory, has developed electrolytes that improve the capabilities of ultracapacitors. Eonix designed and developed an empirically driven process that selects additives and optimizes electrolyte performance. This work has resulted in electrolytes that can operate at higher voltages and with less resistance than traditional electrolytes. This will allow for an increase in energy storage per capacitor cell, reducing the cost and size required for ultracapacitor modules. The empirical process developed will also enable the development of a portfolio of electrolyte products for various battery and ultracapacitor applications.

Eonix was founded in 2013 to research and develop advanced electrolytes for commercial applications. The first sales for their high voltage electrolytes for ultracapacitors are expected in late 2020 with full product integration expected in 2021. Eonix is considering either direct sales or licensing options for the technology. They are seeking partners for chemical manufacturing, production scale-up and ultracapacitor device manufacturing companies for product development.



Ultracapacitor using Eonix high voltage electrolyte

Overview

- Developed by Eonix beginning in 2013.
- Currently seeking partners in ultracapacitor device manufacturing and chemical manufacturing.
- Product Integration expected in 2021.

Applications

The primary application is in tandem with lithium-ion battery systems such as electric and hybrid vehicles.

Capabilities

- Electrolyte increases the individual battery cell voltage from 2.7V to 3.5V.
- Electrolyte performance can increase energy storage capacity (reduces size and cost) in electric vehicle and grid energy storage applications.
- Empirical process for developing optimal electrolytes for a given electrode.

Benefits

Cost Savings

The electrolytes higher operating voltage increases the energy stored by up to 68%. The increased energy storage capacity will require fewer cells for the same ultra-capacitor output, reducing costs and lowering size requirements.

Energy Density

Eonix's electrolytes smaller average ion size can fill small electrode pores and enable formation of thicker layers which increases overall capacitance and improves power density by 42% and cell energy density by 39%.

Retrofittable

Eonix's electrolytes are designed to be a drop-in replacement for current ultracapacitor systems. No costly manufacturing procedures or changes to electrode surface chemistry are required.

Contact Information:
Don Derosa
Email: dderosa@eonixenergy.com
Eonix
2641 Osprey Vista Way
Knoxville, TN 37920
Website: https://www.eonixenergy.com

Highly Efficient Conical Gap Motor Using Soft Magnetic Composites and Grain-Oriented Electrical Steel

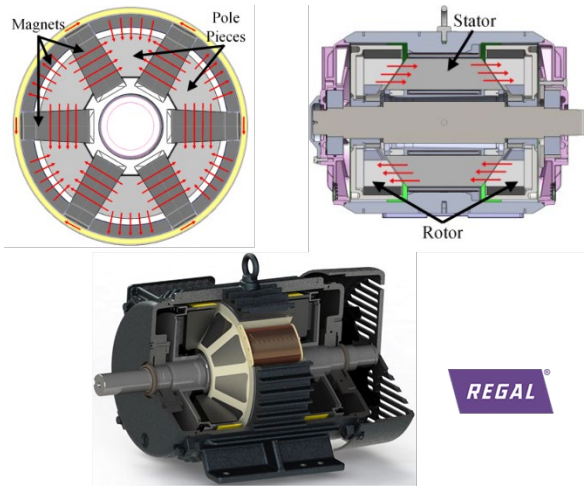
Critical Materials **Emerging Technology**

Reducing Energy Losses in Electric Motors Through Improved Materials and Design

Energy losses in electric motors can be divided into five major categories: core losses, windage and friction losses, stator losses, rotor losses, and stray load issues. Mitigating energy losses from any of these categories can greatly improve motor efficiency. One way to reduce energy losses from many of these categories is to use materials with greater magnetic permeability and flux density in motor construction, such as grain-oriented electrical steel (GOES) and soft magnetic components (SMC) in place of non-oriented electrical steel. However, the benefits from using GOES over non-oriented electrical steel only apply when the flux is primarily in the direction of the grain orientation. Because most motors employ a rotating magnetic field, the motor complexity must be increased to accommodate the GOES.

Regal Beloit Corporation, with assistance from AMO, developed a performance model for their NovaMAX motor, which utilizes SMC and GOES in the rotors and stator, respectively. NovaMAX uses conical air gaps, which have a larger surface area than standard motors, and which reduces the reluctance of the magnetic flux path, resulting in an increase in flux traveling from the rotor to the stator. While these changes in the stator pole construction create slightly higher losses due to hysteresis, the increased stator flux from the SMC and the inherent benefits from the GOES is significant enough to decrease the overall losses, even though ferrite magnets are used instead of rare earth magnets. To further improve the efficiency of NovaMAX, the stator teeth were reduced in length and topped with SMC tips to form a flat, uniform air gap to further increase the flux.

In 2019, Regal Beloit Corporation used results from their model to develop a prototype motor design with the aim of reaching their target efficiency of 96.8%, compared to the original NovaMAX motor's efficiency of 96%. Currently, Regal Beloit Corporation plans to incorporate the design enhancements from the prototype into their production design by 2021, and potentially extending the technology to include larger and smaller motor frame sizes going forward.



Magnetic flux paths across the Rotor (Upper Left), and Conical Air Gaps (Upper Right), in Regal's NovaMAX motor (Bottom)

Overview

- Developed by Regal Beloit Corporation
- Development began in 2017.
- Development finished in 2020.
- Currently working to incorporate enhancements into production design.

Applications

Provides a motor that can be used in machines that run at high duty cycles at variable speeds, such as pumps, compressors, and fans for heating, ventilation, and air conditioning (HVAC) systems.

Capabilities

- Can provide a motor designed at 5 kW, 1,800 rpm, 460V that can operate greater than 96% efficiency.
- Can potentially adapt the motor design into a 7.5 kW, 1800 rpm motor.

Benefits

Increased Efficiency

The use of SMC and GOES in the rotor and stator combined with a uniform air gap between stator teeth can potentially increase the efficiency of the motor from 96% to 96.8%.

Energy Savings

By using GOES in place of non-oriented electric steel in the stator and SMC materials instead of rare earth magnets in the rotor, motor energy losses can be reduced by up to 21% compared to the previous design.

Contact Information:
Alan Crapo
Email: alan.crapo@regalbeloit.com
Phone: (608) 364-8800
Regal Beloit Corporation
1435 Koll Cir.
San Jose, CA, 95112
Website: https://www.regalbeloit.com/

HotZoom™: Imaging-Based Optical Caliper for Objects in Hot Manufacturing Processes

Steel **Commercial Technology**

Non-contact Measurement Provides In-line, Real-time Product Dimension Monitoring

In manufacturing, maintaining production parts within specification (e.g., part dimension) is important in terms of throughput, quality, waste, and cost. Particularly in hot manufacturing processes (e.g., steel industry), poor dimension control can lead to surface defects, incorrect cross-section weight distribution, and final product straightness. In-line dimension measurement and control is of interest to the steel makers, yet current industry focus is on the final product dimension instead of the whole process due to labor and system cost as well as operator safety concerns. As sensor technologies advanced, the industry started to see the need to enforce better dimensional control throughout the process, but lack the proper tools to do so.

OG Technologies, Inc. (OG), with assistance from AMO, as part of the American Recovery Reinvestment Act, has developed an imaging-based optical caliper (OC) for objects in hot manufacturing processes. The OC was designed to provide a lightweight, robust, safe, and accurate portable dimensional measurement device for hot objects with integrated wireless communication capacity to enable real-time process control. The OG used their previous expertise in hot process monitoring to provide a portable, non-contact solution for key dimensional measurements in steel rolling, casting, and forging. The OC allows efficient, flexible, measurements with improved data management, accuracy, and frequency that are safer to perform (farther away from hot objects).

OG's patented optical caliper technology is self-calibrating and has swappable lens functions to accommodate different working distances and can compensate for different on-site environmental noise. The imaging software has the capability to perform measurements with perspective distortions as well as 3D imaging. The device can transmit or upload data to a manufacturing facility's process control system. The OC has been extensively tested under laboratory conditions and on site at participating industrial partner steel mill and forging facilities. OG Technologies began pilot commercialization of the OC technology in late 2013.



OC Operation at an Open Die Forge Plant (top), Edge Measurement on 3D High Contrast Object (bottom)

Overview

- Developed by OG Technologies, Inc., Georgia Institute of Technology and industry partners.
- Commercialized in 2013 at several U.S. forging companies.

Applications

Can be used to monitor and control product dimensions in hot manufacturing processes and other manufacturing processes where in-line product measurement would be beneficial.

Capabilities

- Performs measurements at working distances from 0.5 m up to 5 m with accuracy <0.2 % of measurement range.
- Provides portable, handheld device that is lightweight with wireless data transmission capability.
- Provides real-time dimension control.

Benefits

Cost Savings

In-line, real-time process data enables tighter quality control specifications that will improve production yield, throughput and quality with reduced waste.

Energy Savings

Using OC to improve process control and reduce material and product waste could potentially reduce energy waste, CO_2 emissions, wastewater, and toxic waste.

Contact Information:
Terry Liddy
Email: liddy@ogtechnologies.com
Phone: (734) 973-7500
OG Technologies
4480 Varsity Dr. Ste. G
Ann Arbor, MI 48108
Website: http://www.ogtechnologies.com/

Improved Catalyst Selectivity and Longevity Using Atomic Layer Deposition

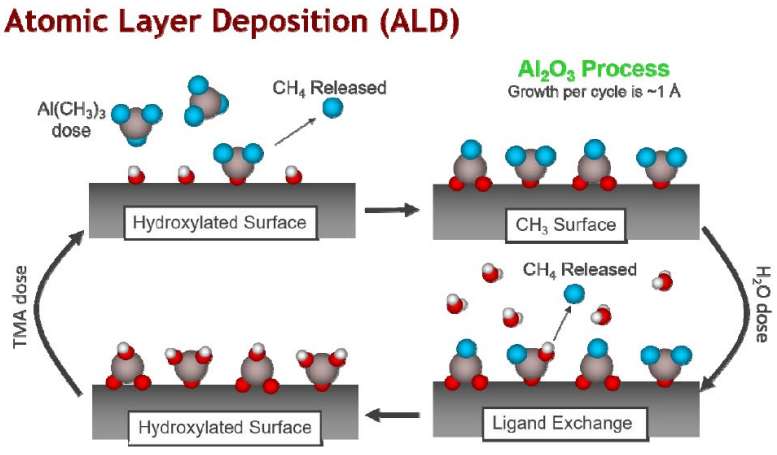
Advanced Materials Manufacturing | **Emerging Technology**

Atomic Layer Deposition overcoating technique improves catalyst lifetime by more than 100%

Catalyst deactivation costs the chemical industry billions of dollars in lost revenue. Imperfect selectivity in catalytic transformations engenders the use of large, costly separation processes to remove unwanted impurities. The use of ALD (Atomic Layer Deposition) will inhibit metal sintering and improve catalyst lifetime by more than 100% and lower energy consumption. The scalability of this technique working in conjunction with its increased validation and acceptance (with very broad applicability in the petrochemical and fine chemical industries) will strengthen the US's position as a leader in advanced materials manufacturing techniques.

Argonne National Laboratory and industry partners, Honeywell UOP (UOP) and Forge Nano (FN), with assistance from AMO are developing an Atomic Layer Deposition (ALD) overcoating technique to overcome catalyst degradation issues. The technique deposits protective layers around the catalysts and preserves catalyst integrity under reaction conditions. Overcoating applies one or more protective layers to the catalyst to inhibit metal sintering which can reduce catalyst activity. Channels can be introduced into the ALD layers to provide reactant access to the catalyst's active particles and improve reaction selectivity. This research will apply the overcoating technology to platinum based heterogeneous catalysts used in the propane dehydrogenation (PDH) to propylene. On-purpose propylene is a rapidly growing market as an essential chemical for plastics manufacturing. An improvement in the efficiency of catalytic reaction will reduce the energy required for the process, and improved selectivity will lead to additional savings.

After only two years of development, the scaled-up techniques' coating performance has been validated and a techno-economic analysis of the scaled up process is underway. A patent application on the technique and process has recently been filed with the U.S. Patent Office.



Formation of a mono layer of alumina film via ALD overcoating using Al(CH3) where the overcoated surface is pre-covered with hydroxy groups.

Overview

- Developed by Argonne National Laboratory, Forge Nano and Honeywell UOP.
- Currently exploring licensing and funding partnership opportunities.

Applications

Broad applicability in the petrochemical and fine chemical industries. Specific applications include petroleum refining, petrochemical production, automobile exhaust treatment, and many other processes requiring chemical reactions.

Capabilities

- Outperforms conventional propylene manufacturing market-leading catalysts.
- ALD overcoating improves selectivity to Olefin thus avoiding coke formation.
- ALD coating improves catalyst lifetime by more than 100%, reducing the deactivation rate.
- Advances the knowledge and application of Al_2O_3 and TiO_2 based ALD overcoating methods in high temperature catalytic transformations (TRL 7).
- Can be scaled up for large volume applications such as catalyst manufacturing.

Benefits

Efficiency

Efficiency of the catalytic reaction improves, thus reducing the energy required for the process

Energy Savings

Improved catalytic reaction selectivity leads to a reduction in energy requirements.

Environment

Expected to reduce the lifecycle of energy consumption required to manufacture light olefins by 50% in 10 years.

Higher Catalytic Lifetimes

Improved catalyst lifetime >100% due to a reduction in deactivation rate.

Contact Information:
Dr. Christopher L. Marshall
Email: Marshall@anl.gov
Phone: (630) 252-4310
Argonne National Laboratory
9700 South Cass Avenue
Lemont, IL 60439
Website: http://www.anl.gov

Induction Consolidation/Molding of Thermoplastic Composites Using Smart Susceptors

Composite Materials **Commercial Technology**

Efficient Processing of Lightweight Thermoplastic Composites

Today, hundreds of millions of pounds of composite components are processed each year using energy-inefficient processing methods. With many markets transitioning to lightweight composites for performance gains, the use of these components is rising rapidly. In this fast-growing sector, manufacturers have the opportunity to introduce new energy-efficient systems and materials that may yield large energy savings and improved recycling.

Boeing, in partnership with Ford Motor Company, Cytec Engineered Materials, Steeplechase Tool & Die Inc., Temper, Inc., Vestas Wind Systems, and Ajax TOCCO, is exploring and defining the technical and economic viability of induction consolidation/molding of thermoplastic composites using smart susceptors as a sustainable manufacturing platform. Component and material evaluations are being made for aerospace, wind power, and automotive applications and results will be used as the basis for decisions to proceed to a pre-production scale development.

Induction consolidation/molding of thermoplastic composites using Smart susceptors will significantly reduce the cycle time and energy used for manufacturing and will increase the performance of the resulting components. Smart susceptors are ferromagnetic alloys that have a specific Curie temperature or point where they lose their magnetic properties. At this temperature, colder sections of these smart susceptors continue to produce heat while hotter sections stop producing heat, thus improving temperature uniformity. The characteristic rapid processing cycle of induction consolidation of thermoplastic composites not only saves energy but may also significantly improve component affordability. In addition, integrating these lightweight components into aerospace and automotive vehicles will reduce the vehicles' fuel consumption and carbon emissions.



Boeing's Smart susceptor tool.

Overview

- Developed by Boeing in partnership with Ford Motor Company, Cytec Engineered Materials, Steeplechase Tool & Die Inc., Temper, Inc., Vestas Wind Systems, and Ajax TOCCO.
- The smart susceptor processing technology has resulted in the commercialization of inductively heated smart blankets available in 2016.

Applications

Can be used to make a significant number of composite components in aerospace, automotive and wind energy markets to replace steel or thermoset composite materials and reduce weight by up to 10%.

Capabilities

- Produces optimal thermal cycles allowing optimization of productivity/affordability
- Achieves greater structural durability via thermoplastic resin-based composites for improved performance
- Allows significant energy savings over traditional processing across several industrial segments.

Benefits

Cost Savings

Enables rapid high rate automotive production with molding at the melt temperature with significantly reduced press costs along with general reduction of factory floor space requirements.

Productivity

Combines induction heating using smart susceptors and thermoplastic composites which enables high rate production of high-performance structure, eliminating factory bottle necks for aerospace and wind energy.

Enhanced Recycling Characteristics

Enables full recycling of the composite structure due to its ability to be melted and remolded. This enables a tiered recycling system that allows multiple reuses from one industrial segment to the next.

Contact Information:
Marc Matsen
Email: marc.r.matsen@boeing.com
Phone: (206) 544-7579
The Boeing Company
Seattle, WA 98108
Website: http://www.boeing.com

Integrated DC-DC Converters Using Thin-Film Magnetic Power Inductors

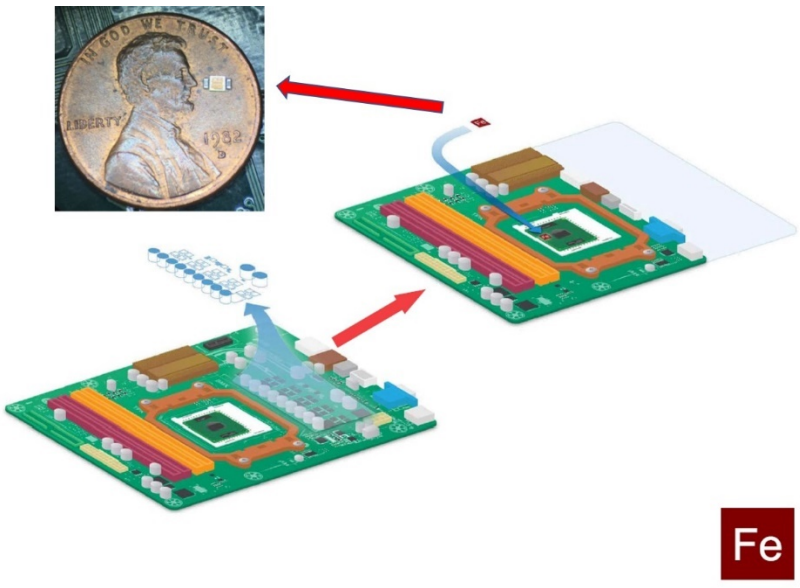
Semiconductors for Power Electronics **Commercial Technology**

On-chip Low-Cost Inductors Improve Power Supply Efficiency

Energy consumption has doubled since 1980 in the U.S. and continues to nearly double forecasted rates for device energy use.[1] Variance in power required by and delivered to microprocessors leads to inefficiencies in voltage distributions in common electronic devices and datacenters, which increases energy use. Some devices are equipped with voltage controllers that work pre-power-supply, but these controllers often have a large form factor and only condition power supplied, ignoring demand variance. As a result, most electronic devices do not make use of voltage regulators. To reduce energy needed by electronic devices, a small form factor voltage regulator is needed.

Ferric, Inc. (FS), with assistance from AMO, in the form of SBIR grants, has developed a low-cost, small form factor magnetic inductor for use with microprocessors. The developed thin-film inductors can be fabricated on 300mm CMOS wafers and other smaller sized wafers. Ferric is now selling single-chip DC-DC power converter products into various processing modules for government and commercial applications. The adopting modules have all demonstrated a size, weight and power savings ranging from 20-50% each, consistent with analytical models.

Ferric started high-volume production of single chip-power converters in 2020 and is rapidly gaining adoptions in both government and commercial applications. Meanwhile, Ferric is continuing investment in our core technology and product offerings.



Ferric's Integrated Voltage Regulator (IVR) Solution

Overview

- Developed by Ferric (Semiconductor) Inc., and TSMC
- Commercialized in 2018.
- Currently improving based on customer feedback and self-development for efficiency and O/P power.

Applications

Can be used to provide integrated power regulation for electronic devices.

Capabilities

- Increases energy efficiency by up to 50%
- Achieves low cost on-chip power regulation.
- Offers cross wafer variability <3%.

Benefits

Cost Savings

Reduces upfront costs by removing the need for more expensive and obsolete discrete components

Efficiency

Regulates voltage with better accuracy and improved temporal resolution to exercise improved power management in digital SoC's and achieve up to 50% energy savings.

Usability

Introduces low cost small form factor voltage regulators to the microprocessor market.

Contact Information:
Dr. Noah Sturcken
Email: nsturcken@ferricsemi.com
Phone: (646) 599-0765
Ferric (Semiconductor) Inc.
350 7th Avenue, Suite 900
New York, NY, 10001
Website: www.ferric.com

[1] How Small Devices are Having a Big Impact on U.S. Utility Bills, ENERGY STAR, 2010

Large Area Projection Sintering

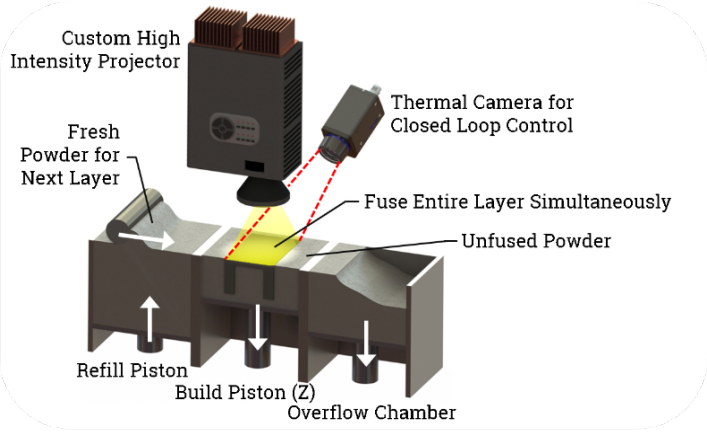
Additive Manufacturing **Emerging Technology**

Additive Manufacturing using Large Area Projection Sintering Increases Throughput and Quality

Additive manufacturing (3D printing) has dramatically reduced the cost and timelines to produce prototypes and bring them to market when compared to traditional manufacturing technologies. However, additive manufacturing technologies are unable to print with a large variety of materials and struggle to meet the same quality assurance standards of traditional manufacturing without sacrificing throughput speed. The ability of additive manufacturing to create complex shapes, produce large volumes, and provide mass customization at a low cost has not supplanted traditional manufacturing techniques in commercial applications because no company or technology has been able to solve that problem. Ascend Manufacturing has patented its novel technology that increases throughput speeds, prints with materials impossible by any other technology (from ultra-low cost to high performance), all while integrating quality control and assurance measures. They are aiming to be the first company ever to offer in-situ qualification of every part produced, certifying that it meets geometrical and mechanical performance metrics and is defect free.

Ascend Manufacturing, with assistance from AMO through the LEEP Innovation Crossroads program at Oak Ridge National Laboratory, has developed Large Area Projection Sintering (LAPS), an additive manufacturing technology that can be used to fabricate plastic components. Development of the LAPS system began in 2013 at the University of South Florida. The process uses a high intensity projector that can simultaneously fuse an entire 2D area while being actively monitored and controlled by thermal and optical cameras in a closed loop. This yields the highest manufacturing speeds in the industry, while also providing more quality control than other additive manufacturing technologies. This technology will bridge the gap of providing economical parts from small to large volumes.

Full system commercialization planning is already in progress and Ascend's goal is to manufacture and develop components for the consumer product,



Portrayal of the Large Area Projection Sintering Technology

Overview

- Developed by Ascend Manufacturing, founded in 2018.
- Currently seeking investors, beta customers, and powder material manufacturers for partnership.
- Full commercialization expected in 2022.

Applications

Large Area Projection Sintering is an additive manufacturing (3D-printing) technology than can be used for all types of plastics manufacturing.

Capabilities

- Provide cost effective prototyping and production components at low or high volumes.
- Can print with unique materials from ultra-low cost, to high performance aerospace grade materials.
- High part-to-part uniformity with automated quality assurance and control measures.

Benefits

Increased Recycling Rates

Unlike other additive manufacturing technologies, LAPS can apply heat only where needed, leading to the highest recyclability rates in the industry.

Increased Throughput

Printing time no longer depends on the number of parts in the build area, only on the height of the build. This allows the technology to scale to the highest throughput in the industry.

Quality Control

Each part manufactured includes a post build quality analysis report that can be used for certification purposes. The system automatically flags parts that contain defects or fall outside of the input engineering specifications both for geometry or thermal history (which defines the mechanical performance of a material).

Contact Information:
Justin Nussbaum
Email: justin@ascend-3d.com
Phone: (727) 515-1859
Ascend Manufacturing – ORNL MDF NTRC-3
2370 Cherahala Blvd
Knoxville, TN 37932
Website: https://www.ascend-3d.com

Low Energy Low Cost Production of Ethylene by Low Temperature Oxidative Coupling of Methane

Process Intensifications (Chemicals) **Emerging Technology**

Alternative Method for Small-Scale Production of Ethylene with Reduced Energy Consumption and Emissions

Ethylene is an essential chemical building block that is used to manufacture countless products. Most ethylene is produced via steam cracking, a process where the feedstock (mostly ethane, sometimes naphtha or propane) is heated to high temperatures over a catalyst. However, steam cracking is energy intensive, occurs in large-scale facilities, and can also bottleneck the ethylene production capabilities to manufacturing sites located in vicinity of the ever-depleting oil resources. An alternative method of ethylene production, oxidative coupling of methane (OCM), has been researched due to the potential of the technology to reduce costs, energy, and environmental emissions in the production of ethylene.

Siluria Technologies, with assistance from AMO, has developed a new oxidative coupling of methane process designed for distributed small-scale production of ethylene, performed at low temperatures using Siluria Technologies' advanced OCM catalyst. In OCM, methane and oxygen react over a catalyst exothermically to form ethylene, water, and heat. These catalysts are formed through a combination of: (1) synthesis of nanowire catalysts, (2) unique templating technologies; and (3) high throughput screening tools to rapidly evaluate hundreds of catalysts, unlike traditional methods that evaluate one catalyst at a time. Siluria Technologies focused on all key process variables such as temperature, pressure, activity, and catalyst stability and lifetime, not solely conversion and selectivity.

In 2017, Siluria Technologies was able to implement a small-scale OCM production of ethylene. Additionally, Siluria's reaction process is flexible to the source of oxygen and methane feedstocks. The catalyst is not impacted by the source of oxygen, whether it is pure oxygen, enriched air, or compressed air, although the specific downstream purification and separation processes vary depending upon the oxygen source. In 2019, Siluria Technologies was acquired by Lummus Technology, and there are plans to commercialize this technology by 2022.

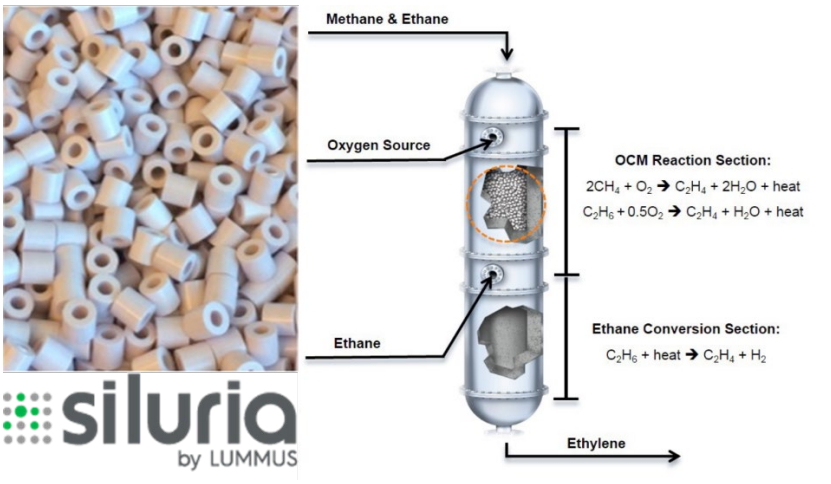


Illustration of Siluria Technologies' Low-Temperature OCM catalyst (Left) and reactor with catalyst installed (right) for distributed production of ethylene.

Overview

- Developed by Siluria Technologies in partnership with RTI International from 2015 to 2017.
- Siluria Technologies was acquired by Lummus Technology in 2019.
- Commercialization expected by 2022.

Applications

Can be used to provide distributed, small-scale conversion of methane to ethylene for downstream consumers.

Capabilities

- Capable of accommodating natural gas as a feedstock for ethylene production instead of just pure oxygen and methane sources.
- Capable of on-site production of ethylene and other high value derivatives including polymers without being restricted to large-scale manufacturing facilities.

Benefits

Energy Savings

The refined configuration with PSA based C1/C2 separation results in significant reduction in energy consumption (over 15%) of the overall unit.

Cost Savings

Enables economically competitive, distributed, small-scale production of ethylene.

Environmental Benefits

Allows the use of natural gas reserves as feedstock, thus lowering dependence on crude oil for production of high value petrochemicals.

Contact Information:
Guido Radaelli
Email: guido@siluriatech.com
Phone:
Siluria Technologies
2107 Research Forest Dr.
The Woodlands, TX, 77380
Website: https://siluria.com/

Manufacturing of Protected Lithium Electrodes for Advanced Batteries

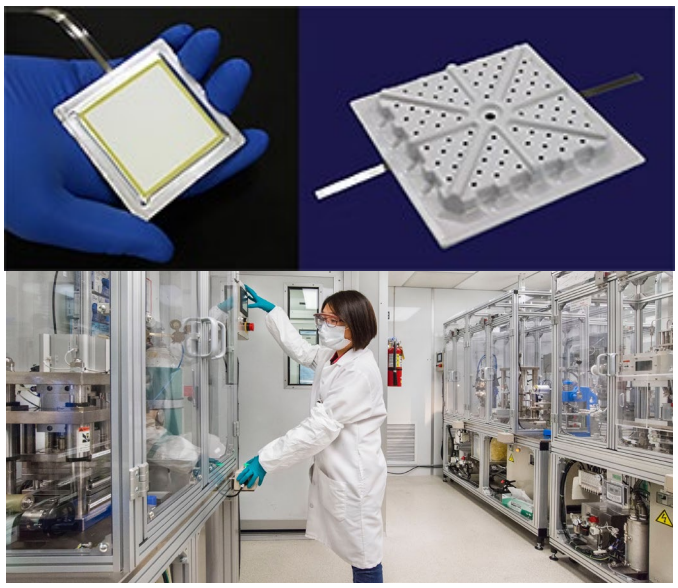
Advanced Materials Manufacturing | **Commercial Technology**

PLE-based Batteries Offer High Energy Density and Improved Cycle Performance

Rechargeable lithium metal batteries represent the next major advance in battery technology, with applications that span electric vehicles (EV-cars/EV-buses), grid storage, consumer electronics, aerial vehicles (drones and air taxis), and military applications. Compared with graphite electrodes used in current Li-ion batteries, Li metal is ten times lighter and one third the size. However, the use of lithium metal as an electrode presents unique challenges. Solving these problems is the key to boosting domestic battery manufacturing in this globally competitive, emerging technology area.

PolyPlus Battery Company developed the protected lithium electrode (PLE^{TM}), an invention that has enabled lithium metal as an electrode in advanced primary and secondary battery technologies. With assistance from AMO and Corning Inc., PolyPlus developed the novel manufacturing processes to produce PLE's for lithium-air (Li-air), lithium-water (Li-water) and lithium sulfur (Li-S) batteries and is working to scale up manufacture of these technologies. The Li-S battery offers double the energy at half the weight of a Li-ion battery and uses low cost abundant raw materials. PolyPlus' Li-air battery is the ultimate solution for lightweight manpower, with specific energy of more than 800Wh/kg. And for underwater applications, PolyPlus' Li-seawater battery, currently being scaled for high volume commercial manufacture, delivers remarkable performance of 1300Wh/kg in a fully engineered battery pack.

PolyPlus continues to push their lithium-based batteries toward scale up for mass manufacturing. The Li-S battery has potential applications in several industries including grid storage, military, and portable devices, necessitating increased production to ensure low cost and battery availability. PolyPlus is exploring the use of its Li-water battery in oceanographic exploration and other maritime endeavors. PolyPlus' Li-air battery is aimed at man-portable power applications, as well as for powering remote sensors.



PolyPlus' 11-amp hour (Ah), water-stable protected lithium electrode (PLE) (left). A lithium air cell (right). PLE pilot line (below).

Overview

- PLE-based batteries developed by PolyPlus Battery Company were commercialized in 2017, starting with the U.S. Navy.
- A new process for producing lithium-ion conductive ceramic membranes was developed by Corning Incorporated.
- IMI funded the design and installation of the first of its kind pilot line for the manufacture of PLEs and PLE-enabled batteries.
- Current focus is on PLE^{TM} manufacturing and commercialization of PLE-enabled batteries.

Applications

- Lightweight replacement for Li- ion batteries when energy density and runtime is paramount, such as drones.
- Underwater power, including oceanographic and other maritime applications, oil and gas exploration, autonomous underwater vehicles and buoys.
- Man-portable power in need of the ultimate lightweight power source.
- Long life power for sensors and beacons requiring near zero self-discharge.
- Water stable lithium electrode for institutional R&D.

Capabilities

- Water stable PLE electrodes approach theoretical capacity of Li metal (3860 Ah/kg)
- PolyPlus' Li-air battery > 800Wh/kg.
- Li/seawater battery > 1300Wh/kg.
- High energy density operation in open-water and open-air environments. Pressure tolerant to over 10,000 psi.
- Extremely long shelf life, zero self-discharge

Contact Information:
Dr. Steven Visco
Email: svisco@polyplus.com
Phone: (541) 841-7242
PolyPlus Battery Co.
2424 Sixth St.
Berkeley, CA 94710
Website: http://polyplus.com

Medium Voltage Integrated Drive and Motor

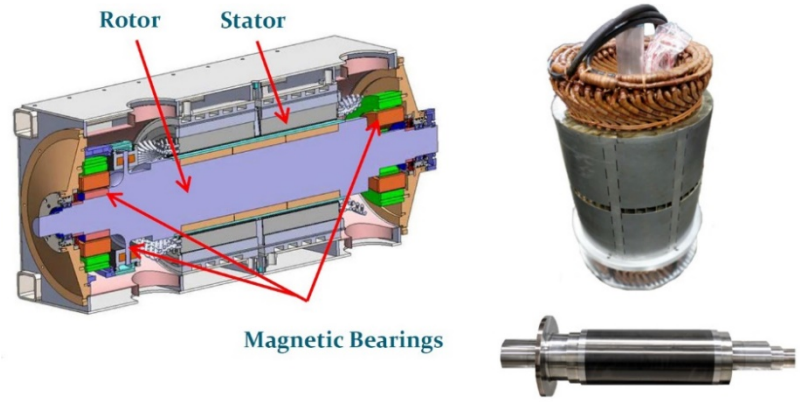
Wide Bandgap Semiconductors **Emerging Technology**

Silicon Carbide Drive for High-Speed Motor Applications

In many heavy industrial applications, gas turbine powered drive systems are the standard. However, an increasing number of end users are showing greater interest in electric drive systems due to more stringent emission standards and demand for increased reliability, better availability, and more operational flexibility. Despite this interest, deployment of variable speed drive (VSD) medium and high voltage motors is lagging. Market barriers include high capital cost, large footprint, low switching frequency, and high losses at high voltage ratings for VSDs based on today's silicon power electronics. One way to address these barriers is to incorporate next-generation power conversion technologies based on high voltage silicon carbide semiconductor switching technology.

Calnetix Technologies, with funding assistance from AMO, has developed a medium voltage drive that is to be integrated with a high-speed motor for use in direct drive equipment, utilizing silicon carbide switching devices that enable higher voltage operating conditions and improved efficiency. The major focus is on the silicon carbide-based high frequency switching devices that can work directly with high voltages, switch at high frequencies, and do so very efficiently. Based on the project team's assessment of the most likely applications to first adopt the technology, the developed electric machine will be rated at 1.6 megawatts (MW).

By 2020, Calnetix has completed the manufacturing of a 1.6 MW, 4160 V medium voltage motor with magnetic bearings that has been tested at a speed of 12,000 rpm. Additionally, Calnetix also completed the manufacturing of a 1.0 MW medium voltage silicon carbide inverter, which has been tested up to 4,500 VDC and 70 A. The next step is to test both the motor and inverter at their full rated ranges (up to 15,000 rpm for the motor and 6,200 VDC for the inverter).



Calnetix Technologies' 1.6 MW Machine Layout and Motor Components

Overview

- Developed by Calnetix Technologies.
- Development began in 2016.
- Motor construction completed in 2020; testing currently in progress.
- Product release slated for 2022.

Applications

Can be used as an electric alternative for high-speed direct drive equipment in many industry sectors, including natural gas compression, air compression, air separation, and various power generation and turbo expansion applications.

Capabilities

- Can achieve approximately 94% total system efficiency.
- Total system footprint of 3.1 m^2/MW.
- Maintenance free.

Benefits

Improved Efficiency

Provides higher efficiency than existing electric drive motors.

Cost Savings

Provides a reduction in electric grid loads and infrastructure costs.

Environmental Benefits

Has a greatly reduced energy footprint than existing motor systems.

Contact Information:
Octavio Solis
Email: osolis@calnetix.com
Phone: (562) 282-5507
Calnetix Technologies
16323 Shoemaker Ave.
Cerritos, CA 90703
Website: www.calnetix.com

Monitoring and Control of Chemical Composition of InGaN Layers during MOCVD

Wide Bandgap Semiconductors **Commercial Technology**

Monitoring and Control System Improves Manufacturing Yield

Improving lighting efficiency is a key facet of DOE's plan to save 40% of predicted annual energy expenditures.[1] Widespread adoption of LEDs is considered a large part of the plan to achieve this goal. Current LED manufacturing methods involve several techniques that suffer from high defect rates, increasing unit cost, and reducing LED adoption rates. Central wavelength non-uniformity is a major contributor to defect related losses arising from metal organic chemical vapor deposition processes. Pyrometry can be used to control reactor temperatures but is ineffective when working with Gallium Nitride (GaN) based substrates that are transparent in the infrared spectral region.

AccuStrata, Inc., with assistance from AMO, has developed an improved method for vapor deposition process control that addresses shortcomings in traditional control strategies. AccuStrata's OM2 system uses a combination of optical monitoring and model predictive control (MPC) to improve deposition uniformity on a variety of substrates. A fiber optics-based probe and fiber optic assembly send process data to the MPC allowing the OM2 to operate anywhere in the 400 – 1000 nm range.[2] OM2's in-situ data collection and MPC are designed to function in both normal and planetary rotation configurations. The system can detect deviations in uniformity in single wafers, from wafer-to-wafer, run-to-run, or machine-to-machine situations. If deviations are detected, OM2 notifies the user automatically.

AccuStrata's OM2 can be used to increase total wafer yield by up to 14% or epitaxy yield up to 60%. The OM2 can be purchased in either generic or custom configuration per end-user specification.



AccuStrata's Optical Monitor (left) and Sensor Setup (right)

Overview

- Developed by AccuStrata, Inc.
- Currently improving circuit design, fabrication, and reliability in preparation for field-testing.

Applications

Can be used to reduce wafer losses to central wavelength non-uniformity.

Capabilities

- Increases manufacturing yield by up to 14%.
- Monitors both planetary and standard rotation configurations.
- Allows optical monitoring and MPC of GaN, Indium Gallium Nitride (InGaN), and Aluminum Gallium Nitride (AlGaN) layer thickness.
- Offers a broadband optical range of 400-1000 nm with 1 nm resolution.

Benefits

Cost Savings

Reduces costs by reducing waste from product binning.

Efficiency

Allows active process control through in-situ data acquisition.

Productivity

Enables high-volume production by increasing run-to-run reproducibility.

Contact Information:
George Atanasoff, Ph.D.
Email: gatanasoff@accustrata.com
Phone: (301) 332-6167
AccuStrata, Inc.
11900 Parklawn Drive
Rockville, MD 20852
Website: http://www.accustrata.com/

[1] Solid Sate Lighting R&D Plan, U.S. DOE, May 2015

[2] For More information: OM2.

Near Net Shape Manufacturing of New, Low-Cost Titanium Powders

Materials for Harsh Environment **Commercial Technology**

Titanium Powder Improves Efficiency of Near Net Shape Consolidation

Advanced materials use in domestic manufacturing is driving U.S. based manufacturers toward increases in performance, durability, and energy efficiency. Titanium offers performance-increasing capabilities that are attractive in several industries that benefit from its potential in lightweighting as well as its high strength and durability. Several industries currently make use of titanium but suffer from high fabrication and materials costs associated with its use. Reductions in material and fabrication costs will benefit domestic manufacturers and could lead to future beneficial developments in the manufacturing sector.

Oak Ridge National Laboratory (ORNL), with assistance from AMO and industry partners, has developed a new additive manufacturing process for the production of titanium parts used in the manufacturing sector. This development capitalizes on low-cost titanium powders produced by the Armstrong process that has been implemented by Cristal USA, Inc. and has significantly reduced the cost of titanium powders. Electron-beam melting (EBM) is used to incrementally melt layers of titanium powder into a near net shape final product. The process functions independently of build orientation in the fabrication area and allows manufacturers to reuse excess powder.

ORNL's EBM process has shown performance characteristics that make it favorable for use in new aircraft and indicate that it could reduce production waste substantially.[21] Blead air leak detect (BALD) brackets manufactured for Lockheed Martin using the EBM process reduce scrap generation by over 20x (Buy-to-Fly ratio reduced from 33:1 to ~1.5:1).[22] This reduces the final cost of the BALD bracket by 50% with no reduction in performance characteristics.[23]



Ti-6Al-4V BALD Bracket Fabricated using Additive Man

[21] "Near Net Shape Manufacturing of New, Low Cost Titanium Powders for Industry", ORNL, March 2013

[22] For more information: In-Situ Process Monitoring and Big Data Analysis for Additive Manufacturing of Ti-6All-4V

[23] "Case Study: Additive manufacturing of Aerospace Brackets", ORNL, March 2013

Overview

- Developed by ORNL in partnership with Lockheed Martin, Ohio State University, Ametek, Inc., LMC, Inc., and Aqua-Chem, Inc.
- Commercialized in 2016.

Applications

Can be used in processes that benefit from low-cost titanium parts.

Capabilities

- Produces low cost, net shape components from titanium and titanium alloy powders.
- Fabricated products can meet specifications and requirements for aerospace, heat exchanger and other energy applications.
- Optimizes press and sinter process to achieve 90% of theoretical density.

Benefits

Cost Savings

Reduces the cost of titanium per purchased pound by up to 95% and can reduce the energy used in processing by 50% per pound.

Environment

Reduces energy consumption by up to 50% when compared to conventional titanium production processes.

Quality

Produces up to 96% less scrap during the fabrication process than conventional processes.

Contact Information:
Dr. William Peter
Email: peterwh@ornl.gov
Phone: (865) 241-8113
Oak Ridge National Laboratory
1 Bethel Valley Rd
Oak Ridge, TN 37830
Website: http://www.ornl.gov

New Manufacturing Method for Paper Filler and Fiber Materials

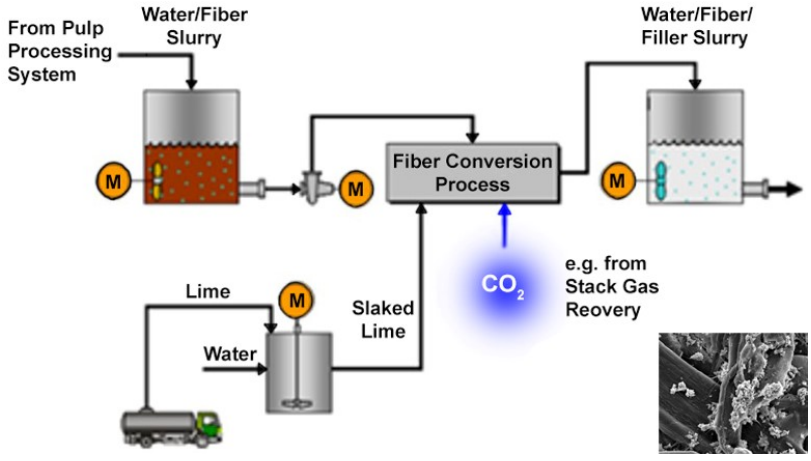
Sustainable Manufacturing **Emerging Technology**

New Material Leads to Energy Savings and Reduced Green House Gas Emissions

Today's paper making operations are very dependent on energy and raw material resources. Increasing filler material (typically calcium cabonate or Kaolin) in the paper product has advantages such as higher optical properties, improved printability, and energy and pulp savings during the paper manufacturing process. Increasing the filler level may also result in disadvantages for printing and processing paper, such as less mechanical integrity of the paper sheet, loss of bulk, and problems in the paper manufacturing process. Research on the new manufacturing method for the fiber filler material showed that the paper filler content can be increased by up to 12% without losing mechanical properties and therefore have a significant impact on a paper mill's operational cost by saving raw material and energy needed in the paper manufacturing process.

State University of New York's (SUNY) College of Environmental Science and Forestry (SUNY-ESF), and industry partners Empire State Paper Research Association, Lhoist North America, Specialty Minerals Inc., International Paper, and NewPage (now Verso Corporation), with assistance from AMO has developed a manufacturing method for the fiber filler material where the paper filler content can be increased by up to 5% without losing mechanical properties. SUNY and partners investigated the various types of fibers and fillers used in paper production as well as the various processing techniques used by the industry. The resulting test sample's structural, optical and mechanical properties were evaluated and optimized to down select and identify the most suitable market-available calcium carbonate filler, fiber and process for the production of printing paper.

If the new technology could be implemented the estimated annual savings from using up to 12 % filler material can save 51 million barrel of oil equivalent (BOE) or 13.7% of the paper industry's energy demand. This can lead to an increase of renewable energy usage from 56% to close to 70% for the industry sector. CO_2 emissions could be lowered by over 7.4 million tons annually. Currently, this technology has two patent invention disclosures and is seeking installations for a pilot scale plant.



Manufacturing Process and SEM Image of Fiber Filler (inset)

Overview

- Developed by SUNY-ESF, Department of Paper and Bioprocess Engineering.
- Currently seeking installation for pilot scale plant.

Applications

Production of an on-line precipitated fiber filler material to enhance paper mill efficiency as well as cost savings of the paper manufacturing process.

Capabilities

- Achieve raw material savings by fiber replacement with mineral filler material
- Reduce production cost through energy savings.
- Environmental benefit by lowering CO_2 emissions.

Benefits

Cost Savings

Production cost savings over $12/metric ton of paper produced for 1% filler increase.

Energy Savings

Energy savings of 100,900 btu/metric ton of paper produced for 1% filler increase.

Environment

Up to 33lbs/metric ton of paper produced of CO_2 emission savings per 1% filler increase.

Installation

Filler production system can be retrofitted in existing paper mill infrastructure or new installations regardless of paper grade.

Contact Information:
Dr. Klaus Doelle
Email: kdoelle@esf.edu
Phone: (315)-470-6531
SUNY-ESF
Department of Chemical Engineering
1 Forestry Drive,
Syracuse, NY 13210
Website: https://www.esf.edu/

Next Generation Manufacturing for Photovoltaics

Advanced Materials Manufacturing

Low-cost, Screen-Printed, Photovoltaic Device

The amount of solar energy reaching the earth's surface in one year is about double that of all the Earth's non-renewable energy resources combined. Solar energy is typically harnessed using either passive (e.g. heat absorption) or active (e.g. photovoltaic conversion) technologies. Until recently, the high manufacturing cost and the amount of energy required to manufacture solar photovoltaic (PV) modules has stalled widespread adoption of solar energy for electricity generation. Solar cells are commonly used in remote locations where cost-effective access to local power grids are not possible.

With assistance from private industry and a SBIR grant through DOE's Advanced Manufacturing Office, the University of California, Santa Cruz (UCSC), developed a print-based manufacturing process for fabricating photovoltaics that could half the energy consumption and emissions associated with conventional PV manufacturing methods. The luminescent solar concentrators developed by UCSC use fluorescent materials inside an "optical" waveguide device. The device directs the fluorescent emissions towards small, highly efficient solar cells embedded in the panel. The solar cell's properties and specifications are chosen such there is optimum light conversion into usable electricity. The solar concentrators are fabricated using solution-based processes and large arrays of luminescent solar concentrators with small strip solar cells that can be manufactured at a significantly reduced cost compared to large arrays of crystalline solar cells.

UCSC successfully applied their technology to absorb certain wavelengths of light to generate electricity while allowing transmission of wavelengths important for plant growth and has been shown to improve plant yields. The solar greenhouse technology – "redhouses", is now available as Lumo through UCSC's spin-off company Soliculture. Lumo redhouses reduce electricity costs with a faster payback time than typical solar panels because of the power generation efficiency and the reduced construction and installation cost. Soliculture's Lumo product family includes a higher density panel for non-production areas enabling maximum energy generation from the entire greenhouse installation. Lumo energy systems can be configured for on-grid and off-grid (battery storage) operation.



Soliculture's Lumo Energy System

Overview

- Developed by University of California Santa Cruz and Abengoa Solar
- Available from Soliculture.
- Commercialized in 2015.

Applications

Can be used to generate electricity primarily in commercial greenhouse applications.

Capabilities

- Facilitates crop growth with up to 2x higher crop yields in some cases.
- Allows PV construction using much less silicon cells (10%) and reduced weight.
- Allows shorter payback periods and significant offset of electricity consumption.

Benefits

Cost Savings

Reduces costs by using less materials that are cheaper and more abundant.

Capital Cost

Capital costs are reduced through tax rebate incentives, energy production, improved plant yields and land use (co-production of crops and electricity).

Environment

Reduces potential for harmful waste by reducing the amount of cadmium, lead, and other materials used in thin-film solar cells.

Contact Information:
Dr. Glenn Alers
Email: info@soliculture.com
Phone: (831) 234-6056
Soliculture
54 Old El Pueblo
Scotts Valley, CA 95066
Website: www.soliculture.com

No Heat Spray Drying Technology

Other Materials | **Commercial Technology**

Drying System Uses Low Temperature to Increase Product Quality, Yield and Lower Energy Usage

Spray drying produces a dry powder from a liquid solution through rapid drying with a hot drying gas. Spray drying dates back to the late 1800s when nozzle atomizers were used; rotary atomizers were introduced several decades later. Atomizers disperse the liquid solution into a controlled drying chamber; newer generation drying processes have multiple drying chambers or stages to produce larger and more manageable particle sized powders. The process and system design evolved as manufacturers tried to accommodate heat-sensitive products, emulsions, and mixtures. Spray drying is now used in many industrial applications, including in the manufacture of powdered soaps and detergents, powdered milk, instant coffee, corn starch, fertilizer production, powdered polymer resins, and the production of mineral ores and clays.

One of the disadvantages of spray drying is the high temperature (> 400ºC) used. High temperature exposure can damage high-value and sometimes sensitive and/or volatile ingredients contained in emulsified products. This exposure damages the product's properties, such as flavor, aroma, color, consistency, or the active ingredient of a pharmaceutical. ZoomEssence (Zoom) has developed a new no-heat process for spray drying liquid emulsions into powders. Their patented technique, called DriZoom™, involves applying an electrostatic charge before atomizing the liquid. The charged, wet particles (when suspended) then repulse, causing the particles to divide into wet and dry sub-particles without the presence of any heated drying. By eliminating the use of heat, the quality, solubility, stability and overall performance of the powdered products is improved.

Recently, Zoom, with AMO support in the form of SBIR grants, have further improved their process through new equipment design for longer dryer times at a lower temperature and new emulsion formulations to reduce the moisture content in the finished powders. Zoom used computational modelling to analyze air flow fluid dynamics, particle heat and mass transfer properties, and particle trajectories to develop and optimize the dryer and controller design. Zoom has also developed an atomizer technology to work with their new emulsion formulations. Zoom's new developments have been deployed in their manufacturing operations, resulting in improved product yields, reduced system costs, and energy savings and water conservation.

Overview

- Developed by ZoomEssence, Inc.
- Commercialized in 2016.
- Currently observing and optimizing pilot manufacturing system operation.

Applications

Can be used to produce dry ingredients used worldwide in pharmaceuticals, food, and chemicals.

Capabilities

- Achieves spray drying at much lower temperatures (T ≤ 200ºC)
- Provides improved end product properties including flavor, aroma, color and consistency.
- Achieves lower evaporation of active and/or high-value ingredients.
- Provides membrane that can be cleaned and reused without reduced performance and costly replacement.

Benefits

Cost Savings

Reduces system capital cost through an optimized design using computer modelling of multiple spray-drying process parameters.

Energy and Water Conservation

New system design operates at a lower temperature, consuming up to 60% less energy and less water.



ZoomEssence's Powdered Flavors and Spray Drying Analysis Tools

Contact Information:
Charles Beetz
Email: cbeetz@zoomessence.com
Phone: (859) 534-5974
ZoomEssence, Inc.
1139 Victory Place
Hebron, KY 41048
Website: http://zoomessence.com

Novel Flash Ironmaking Process

Sustainable Manufacturing – Flow of Materials through Industry **Emerging Technology**

Advancing a Cost-Efficient Option to Produce Iron and Eliminate Pelletizing Operations

Steel is used in a wide variety of manufactured products such as skyscrapers, automobiles, and bridges. The traditional blast furnace process that produces pig iron for steelmaking requires additional energy to prepare the raw iron material as sinter and pellets, consuming large amounts of carbon and producing significant greenhouse gas emissions. There is an opportunity for cost-efficient alternative processes with reduced greenhouse gas emissions, but these have traditionally been limited by low iron production capacities and an inability to use untreated raw iron material in large amounts.

University of Utah, with assistance from American Iron and Steel Institute (AISI) and funding from AMO, have developed a flash ironmaking process that can be scaled-up to an industrial-scale as an alternative to the blast furnace process. The flash process is based on the direct gaseous reduction of iron oxide concentrate with natural gas to generate a hot reducing gas mixture of hydrogen and carbon monoxide together with water vapor and carbon dioxide. This avoids the energy intensive and pollution-prone sintering or pelletization steps used in blast furnace processes as well as the need for coke as a fuel source, significantly lowering energy consumption and reducing greenhouse gas emissions. In addition, due to the fine particle size of the raw iron concentrate, the flash process allows for faster reduction rates, reducing the required residence time of the material down to seconds instead of the minutes and hours it takes to reduce pellets in the blast furnace method. In addition to testing the flash process in a Large-Scale Bench Reactor the reduction kinetics of the iron concentrate were determined in greater detail using a smaller laboratory flash reactor.

In 2018, development on the flash ironmaking process at the laboratory scale was completed with the determination of optimum conditions to operate the reactor. With assistance from AISI, a commercialization plan for an industrial-scale pilot plant has been developed, with additional funding being sought for its construction.



Department of MATERIALS SCIENCE & ENGINEERING THE UNIVERSITY OF UTAH

American Iron and Steel Institute

University of Utah's Large-Scale Bench Reactor Facility

Overview

- Developed by University of Utah beginning in 2005.
- Laboratory tests were conducted with AISI under the CO_2 Breakthrough Program from 2008-2011.
- Funding from AMO provided in 2012.
- Laboratory-scale development completed in 2018.
- Currently have developed a commercialization plan with AISI and working towards construction of a pilot-scale plant.

Applications

Can be used to provide an alternative method to produce iron in steel making plants, fitting in the production line as a feed to either a subsequent or continuous direct steelmaking process.

Capabilities

- The Large-Scale Bench Reactor can achieve greater than 90% metallization with 1.5 times the theoretical minimum amount of reducing gas operating at a temperature of 1350 ºC and a feed rate of 5 kg/hr.
- The laboratory flash reactor can achieve greater than 90% metallization with 2 times the theoretical minimum amount of reducing gas operating at temperatures of 1150-1200 ºC at a feed rate 0.1-0.5 kg/hr.

Benefits

Energy Savings

Can reduce total energy consumption by up to 30% compared to the average blast furnace process.

Environmental Benefits

Can lower CO_2 emissions by 39 – 51% compared to the average blast furnace process. If the hydrogen used is produced from sources with no carbon footprint, the CO_2 emissions can be lowered to 4% of that of the average blast furnace process.

Contact Information:
Dr. Hong Yong Sohn
Email: h.y.sohn@utah.edu
Phone: (801) 581-5491
University of Utah
201 Presidents Circle
Salt Lake City, UT, 84112
Website: https://mse.utah.edu/

Novel Membranes and Processes for Oxygen Enrichment

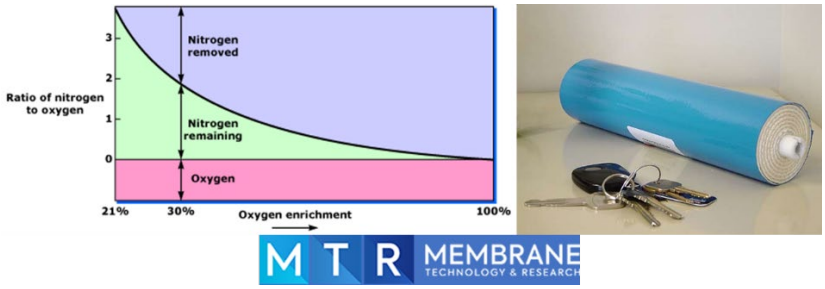
Sustainable Manufacturing **Commercial Technology**

Membrane Technology provides Oxygen-Enriched Air for Combustion and Controlled Environment Applications

Most oxygen-enriched air is produced either through cryogenic separation of air or through vacuum pressure swing adsorption, both of which are technologies that are too cost-prohibitive to produce enough oxygen-enriched air to be widely used in combustion applications. Ion transport membranes (ITM) have been identified as an emerging alternative for oxygen production. However, ITMs have required largescale units operating at very high temperatures (800°C) and are often proposed as membrane reactors for hydrocarbon oxidation to produce synthesis gas instead of oxygen-enriched air.

Membrane Technology and Research Inc. (MTR), with assistance from AMO, has developed a membrane-based technology to produce oxygen-enriched air. This technology can produce air containing 25-35% oxygen, at a cost of $25-40/ton of equivalent pure oxygen (EPO_2), compared to cryogenic separation and vacuum pressure swing adsorption, which cost $40-100/ton EPO_2 and $40-60/ton EPO_2, respectively. EPO_2 is defined as the amount of pure oxygen that needs to be mixed with atmospheric air to obtain a specified volume of oxygen-enriched air with a specified oxygen concentration. Oxygen-enriched air at this cost can allow existing air-fueled furnaces to be converted economically to oxygen-enriched furnaces, which in turn will improve the economic and energy efficiency of combustion processes significantly, and reduce the cost of CO_2 capture from flue gases throughout the U.S. manufacturing industries.

In 2011, MTR finished their initial design and have used the results to demonstrate that membrane processes can produce oxygen-enriched air in a low-cost manner that will lower operating costs and energy consumption in industrial combustion processes. One application that has been developed in a partnership with Ube Industries is to develop membranes for HVAC systems providing around 28% oxygen-enriched air for human health benefits. In addition to this, MTR is continuing work to apply this technology to areas including oxy-enriched combustion processes and controlled environment cases.



Membrane Technology and Research's Module for generating oxygen-enriched air using HVAC Systems.

Overview

- Developed by Membrane Technology and Research, Inc. in partnership with Tetramer Technologies and Gas Technology Institute in 2010.
- Commercialized in 2012.
- Commercially producing membranes for oxygen-enriched air in a partnership with Ube Industries.

Applications

Can be used to produce enriched oxygen from air, which can be applied to oxy-enriched combustion processes and controlled environment cases.

Capabilities

- Enriches oxygen content of air to up to 25-35%.
- Can enrich oxygen at ambient temperatures.
- Reduces nitrogen gas ballast effects in rotary pumps for air conditioners/purifiers.
- Reduces natural gas consumption in combustion heaters.

Benefits

Cost Savings

Capable of producing oxygen at less than $40/ton EPO_2, providing savings compared to conventional oxygen-enriching technologies.

CO_2 Emissions Reduction

Capable of significantly reducing CO_2 emissions from combustion of hydrocarbon fuels.

Contact Information:
Tim Merkel
Email: tim.merkel@mtrinc.com
Phone: (650) 543-3362
Membrane Technology and Research, Inc.
39630 Eureka Drive
Newark, CA 94560
Website: https://www.mtrinc.com/

Promote SiC and GaN Applications Through Development of WBG Evaluation Kits

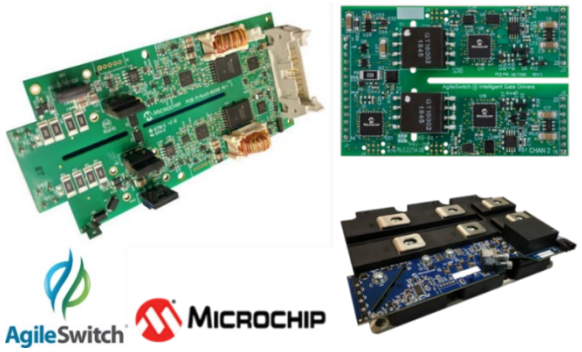
Wide Bandgap Semiconductors | **Commercial Technology**

Improving Wide Band Gap Power Semiconductor Market Through Flexible Design

Renewable energy generation technologies have become more cost-effective in recent years shifting the focus on improving size, and weight reduction to inverters. Wide Bandgap (WBG) power modules have been promoted as a solution but the cost of silicon carbide (SiC) and gallium nitride (GaN) devices have been prohibitively expensive until recently. As more companies have participated in the market, the device cost has lowered, allowing further improvements to reduce cost and improve efficiency. While WBG power modules enhance efficiency, operation at higher voltages and frequencies introduce switching oscillations due to the higher changes in current. The transistors are robust and can handle oscillations but the radiated and conducted noise becomes a nuisance for components or circuits downstream. This noise may lead to erroneous faults forcing designers to significantly derate the transistors, thereby reducing usable ratings of the power module.

AgileSwitch, LLC, with assistance from AMO through the PowerAmerica Consortium at North Carolina State University, has developed WBG evaluation kits designed both to enable commercial, industrial, and research organizations to evaluate and incorporate SiC power semiconductor devices into existing applications, and to mitigate the effects of voltage spikes. Key elements of the evaluation kits include SiC module compatibility through a universal motherboard and module-specific daughtercard, capable of operating up to higher voltages and switching frequencies than current WBG kits. These features are designed to minimize the impact of wild voltage spikes while improving energy efficiency and long-term reliability through advanced digital controls, programmability, and implementation of techniques for switching on and off the devices under various conditions.

In 2019, AgileSwitch was acquired by Microchip, and through them have worked to commercialize their gate driver products. Currently, the SiC Gate Driver Core and Board modules, an IGBT Gate Driver Board module, and two varieties of Augmented Switching Accelerated Development Kits have been made commercially available through Microchip, with further steps being taken to improve product commercialization.



AgileSwitch's Programmable Gate Drivers: Master SiC gate driver ((left), SiC gate driver core (top right), and IGBT gate driver (bottom right)

Overview

- Developed by AgileSwitch, LLC (now owned by Microchip Technology, Inc.)
- Development began in 2016
- Microchip Technology, Inc. acquired AgileSwitch in 2019 to accelerate commercialization of gate drivers.
- Products commercialized by 2020.

Applications

Can be used to create power supplies for various applications including trains, trucks, buses, heavy duty vehicles and solid-state transformers.

Capabilities

- SiC Gate Driver Cores have 1.2 kV and 1.7 kV rated modules and can switch up to 150 kHz.
- SiC Gate Driver Boards are rated at 1.7 kV and can switch up to 200 kHz.
- IGBT Gate Driver Boards are suitable for up to 3.3 kV and can switch up to 15 kHz.
- Augmented Switching Accelerated Development Kits are compatible with 1.2 kV and 1.7 kV SiC power modules.
- All gate drivers can provide up to 7 unique fault and monitoring conditions, including temperature and high-voltage monitoring.

Benefits

Efficiency

Compared to existing evaluation kits, decreases power switching losses by 50%, reduces voltage overshoot by up to 80%, and detects short circuits up to 20% faster.

Resiliency

Can prevent false faults, mitigate ringing, and reduce Electromagnetic Interference (EMI), overshoot, and undershoot in SiC and IGBT power devices.

Contact Information:
Rob Weber
Email: Rob.Weber@microchip.com
Phone: 1-(610)-889-2255
AgileSwitch, LLC
2025 Washington Avenue
Philadelphia, PA, 19146
Website: https://www.microchip.com

Quenching and Partitioning Process Development to Replace Hot Stamping of High-Strength Automobile Steel

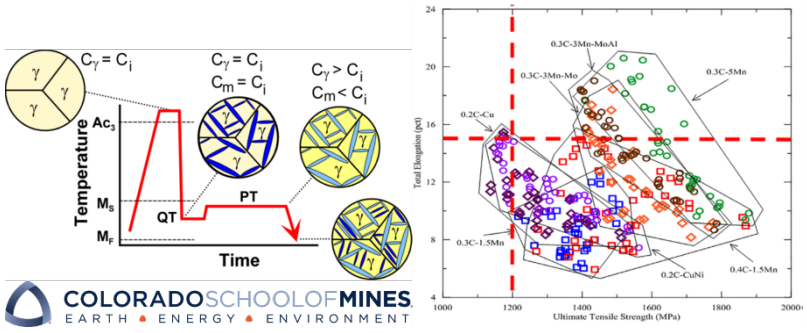
Advanced Materials Manufacturing | **Commercial Technology**

Steel Heat Treatment Process Allows for Room-Temperature Stamping Operations

The automotive industry is meeting the challenge of improving fuel efficiency without compromising vehicle safety in part by using lighter-weight materials such as first-generation Advanced High-Strength Steels (AHSS). Producing body and structural automotive components using these steels traditionally requires an energy-intensive hot stamping process where the steel is heated to temperatures above 900°C to achieve the necessary strength and ductility. Second-generation AHSS can be created with ultra-high strength and exceptional formability using higher-efficiency room-temperature stamping. However, they require high levels of alloying, making them too expensive for widespread implementation. Recent developments toward producing Third-Generation Advanced High-Strength Steels (3GAHSS) aim to provide the needed balance between cost, strength, and formability.

Colorado School of Mines, with assistance from AMO, has developed a quenching and partitioning (Q&P) process to meet the 3GAHSS cost and performance targets. This two-step process takes place after cold rolling during the formation of AHSS. First, the steel is heated to a red-hot temperature and then quenched to a critical temperature to produce a mixed microstructure, balanced between strong martensite and softer but more formable austenite. Next, the steel's temperature is raised slightly to force carbon atoms to move from the martensite into the austenite and form a carbon enriched austenite phase, resulting in a stable alloy that remains highly formable after cooling to room temperature.

In 2016, Colorado School of Mines successfully completed the project, developing 12 unique 3GAHSS alloys that surpassed target goals in both tensile strength and elongation. Currently development is focused on transitioning from lab-scale to manufacturing scale processing. Project partners, including AK Steel, have installed or are considering facilities capable of implementing this technology. If industry trials are successful, parts manufactured with this technology can be incorporated into new vehicle designs.



High-temperature profile and steel structure changes in CO School of Mines' Quenching and Partitioning Process (left), and graph of final alloy results of ultimate tensile strength vs. elongation (right).

Overview

- Developed by Colorado School of Mines in 2013.
- Currently licensing out the Quenching and Partitioning process to several project partners for implementation on an industrial level.

Applications

Can be used in automotive or other industries for efficient production of high-strength, low-weight steels.

Capabilities

- Can create advanced high strength sheet steels at room temperature without the need for reheating in a hot stamping process.
- Creates steel alloys with an ultimate tensile strength of up to 1550 MPa and total elongation in excess of 20%.

Benefits

Cost Savings

Successful Q+P produced steel would reduce the weight of steel by 20% compared to previous AHSS, resulting in fewer tons of steel needing to be produced to obtain the same performance.

Energy Savings

Avoids the high-temperature hot stamping process necessary for older methods of producing Advanced High-Strength Steels.

Increased Product Quality

Produced alloys have improved tensile strength and elongation compared to previous generation AHSS.

Contact Information:
Emmanuel De Moor
Email: edemoor@mines.edu
Phone: (303) 273-3624
Colorado School of Mines
1500 Illinois St.
Golden, CO 80401
Website: https://www.mines.edu/

Reactive Dehydration Technology for Production of Fuels and Chemicals from Biomass

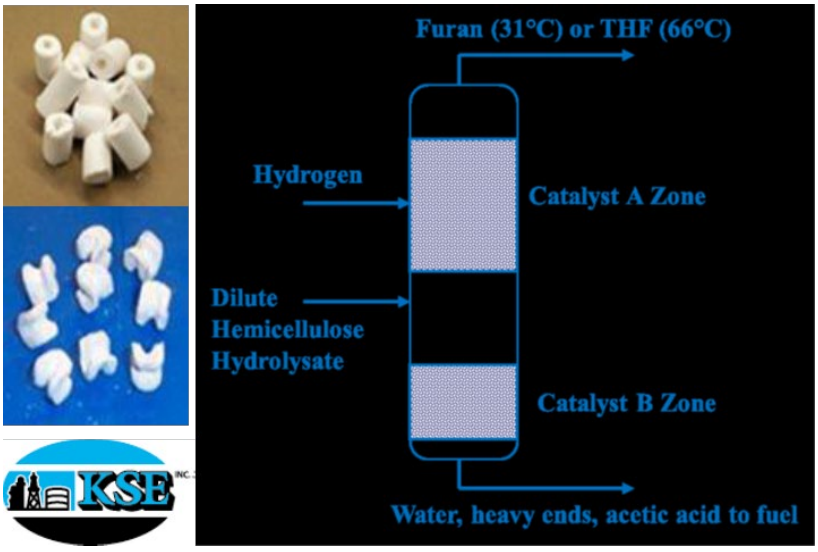
Process Intensification **Emerging Technology**

Compact Production of Biomass-Based Chemicals from Complex Aqueous Mixtures

Biomass can be a source of valuable chemicals for a variety of applications, but the separation and purification of these chemicals is difficult and expensive. One example is the compound tetrahydrofuran (THF) which can be produced from xylan, a byproduct in the pulp and paper mill industry. Biomass chemicals such as xylan are present in complex mixtures typically found within dilute aqueous streams. Despite their potential benefits, these streams are set to be burned as waste heat as the excess water present inhibits biomass conversion, drives unwanted byproduct reactions, and is costly to remove. Conventional technologies used to separate these components such as distillation and membrane separation have limitations in the types of chemicals that each technology can extract, as well as steep energy and maintenance costs.

KSE, Inc., with assistance from University of Massachusetts and funding from AMO, has developed a reactive distillation technology using the Intensified Catalytic and Reactive Distillation (iCARD) platform for the separation of biomass-based chemicals from complex aqueous mixtures. This process uses two catalyst-supported reactions to convert biomass intermediates into easily removable chemicals and separate out water through a reversible reaction. This process was tested on the conversion of xylan hydrolysate to THF, focusing on containing the reaction and separation steps within a single compact unit. Catalysts were also developed to combine the dehydration, decarbonylation, and hydrogenation functionalities of the reaction into a single cost-effective, highly intensified process.

In 2014, KSE, Inc. demonstrated their process on a laboratory scale and began scaling up to pilot-level production. Currently, KSE, Inc. is working with a member within the paper and pulp industry towards the commercial licensing of their iCARD process, with the aim to achieve pilot-scale plant production by 2021.



KSE, Inc.'s Reactive Dehydration Resistor Components (Left) and Resistor Diagram (Right)

Overview

- Developed by KSE, Inc. beginning in 2010
- Development finished in 2014
- Currently working towards pilot plant production.

Applications

Can be used to extract biomass compounds such as fuel grade ethanol from water, as well as separation of water during chemical reactions and desalination through dehydration of solvent extractant

Capabilities

- Can convert xylan from biomass to THF through reactive dehydration with 100% THF selectivity
- Can manufacture THF with a cumulative energy demand of 75 MJ/kg, at a cost of $0.70/pound THF.

Benefits

Energy Savings

Can produce THF using less than 30% of the energy needed for the conventional method to manufacture THF.

Cost Savings

Can produce THF using less than 50% of the cost of the conventional method to manufacture THF.

Contact Information:
Keith Kitrell
Email: kdkittrel@kse-online.com
Phone: (615) 549-9084
KSE, Inc.
PO Box 368
Amherst, MA, 01004
Website: https://kse-online.com/

Reliability Analysis of Wide Bandgap Power Devices

Wide Bandgap Semiconductors **Emerging Technology**

Innovating Wide Band Gap SiC and GaN micro Inverters

Power semiconductors have played a major role in improving the performance of power converters in all applications. Wide bandgap (WBG) semiconductors such as silicon carbide (SiC) offer several advantages over silicon, the material of choice for decades. In particular, they can operate at higher temperatures (thereby reducing cooling requirements) and are capable of higher power density—leading to smaller devices. However, the technology is not as advanced as for Si, and the reliability characteristics are not as well established. The work at Texas Tech University (TTU) was aimed at advancing the field of reliability assessment.

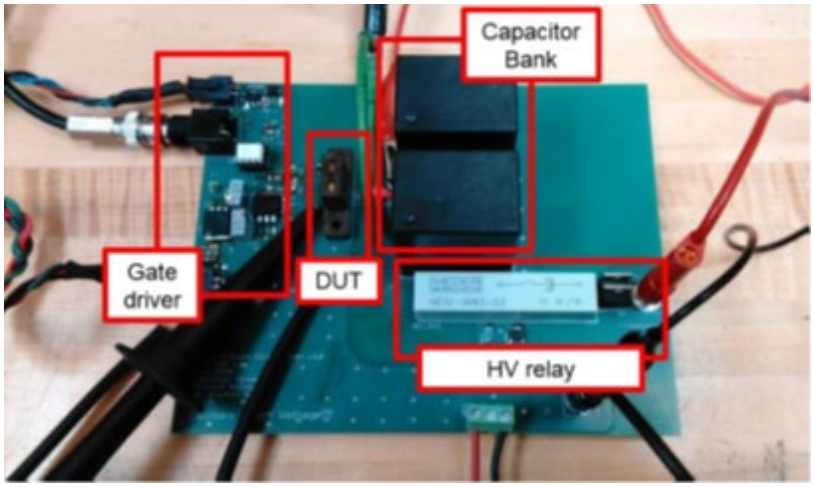
Reliability has to do with predicting and guaranteeing the life of a product. In technical terms, it is probabilistic. To know the reliability, it is necessary to know the probability that the product will work, and work adequately, over some desired span of time, under specified operating conditions. In testing reliability, it is therefore necessary to know what is meant by working "adequately," and what the operating conditions are to be.

For WBG semiconductors, the reliability is affected by the voltage, the current, and the temperature. Testing yields a set of absolute maximum rating values. Operation that exceeds these ratings may lead to immediate failure, or it may lead to reduced operating life.

Testing aimed at supplying this kind of information is already performed on semiconductors based on silicon. Information about this testing formed the basis for the testing done in SiC by Texas Tech University.

With assistance from AMO through the PowerAmerica Consortium at North Carolina State University, TTU has tested several SiC diodes and SiC MOSFETs. The tests were of the ratings in terms of what is termed a non-repetitive short-circuit. To do this test, current is passed through the device under test (DUT) from a capacitor bank. (In fact, the test is repetitive, but the devices are allowed to cool between tests, so the current pulses are as if they were independent.) By characterizing the tested devices before and after applying 500 pulses, it was determined that there was minimal change in the characteristics of the devices being tested.

The results essentially confirmed some existing ratings for the devices, and established new ratings for some. The voltage rating of some MOSFETs was confirmed as well.



Texas Tech's Short-circuit Test Setup

Overview

- Developed by Texas Tech University, Lubbock, Texas.
- Development began in 2017.
- SiC diodes and SiC MOSFTEs tested under short-circuit conditions.

Applications

Testing of the kind done is applicable to a wide range of devices fabricated in wide bandgap materials. Good data on device performance is part of establishing reliability statistics.

Capabilities

- Supports growing confidence in the long-term reliability of WBG devices by providing hard evidence
- Can lead to more exhaustive test suite design, addressing aspects of performance specific to SiC or other WBG materials, rather than simply imitating the testing done of silicon devices.

Benefits

Reliability

Reliability numbers give an estimate of the probability of the time that a device or system will continue to do its job under normal operating conditions. For a semiconductor in a power converter those conditions might include the occasional short circuit. Such an event should not result in failure, and normally the duration of such events is limited by design so as to protect the equipment. However, since power converters are generally "installed and ignored," and not subject to maintenance until they fail, the ability of a device to survive must be demonstrated if designers are to have confidence in their designs and manufacturers are to produce long-lived converters.

Contact Information:
Dr. Stephen Bayne
Email: stephen.bayne@ttu.edu
Phone: (806) 834-0526
Texas Tech University
Center for Pulsed Power and Power Electronics
Lubbock, TX *79409-3102*
Website: http://www.p3e.ttu.edu/

RPM XE: Ultra-Efficient and Power-Dense Electric Motors

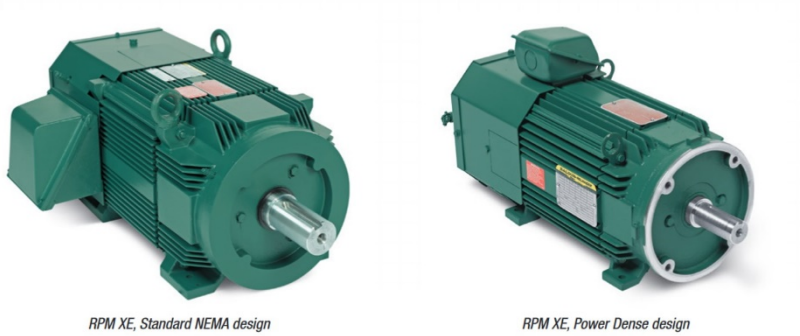
Crosscutting | **Commercial Technology**

Robust General Purpose Motor Offers Increased Efficiency and Power Density

Energy efficiency is a topic of growing concern and has affected the manufacturing sector by increasing the demand for streamlined and efficient industrial processes. Pumps, fans, and compressors account for more than 50% of the electrical demand in U.S. and more than 85% of the electricity used by the industrial sector.[1] These motors are largely used in constant-speed applications and designed to run across the line (voltage). Some applications include variable-speed motors powered from an open-loop variable-speed drive. In both cases, the industrial sector could benefit from a power-dense general-purpose drive that could replace older options with a more efficient solution.

Baldor Electric Company, with assistance from AMO and industry partners, has developed the RPM XE Motor.[2] The RPM XE is a permanent magnet system that achieves a performance efficiency level that is two to four bands above the NEMA Premium® level (IE3).[3] The motor and drive package is offered in standard NEMA frame sizes to allow "drop in" replacements of existing systems. The RPM XE platform has shown energy performance characteristics that offer improved performance over a conventional induction motor with the advantageous running characteristics of a synchronous motor (e.g., cooler operation, compact footprint, high power density, and efficiency at low load). This performance improvement is achieved while operating at a temperature that is much cooler than traditional induction motors by using a laminated finned frame that extends motor life.

The RPM XE platform is offered in both the standard NEMA enclosures as well as a more power-dense format. RPM XE's severe duty design makes it ideal for centrifugal fan and pump applications as well as continuous applications that demand energy efficiency as well as reduced weight or inertia.[4]



Baldor Electric Company's RPM XE Motor Platform

Overview

- Developed by Baldor Electric Company and several industry partners.
- Commercialized in 2016.

Applications

Can be used to replace constant and variable-speed induction motors in pumps, fans, and compressors.

Capabilities

- Low motor temperature rise provides extended motor life.

Benefits

Cost Savings

Smaller motor size and weight reduces capital cost compared to conventional motors.

Flexible

Operates at true synchronous speed regardless of load.

Simplicity

Can be run across the line or operated from a standard drive without the need for a rotor position feedback device.

Contact Information:
Steve Evon
Email: Steve.Evon@Baldor.ABB.com
Phone: (864) 281-2457
Baldor Electric Co.
5711 R.S. Boreham Jr. Street
P.O. Box 2400
Fort Smith, AR 72901
Website: http://www.baldor.com/

[1] "Energy Efficiency," Nidec Motor Corporation, June 2017.
[2] For more information: Ultra-Efficient and Power Dense Electric Motors for U. S. Industry.
[3] For more information: RPM XE – eXtreme Efficient AC MOTORS.
[4] For more information: 501 Stock Product Catalog.

Sensor-based In-line Control System for the Surfaces of Continuously Cast Slabs

Steel **Emerging Technology**

Sensor-based In-line Control System Improves Energy Consumption and Yield

Current steel making processes result in millions of tons of scrapped metal and trillions of BTUs of wasted energy per annum. Over 97% of US steel is produced through continuous casting that requires a cooling and reheat step that uses 2 million BTU per ton of steel. Advanced imaging and process control technologies would reduce the need for the cooling and reheat step by detecting surface defects on the hot steel slabs which can be immediately reworked. Reworking the metal surface defects while the metal is still hot could promote energy efficiency and improve yield.

OG Technologies Inc., with assistance from AMO, in the form of SBIR grants, has developed a sensor-based in-line control system for continuous casting of steel. This advanced process uses in-line sensors and advanced imaging to collect data in near real-time during the casting process. OG Technologies has designed a process that can detect cracks and symptoms of potential flaws without requiring an intermediate cooling step. This will allow for the removal of the reheat process and recover 2-3% loss in steel yield. The system has a novel design that allows for operation in the harsh environment of continuous casters.

In 2019, OG Technologies completed two pilot commercial installations with one in Japan and one in the USA. Data from the pilot commercial campaigns to improve the imaging process and further market the system. OG technologies is also exploring the possibility of integrating an in-line surface clean up with the in-line surface inspection.



OG Technologies Sensor based Inline Control System (Top) and Surface Defect Photos (Left) and Sensor Detection Imaging (Right)

Overview

- Developed by OG Technologies, Inc. from 2009-2013
- Pilot commercial systems installed in 2019
- Commercialization planned to begin in 2021

Applications

Can be used in continuous casting steel manufacturing to improve quality control.

Capabilities

- Inspects surfaces during continuous casting of steel to detect and identify casting flaws
- Verifies product quality in near real-time, providing process control without cooling and reheating

Benefits

Energy Savings

The sensor based inline control systems has the potential to save 2 million BTUs of energy per ton of steel produced.

Improved Productivity

Increasing the yield of continuous cast steel by 2-3% could increase productivity by up to $1 billion annually.

Modularized Design

Modularized sensors allow for scalability to the installation requirements and allows for easier maintenance.

Waste Reduction

Reduces the amount of waste water and toxic waste required for steel production.

Contact Information:
Terence Liddy
Email: liddy@ogtechnologies.com
Phone: (734) 973-7500 x 225
OG Technologies, Inc.
4480 Varsity Dr., Suite G
Ann Arbor, MI 48108
Website: http://www.ogtechnologies.com

Shear Rolling of Magnesium Sheet for Energy, Transportation, and Defense Applications

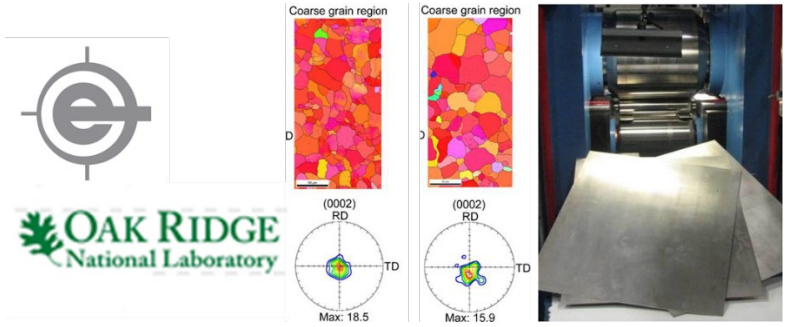
Advanced Materials Manufacturing **Emerging Technology**

Lightweight Metal Process Uses Asymmetric Rolling to Improve Formability

Magnesium is the lightest-known structural metal, less dense than steel, titanium, and aluminum, offering potential weight savings for numerous transportation and defense applications.[28] The major hurdle to the deployment of magnesium products is the cost of magnesium-alloy sheet production and its poor formability. The key to improving the formability of magnesium sheet is to modify the predominantly basal texture that develops in magnesium alloy sheets due to traditional casting and rolling techniques. As part of this project, a new laboratory scale asymmetric rolling mill with unique capabilities was designed and fabricated to enable asymmetric rolling of magnesium alloy sheets.

ORNL, with assistance from AMO and in partnership with Magnesium Elektron North America (MENA) and FATA Hunter, created a shear rolling mill that is designed and fabricated for process development. The alloy sheets were then tested for formability and two industrial components were fabricated from the sheets manufactured using the new shear rolling process. Tests at ORNL showed that certain asymmetric rolling paths resulted in improved formability for one of the magnesium-alloy sheets. Additional testing was done at MENA to investigate issues arising from larger scale shear rolling, demonstrating that the process is amenable to high throughput industrial processing.

Currently, the shear rolling mill remains at laboratory scale, with ORNL in the process of enabling commercialization of the technology. Magnesium is seeing an increased use, and the energy benefits have been shown, but additional opportunities to demonstrate capabilities are contingent on acquiring additional funding.



Improved formability of magnesium sheets in symmetric (left) vs. asymmetric (right) rolling in ORNL's rolling mill.

Overview

- Developed by ORNL and MENA, with the laboratory-scale shear rolling mill installed in 2012.
- Isothermal shear rolling and texture disruption of Mg and Mg alloys completed in 2015.
- Technology is currently ready for commercialization.

Applications

Can be used to make magnesium sheets for use in aerospace, automotive and defense markets with decreased energy costs and improved formability.

Capabilities

- Able to form magnesium sheets at temperatures less than 200ºC.
- Able to produce magnesium-alloy sheets at an industrial processing level.

Benefits

Cost Savings

Enables cost-effective production of magnesium-alloy sheets in high volume production, saving up to 50% of the production cost.

Lower Energy Consumption

Reduces energy consumption by producing magnesium sheets at lower temperatures.

Improved Product Formability

Improved formability of magnesium-alloy sheets compared to traditional fabrication methods.

Contact Information:
Govindarajan Muralidharan
Email: muralidhargn@ornl.gov
Phone: (865) 574-4281
Oak Ridge National Laboratory
Oak Ridge, TN 37831
Website: https://www.ornl.gov/

[28] Muralidharan, Muth, et al. "Shear Rolling of Magnesium Sheet for Automotive Defense, and Energy Applications", October 29.2013

SLAC + Citrine Informatics: Aggregation and Structuring of Materials and Chemicals Data from Diverse Sources

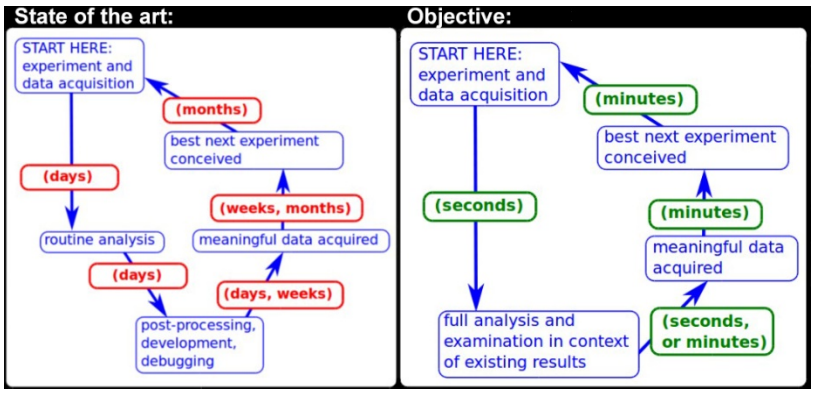
Advanced Materials Manufacturing | **Commercial Technology**

Development of a platform to integrate AI into Materials Development

Advanced materials are a crucial component in many aspects of the economy, including clean energy, electronics, automotive, and aerospace and defense. However, a major issue in developing the next level of advanced materials is the lack of comprehensive databases of materials and their properties. Without access to such data, the materials industry is unable to efficiently aggregate data to invent next-generation materials, resulting in long development cycles taking several years to develop new breakthroughs in materials development.

SLAC, in cooperation with Citrine Informatics and with financial support from AMO, in the form of SBIR grants, has developed an approach for the integration of AI into materials development. Working from Citrine's platform that was already in development, SLAC collaborated with Citrine to add new use cases to the platform and expand its AI for materials discovery capabilities into new areas. Citrine has begun to use this platform with the materials R&D processes for several partner companies.

SLAC continues to expand and build upon the platform in cooperation with Citrine, starting with the automation of discovering new catalysts for propane dehydrogenation and the discovery of high strength metallic glasses. A closed-loop process used for the discovery of new catalysts has been demonstrated, and the current research in the metallic glasses is starting to show promising discoveries.



Timeline of data aggregation and manipulation (left) vs. timeline after implementing SLAC and Citrine Informatics's AI-driven approach (Right)

Overview

- Developed by SLAC and Citrine Informatics.
- Commercialized in 2019.
- Successfully demonstrated ability of closed-loop AI driven discovery for targeted catalyst materials.

Applications

Can be used to aggregate data on materials and chemicals data from various sources into a single database.

Capabilities

- Can integrate AI and machine learning into the creation of materials and chemical databases.
- Can automate the discovery of new chemical catalysts for processes such as propane dehydrogenation.
- Can assist in the development of new materials such as high-strength metallic glasses.
- Can create open source tools for the database to allow other users to aggregate data.

Benefits

Cost Effectiveness

Reduces the cost of advanced materials and chemicals development by decreasing the amount of time needed to collect and aggregate data.

Efficiency

Reduces the time required to aggregate materials data from various sources by having them all in one easily accessible database, allowing for more efficient development.

Contact Information:
Christopher J. Tassone
Email: ctassone@stanford.edu
Phone: (650) 926-3124
SLAC
2575 Sand Hill Rd.
Menlo Park, CA 94025
Website: https://www6.slac.stanford.edu/
https://citrine.io/

Solvent Recovery by Pervaporation

Chemicals **Commercial Technology**

System Improves Efficiency of Drying Processes

Production of many high purity products require the use of manufacturing processes designed to remove excess solvents and reagents from the product stream after a reaction step. This is often implemented by the use of staged distillation setups that collect and recycle unreacted reagent. While effective, this requires large energy inputs when the process involves an azeotropic system, a system whose proportions cannot be altered by simple distillation. The ability to dry products past an azeotrope in an energy efficient manner represents an opportunity for domestic manufacturers to recover reagent costs and reduce energy expenditures associated with product drying.

Compact Membrane Systems (CMS), Inc., with assistance from AMO, PoroGen Corporation, Sepro Membranes, Inc., and Pall Corp., have developed a membrane drying system which can allow manufacturers to dewater azeotropic solvents.[1] The CMS separation system uses pervaporation as an energy efficient alternative to conventional distillation. The membranes used in the separation process also benefit from high chemical and thermal resistance. As a result, the drying process can be used for a variety of drying applications that would usually have limited solutions due to their corrosive nature or tendency toward fouling. Distillation systems can be added in conjunction to the CMS system to dry solvents to anhydrous levels.[1]

CMS commercialized its drying systems in 2016. A test setup has shown that the use of membrane drying systems instead of conventional distillation can increase solvent recovery to 96% in some cases. The cost reductions offered by reagent recovery alone can allow a CMS system to pay for its self in as little as one year.



Compact Membrane Systems' Solvent Recovery System

Overview

- Developed by Compact Membrane Systems, Inc. in collaboration with PoroGen Corporation, Sepro Membranes, Inc., and Pall Corp.
- Commercialized in 2016.

Applications

Can be used for production and purification of valuable chemicals including the recovery of Tetrahydrofuran (THF).

Capabilities

- Reduces maintenance cost by using robust membranes constructed from inert materials.
- Allows manufacturers to customize the process size through modular design.

Benefits

Cost Savings

Recovers up to 96% of spent solvents from the process stream.

Energy Savings

Reduces energy requirements of azeotropic separations by substituting distillation with pervaporation.

Footprint

Allows manufacturers to reduce the factory footprint required for manufacturing separation processes by using a compact design.

Contact Information:
Dr. Daniel Campos
Email: dcampos@compactmembrane.com
Phone: (302) 999-7996
Compact Membrane Systems, Inc.
325 Water Street
Wilmington, DE 19804
Website: http://www.compactmembrane.com/

[1] For More Information: CMS Solvent Recovery.

Super Boiler

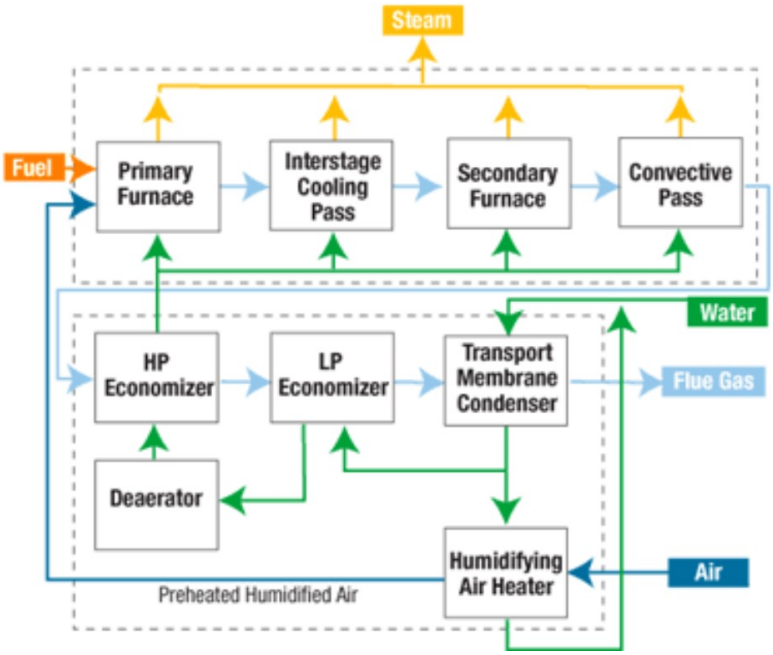
Crosscutting Technologies **Emerging Technology**

High-Efficiency Steam Generation Technologies for Efficient Boiler Design

Steam Boiler technology has a wide range of uses in both the U.S. for both industrial and commercial purposes. However, much of the installed base of steam boilers was old and inefficient, with large emissions of NO_x and CO_2, leaving much room for improvement. In 1999, DOE awarded $2.37 million to the Gas Technology Institute to begin research into developing a new type of boiler with the aim of low-emission, high-efficiency steam-generation technologies that could be integrated in a package boiler.

The Gas Technology Institute, with support from DOE, the Cleaver-Brooks division of Aqua-Chem, and the Southern California Gas Company, designed, built, and tested laboratory and commercial prototype versions of a first-generation, gas-fired Super Boiler. The concept combines a suite of enabling technologies such as a staged intercooled combustion system with forced internal recirculation, high-intensity heat transfer surfaces, an advanced transport membrane condenser, and a smart control system in an integrated package. The performance goals include 94% fuel efficiency, 5 ppmv NO_x and CO, and 50% size and weight reduction compared with conventional firetube boiler emissions as low as 3.8 ppm over a 5 to 1 turndown.

In 2010, Cleaver-Brooks research changed direction and the technology license was bought by Cannon Boiler Works, who subsequently commercialized the technology as its Ultramizer® product the following year. Low commercial prices for natural gas have hindered further development of the super boiler technology, with the most recent installation of note being an installation in 2015.



Flow Diagram of GTI's Super Boiler key design innovations; transport membrane condenser, convective heat transfer and humidifying zones, and staged/intercooled combustion system.

Overview

- Developed by Gas Technology Institute.
- Technology licensed to Cannon Boiler Works in 2010.
- Commercialized in 2011 by Cannon Boiler Works - Ultramizer®.
- Successful deployment at Michael Foods, Inc., Minnesota in 2015.

Applications

Can be used to replace convention boiler technologies to increase efficiency and reduce emissions.

Capabilities

- Greater than 94% thermal efficiency can be achieved by recovering latent heat in a directly usable form as boiler feedwater.

Benefits

Cost Savings

Smaller than conventional size reduces manufacturing and maintenance costs.

Energy Savings

Potential energy savings to industry range upward of $10 billion/year in steam production costs.

Environment

Reduced boiler footprint and weight.

Contact Information:
Bill Liss
Email: wliss@gti.energy
Phone: (847) 768-0753
Gas Technology Institute
1700 S Mount Prospect Rd.
Des Moines, IL 60018
Website: https://www.gti.energy/

Active Technologies Tracked by PNN FY2022

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
1.2 kV Diode and MOSFET Foundry Qualification of 150mm SiC Line	PwrAmr	Wide	Consortia	United Silicon Carbide, inc.	1	9
3.3kV SiC MOSFET Development	PwrAmr	Wide	Consortia	GeneSiC Semiconductor Inc.	1	9
A High-Efficiency, Low-Cost 22kW Fast On-Board Charger for EVs Using Hybrid Switches Combining GaN HEMTs with Si MOSFETs	PwrAmr	Wide	Consortia	HELLA Electronics Corportation	1	9
Additive manufacturing of Polymer Based Bonded Magnets	CMI	AdvMatMfg	Consortia	Momentum Technologies, Inc.	1	2
Additive Manufacturing of Precast Concrete Molds for Construction Applications	MDF	AddMfg	Consortia	Gate Precast	1	9
Alumina-Forming Austenitic (AFA) Steels		?	Steel	Carpenter Technology Corporation	1	1
Atomically Precise Manufacturing for 2D-Designed Materials		AdvMatMfg	?	Zyvex Labs	1	1
Big-Area Additive Manufacturing (BAAM) technology	MDF	AddMfg	Consortia	Cincinnati Incorporated	1	1
Biological Air Emissions Control		?	Forest Products	Bio-Reaction Industries, LLC	1	1
Carbon Films for Next Generation Rotating Equipment Applications	IMF	?	Crosscutting	Carbide Derivative Technology (CDT)	1	1
Carbon Nanosurface for Next Generation Rotating Equipment Applications	IMF	?	Crosscutting	Carbide Derivative Technology (CDT)	1	1
Catalysts for Electrochemical Conversion of CO2	STTR	ProcessInt	Chemicals	Dioxide Materials, LLC	1	1
CF8C-Plus Cast Austenitic Steels		?	Steel	Oak Ridge National Laboratory	1	1
Co-development of world's first large-scale thermoset printer	MDF	AddMfg	Consortia	Oak Ridge National Laboratory	1	9
Data Center Transformation from "Always On" to "Always Available"	ARRA DC	?	Other Industries	Tier44 Technologies, Inc.	1	1
Development and licensing of automotive-grade low-cost carbon fiber	MDF	CompMats	Consortia	Oak Ridge National Laboratory	1	9
Development of High Cerium Content Aluminum Alloys (Ce-Al Alloy)	CMI	AdvMatMfg	Consortia	Eck Industries, Inc.	1	1
Development of low head hydropower devices	MDF	?	Consortia	Emrgy Hydro	1	9

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
ExaBlade™: Very Dense Liquid Cooled Computer Platform	ARRA DC	?	Other Industries	Clustered Systems Company	1	1
Extruder technology for high-volume additive manufacturing	MDF	AddMfg	Consortia	Strangpresse, LLC	1	9
FLAAT Growth Technology for GaN on 6 inch Sapphire with No Wafer Bow	SBIR I,II	AdvMatMfg	Other Industries	Kyma Technologies, Inc.	1	1
Flash Processed Steel for Automotive Applications	SBIR	ProcessInt	Steel	SFP Works, LLC (dba Flash® Bainite)	1	2
Force Modulation System for Vehicle Manufacturing	I&I	?	Crosscutting	Metalforming Controls Corporation	1	1
Foundry Process Kit for 1.2kV SiC Power MOSFETs and JBS Rectifiers	PwrAmr	Wide	Consortia	North Carolina State University	1	9
High Flux Ti Nanofiltration Membrane for Efficient Processing of Bioproducts	SBIR I,II	?	Other Industries	Cerahelix	1	1
High Metal Removal Rate Process for Machining Difficult Materials		?	Crosscutting	Delphi Automotive Systems, LLC	1	1
High Surface Area Inorganic Membrane for Process Water Removal		ProcessInt	Chemicals	Pacific Northwest National Laboratory	1	2
High-capacity, twin-screw production line for large-scale additive manufacturing	MDF	AddMfg	Consortia	Techmer PM, LLC	1	9
High-Octane Fuel-Stocks via Engineered Solid Acid Catalysts	I&I, SBIR I,II	?	Chemicals	Exelus, Inc.	1	1
High-Performance Renewable Base Oils for Industrial Lubricants	I&I	Sustain	Other Industries	BiosyntheticTechnologies	1	1
Improved Methods for Lithium Extraction	CMI	CritMats	Consortia	Oak Ridge National Laboratory	1	9
Industrial Membrane System Suitable for Distributed Used Oil Re-refining	SBIR I,II	Sustain	Chemicals	Media & Process Technology, Inc.	1	1
In-Line Quality and Process Control in Solar and Fuel Cell Manufacturing	SBIR I,II	?	Other Industries	Ultrasonic Technologies, Inc.	1	1
Integrated DC-DC Converters Using Thin-Film Magnetic Power Inductors	SBIR I,II	?	Crosscutting	Ferric Semiconductor, Inc.	1	1
Ionic Membrane Based Desalination System	SBIR I,II	?	?	Xergy Inc.	1	9
ITmk3: High-Quality Iron Nuggets Using a Rotary Hearth Furnace		?	Steel	Mesabi Nugget LLC	1	1
Manufacturing of Protected Lithium Electrodes for Advanced Batteries		AdvMatMfg	Other Industries	PolyPlus Battery Company	1	1

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
MasterPrint	MDF	AddMfg	Consortia	Ingersoll Machine Tools	1	9
Monitoring and Control of Chemical Composition of InGaN Layers During MOCVD	SBIR I,II	AdvMatMfg	Other Industries	Accustrata, Inc.	1	1
Nanocoatings for High-Efficiency Industrial Hydraulic and Tooling Systems	IMF	AdvMatMfg	Crosscutting	New Tech Ceramics, Inc.	1	1
Nanofluids Enhanced Twisted Tape Heat Exchanger	SBIR I,II	WHRsys	Crosscutting	Advanced Cooling Technologies, Inc.	1	1
Next Generation Manufacturing for Photovoltaics		?	Crosscutting	Soliculture, Inc.	1	1
Novel Membranes and processes for oxygen enrichment		ProcessInt	?	Membrane Technology and Research, Inc.	1	1
Novel Sorbent to Clean Biogas for Fuel Cell Combined Heat & Power Systems		?	?	TDA Research, Inc.	1	9
Optimizing Blast Furnace Operation to Increase Efficiency and Lower Costs		?	Steel	Purdue University - Calumet	1	1
Plasma-assisted combustion for jet engines and gas turbines	LEEP-CRI	ProcessInt	Crosscutting	FGC Plasma Solutions, LLC	1	9
PPS™: Capability of Rolling Efficiency for 100M High-Speed Rails	SBIR I,II	?	Steel	OG Technologies, Inc.	1	1
Promote SiC and GaN Applications Through Development of WBG Evaluation Kits	PwrAmr	Wide	Consortia	AgileSwitch, LLC	1	9
Quenching and Partitioning Process Development to Replace Hot Stamping of High-Strength Automobile Steel		?	Steel	Colorado School of Mines	1	1
Reliability Analysis of Wide Bandgap Power Devices/Establish an Independent Testing Facility to Perform Reliability Analysis of Wide Bandgap Semiconductor Devices	PwrAmr	Wide	Consortia	Texas Tech University	1	9
RPM XE: Ultra-Efficient and Power-Dense Electric Motors	EIP	?	Crosscutting	Baldor Electric Company - Advanced Technology Group	1	1
Sensor-Based In-Line Control System (SICS) for the Surfaces of Continuously Cast Slabs	SBIR I,II	?	Steel	OG Technologies, Inc.	1	1
Thermally Conductive 3D Printing Filaments	LEEP-IC	AddMfg	Crosscutting	TCPoly, Inc.	1	9
Towards Low Cost Rectifiers and Medium Voltage Diodes with High Yields and Stable Processes	PwrAmr	Wide	Consortia	GeneSiC Semiconductor Inc.	1	9
Ultramizer®: Waste Heat Recovery System for Commercial and Industrial Boilers	EIP	WHRsys	Crosscutting	Cannon Boiler Works, Inc.	1	1

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
1.2kV SiC Shielded Trench Gate Power MOSFETs	PwrAmr	Wide	Consortia	North Carolina State University	2	9
1.7kV and 3.3kV SiC MOSFET Scale-Up	PwrAmr	Wide	Consortia	Microchip Technology Inc.	2	9
100A, 6.5kV Half-Bridge Module	PwrAmr	Wide	Consortia	United Silicon Carbide, inc.	2	9
A novel radioisotope battery made from nuclear waste	LEEP-CRI	Sustain	Crosscutting	Atlas Energy Systems, LLC	2	9
A Novel Unit Operation to Remove Hydrophobic Contaminants		?	?	Doshi and Associates,Inc	2	2
Acetic Acid Manufacture by the Selective Photocatalytic Oxidation of Ethane	SBIR I,II	ProcessInt	Chemicals	KSE, Inc.	2	2
Acetic Acid Recovery Using Membranes		Sustain	Chemicals	Membrane Technology and Research, Inc.	2	2
Additive Manufacturing of Permanent Magnets	CMI	AddMfg	Consortia	Momentum Technologies, Inc.	2	9
Advanced CHP System Utilizing Off-Gas from Coke Calcination		CHPsys	Crosscutting	Gas Technology Institute	2	2
Advanced Energy Efficient Hybrid Membrance System for Industrial Water Reuse		?	?	RTI International	2	2
Advanced ice-thermal storage	LEEP-IC	?	Crosscutting	Active Energy Systems	2	9
Advanced Membrane Technology for Helium Recovery	STTR	?	Crosscutting	Helios-nrg., LLC	2	2
Advanced Reciprocating Engine Systems (ARES) R&D - Cross-Cutting Technologies Enable Efficient Manufacturing		?	Crosscutting	Argonne National Laboratory	2	2
Advanced Transport Membrane Condenser for Energy and Water Recovery	SBIR I,II	?	Crosscutting	Media & Process Technology, Inc.	2	2
Aggregation and Structuring of Materials and Chemicals Data from Diverse Sources	SBIR I,II	AdvMatMfg	?	Citrine Informatics	2	2
Amorphous and Nanocomposite Magnets for High Efficiency, High Speed Motor Designs	NGEM	AdvMatMfg	Crosscutting	Carnegie Mellon University	2	3
Automatic Continuous Online Monitoring and Control Platform for Polymerization Reactions		?	Chemicals	Fluence Analytics	2	2
Biofine Technology		?	Other Industries	BioMetics, Inc.	2	2
Biomass Fractionation		?	Forest Products	PureVision Technology, Inc.	2	2
Biomaterials for Critical Material Dissolution, Recovery and Separation	CMI	Sustain	Consortia	Idaho National Laboratory	2	9

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
Continuous Processing of High Thermal Conductivity Polyethylene Fibers and Sheets (Lightweight Material for Heat Exchange Applications)		WHRsys	Crosscutting	Massachusetts Institute of Technology	2	2
Conversion of Waste CO2 and Shale to High-Value Chemicals		?	Chemicals	Novomer	2	3
Conversion to Metal, Alloys, and Materials	CMI	AdvMatMfg	Consortia	Colorado School of Mines	2	9
Cost-effective Conductor, Cable, and Coils for High Field Rotating Electric Machines	NGEM	?	Crosscutting	Florida State University	2	3
Design, Fabrication, and Vehicular Testing of 200kW 1050VDC Bus SiC Dual Inverter for Heavy-Duty Vehicles	PwrAmr	Wide	Consortia	John Deere Electronic Solutions, Inc.	2	9
Development of 6.5kV SiC MOSFETs, JBS Diodes, and JBS Diode Integrated MOSFET	PwrAmr	Wide	Consortia	SUNY Polytechnic Institute	2	9
Development of 600V SiC JBS Diodes and MOSFETs	PwrAmr	Wide	Consortia	SUNY Polytechnic Institute	2	9
Dimpled-Tube Heat Exchangers		WHRsys	Chemicals	Gas Technology Institute	2	2
Direct Causticizing for Black Liquor Gasification in a Circulating Fluidized Bed		?	Forest Products	Georgia Institute of Technology - IPST	2	2
Direct Conversion of Carbon Dioxide to Methanol		?	Chemicals	InnoSense LLC	2	2
Direct Process for Wire Production from Sulfide Concentrates		?	?	Massachusetts Institute of Technology	2	2
Electrochemical Activation of Ethane for Co-production of Chemicals and Hydrogen		?	?	Idaho National Laboratory	2	2
Electrochemical growth of carbon nanotubes	LEEP-IC	AdvMatMfg	Crosscutting	SkyNano Technologies, LLC	2	9
Electrochemical recovery of rare earth and specialty elements	LEEP-IC	Sustain	Crosscutting	Nth Cycle, Inc.	2	9
Electro-Recycling of RE Metals (eRECOV)	CMI	Sustain	Consortia	Idaho National Laboratory	2	9
Fibrous Fillers to Manufacture Ultra-High Ash/Performance Paper		?	Forest Products	GR Nano Materials	2	2
Flexible Carbon Conductors for Motors and Generators	NGEM	?	Crosscutting	Rice University	2	2
Fluid and Particle Dynamics in Metal Area Printing	HPC4MFG	AdvMatMfg	Consortia	Seurat Technologies	2	9
GaN RF DC-DC Converter Design	PwrAmr	Wide	Consortia	North Carolina State University	2	9
Gas-Fired Drum Dryer		?	Forest Products	Gas Technology Institute	2	2

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
Gate Oxide and Body Diode Reliability of SiC Power MOSFETs/A Comprehensive Validation Methodology For Benchmarking Wide Bandgap Power Devices for Aerospace Application and Improving Manufacturing Process	PwrAmr	Wide	Consortia	Argonne National Laboratory	2	9
Hard Disk Drive Magnet removal/recovery	CMI?	CritMats	Consortia	Oak Ridge National Laboratory	2	2
Heavy-duty Diesel Engine Combustion Optimization for Reduced Emissions, Reduced Heat Transfer, and Improved Fuel Economy.	HPC4MFG	ProcessInt	Consortia	Caterpillar Inc.	2	3
Hierarchical Nanoceramics for Industrial Process Sensors		AdvMatMfg	Crosscutting	GE Global Research	2	2
High Magnetic Field Processing (HMFP): A Heat-Free Heat-Treating Method		?	Crosscutting	Oak Ridge National Laboratory	2	2
High Performance Solar PV String and Micro Inverters with SiC and GaN Devices	PwrAmr	Wide	Consortia	Arizona State University	2	9
High Voltage Electrolytes for Ultracapacitors	LEEP-IC	?	Crosscutting	Eonix, LLC	2	9
High-Silicone Steel Sheet by Single Stage Shear-Based Processing	NGEM	?	Crosscutting	Purdue University	2	3
High-Temperature Industrial Insulation Utilizing Aerogels		AdvMatMfg	Crosscutting	Touchstone Research Laboratory, Ltd	2	2
Hot Oxygen Injection into the Blast Furnace		?	Steel	Praxair, Inc. (Tonawanda)	2	2
Improved Catalyst Selectivity and Longevity Using ALD		AdvMatMfg	?	Argonne National Laboratory	2	2
Inorganic Membranes for Refinery Gas Separations		ProcessInt	Chemicals	Media & Process Technology, Inc.	2	2
Integration of AI into Materials Research & Development and Processing		AdvMatMfg	?	SLAC National Accelerator Laboratory	2	2
Intensive Quenching Technology for Heat Treating and Forging Industries		ProcessInt	Crosscutting	IQ Technologies	2	2
Large Area Projection Sintering	LEEP-IC	?	Crosscutting	Ascend Manufacturing, LLC	2	9
Lignin Recovery and Purification		Sustain	Forest Products	Techfish, LLC	2	2
Low Head, Vortex Induced Vibrations River Energy Converter	I&I	?	Other Industries	Vortex Hydro Energy, LLC	2	2
Low-Emissions Burner Technology using Biomass-Derived Liquid Fuels		?	Other Industries	University of Alabama	2	2
Making semiconductor devices cool through HPC ab initio simulations	HPC4MFG	Wide	Consortia	Samsung Semiconductor, Inc.	2	9

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
Materials and Processing for Advanced Batteries		AdvMatMfg	Other Industries	Oak Ridge National Laboratory	2	2
Medium Voltage Integrated Drive and Motor	NGEM	?	Crosscutting	Calnetix Technologies	2	2
Membrane Solvent Extraction for Rare Earth Separations	CMI	CritMats	Consortia	Oak Ridge National Laboratory	2	2
Metallic Iron Nodule Technology in Electric Arc Furnace Steelmaking		?	Steel	University of Minnesota - Duluth	2	2
Miniature, Inexpensive, Amperometric Oxygen Sensor		?	Crosscutting	CeramPhysics, Inc.	2	2
Modifications and Optimization of the Organic Rankine Cycle		?	Crosscutting	Idaho National Laboratory	2	2
Nanofluids for Industrial Cooling Applications		AdvMatMfg	Crosscutting	Argonne National Laboratory	2	2
New Design Methods and Algorithms for Multi-component Distillation Processes		?	Chemicals	Purdue University	2	2
New Manufacturing Method for Paper Filler and Fiber Materials		CompMats	?	State University of New York College of Environmental Science and Forestry	2	2
New Regenerative Cycle for Vapor Compression Refrigeration		?	Crosscutting	President, Magnetic Development, Inc.	2	2
New Route To Styrene Monomer		?	Chemicals	Exelus, Inc.	2	2
Novel Flash Ironmaking Process		ProcessInt	Steel	University of Utah	2	2
Novel Membranes and Systems for Industrial and Municipal Water Purification and Reuse		Sustain	Chemicals	GE Global Research	2	2
On-Site Conical Spiral Welders for Large Wind Turbine Towers	SBIR	?	Crosscutting	Keystone Tower Systems	2	2
Open-Source Compact Transformerless Grid-Tied 3kW GaN PV Inverters	PwrAmr	Wide	Consortia	Transphorm, Inc.	2	9
Organic materials for energy storage	LEEP-CRI	AdvMatMfg	Crosscutting	Jolt Energy Storage Technologies, LLC	2	9
Paired Straight Hearth Furnace		?	Steel	American Iron and Steel Institute (AISI)	2	2
Point of Manufacture Microwave Plasma Jet Material Coatings		?	?	Starfire Industries, LLC	2	9
Polydopamine PTFE Composite Coating for Large Scale Journal Bearings in Next Gen Electric Machines	NGEM	?	Crosscutting	SurfTec, LLC	2	9
Production Scale-up of Activated Carbons for Ultracapacitors	I&I	AdvMatMfg	Crosscutting	TDA Research, Inc.	2	2
Pulse Drying of Paper Pulp		?	Forest Products	PC Engineering	2	2
Pyroprocessing Technologies to Recycle RE Metals	CMI	Sustain	Consortia	Idaho National Laboratory	2	9

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
Reactive Dehydration Technology for Production of Fuels and Chemicals from Biomass		?	?	KSE, Inc.	2	2
Recovery and Reuse of Rare Earth Metals from Phosphor Dusts	CMI	Sustain	Consortia	Colorado School of Mines	2	9
Recovery of Critical Materials from Consumer Devices	CMI	Sustain	Consortia	Idaho National Laboratory	2	9
Reduction of Distillation Usage in the Manufacture of Ethanol by Reactive Water Separation		ProcessInt	Chemicals	KSE, Inc.	2	2
Roll-to-Roll - Correlation of Dispersion Rheology and Structured Electrodes for Improved Lithium-Ion Cell Performance		AdvMatMfg	?	Oak Ridge National Laboratory	2	3
Roll-to-Roll - Deposition Using Particulate Loaded Aqueous Inks		AdvMatMfg	?	Saint-Gobain North America	2	2
Shear Rolling of Magnesium Sheet for Energy, Transportation, and Defense Applications		?	Crosscutting	Oak Ridge National Laboratory	2	2
Solar Thermal Assisted Vacuum Freezing Desalination of Seawater at the Triple Point	SBIR I,II	?	Crosscutting	Advanced Cooling Technologies, Inc.	2	2
Solid Catalyzed Isobutane/Olefin Alkylation		?	Chemicals	Precision Combustion, Inc.	2	2
Structural Emission Thermometry Sensor for Burner Control		?	Crosscutting	Spectral Sciences, Inc.	2	2
Supercritical Fluid Beneficiation of Waste Streams	CMI	Sustain	Consortia	Idaho National Laboratory	2	9
Technologist in Residence Partnership Development of next generation process and catalyst technology for the production of energy and chemicals		?	?	Universal Oil Products Company (UOP)	2	3
The Radical Atom: Mechanosynthetic 3D Printing of Atomically Precise Tip		AddMfg	?	UCLA	2	3
Thermal Barrier Coat Recovery	CMI	Sustain	Consortia	Idaho National Laboratory	2	2
Thermo-Magnetic Processing of Rare Earth Magnets	CMI	CritMats	Consortia	Oak Ridge National Laboratory	2	9
Thermophotovoltaic Electric Power Generation Using Exhaust Heat		WHRsys	Other Industries	JX Crystals, Inc.	2	2
Titanium Heat Exchangers Fabricated from New Powders		WHRsys	Crosscutting	Oak Ridge National Laboratory	2	2
Transforming Reuse and Recycling of Rare Earth Magnets	CMI	Sustain	Consortia	Oak Ridge National Laboratory	2	9
Ultra-Thin Antifouling Surface Treatments for Industrial Heat Exchangers		MatHarsh	Crosscutting	Applied Thin Films, Inc. (ATFI)	2	2

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
Wear-Resistant, Nano-Composite Steel Coatings	NM	AdvMatMfg	Crosscutting	Oak Ridge National Laboratory	2	2
Wind Fins: Novel Lower-Cost Wind Power System		?	Other Industries	DCM Studios	2	2
5kV DC to LV DC or 3-Phase AC Microgrid Power Conditioning Modules	PwrAmr	Wide	Consortia	Georgia Institute of Technology	3	9
Ab-initio Guided Design and Materials Informatics for Accelerated Product Development of Next Generation Advanced High Strength Steels (AHSS)	HPC4MFG	AdvMatMfg	Consortia	ArcelorMittal USA, LLC	3	9
Accelerated Alloy Development and Rapid Assessment	CMI	AdvMatMfg	Consortia	CMI - Ames Laboratory	3	9
Accelerated Deployment of Nanostructured Hydrotreating Catalysts		?	Crosscutting	Argonne National Laboratory	3	3
Accelerating Industrial Application of Energy-Efficient Alternative Separations	HPC4MFG	?	Consortia	American Chemistry Society Green Chemistry Institute	3	9
Active Micro-Optical System for a Prototype Plenoptic Camera	LEEP-IC	?	Crosscutting	MantaPoole Technologies, LLC	3	9
Advanced fiber non-woven mats	LEEP-IC	CompMats	Crosscutting	Endeavor Composites, Inc.	3	9
Advanced Manufacturing of Low Density Steels for Transportation		?	Steel	AK Steel Corporation	3	3
Advanced Materials to Enable Hydrogen as Fuel	LEEP-CRI	AdvMatMfg	Crosscutting	Celadyne Technologies, Inc.	3	9
Advanced Optical Sensors to Minimize Energy Consumption in Polymer Extrusion Processes		?	?	Guided wave, inc.	3	3
Advanced Production of High Purity Radioisotopes	LEEP-IC	AdvMatMfg	Crosscutting	Purist, Inc.	3	9
Advanced sample preparation for cryo-TEM	LEEP-IC	?	Crosscutting	Neptune Fluid Flow Systems	3	9
Advanced Search for High-Performance Materials (AS4HPM)	CMI	AdvMatMfg	Consortia	Lawrence Livermore National Laboratory	3	9
Application of HPC to Determine Secondary Cooling Heat Transfer Coefficient of Spray Cooling in Continuous Casting in Steel Manufacturing	HPC4MFG	AdvMatMfg	Consortia	Steel Manufacturing Simulation and Visualization Consortium (SMSVC)	3	9
Application Targeted Magnetic Materials	CMI	CritMats	Consortia	CMI - Ames Laboratory	3	9
Atomically Precise Membranes for Separation of Hydrocarbons	SBIR I,II	AdvMatMfg	?	Mainstream Engineering	3	3
Autoclave tooling	MDF	?	Consortia	Oak Ridge National Laboratory	3	3

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
Biogeochemical Impacts of Wastes from Critical Materials Recovery	CMI	Sustain	Consortia	Idaho National Laboratory	3	9
Bio-inspired Macromolecules Containing Atomically Precise Catalytic Active Sites	SBIR I,II	AdvMatMfg	?	Mainstream Engineering	3	3
Biologically Inspired Ammonia Production with Immobilized Nitrogenase	SBIR I,II	?	?	Fulcrum Bioscience	3	3
Biologically Mediated Recovery of Tellurium from Mine Wastes	CMI	Sustain	Consortia	Idaho National Laboratory	3	9
Carbon-Free Iron		?	?	Boston Metal	3	3
Ce Gettering of Cu and Fe in Aluminum Alloy Recycling	CMI	Sustain	Consortia	CMI - Ames Laboratory	3	9
CFD Simulations of Metal Powder Production by Gas Atomization	HPC4MFG	ProcessInt	Consortia	Praxair Surface Technologies, Inc.	3	9
Coatings and Process Development for Reduced Energy Automotive OEM Manufacturing		?	Crosscutting	PPG Industries, Inc.	3	3
Combined Micromagnetic and Finite-element simulation of Integrated Magnetic Inductors for Improve DC-DC Voltage Regulator Energy Efficiency and Manufacturing Yield	HPC4MFG	?	Consortia	Ferric Semiconductor, Inc.	3	9
Compact modular process for converting natural gas to high value hydrocarbons		?	?	Argonne National Laboratory	3	3
Comparing SiC and GaN Electric Vehicle Chargers	PwrAmr	Wide	Consortia	Kettering University	3	9
Converting Waste Carbon Dioxide to Plastic Monomers	LEEP-CRI	Sustain	Crosscutting	RenewCO2, LLC	3	9
Covetics High Performance Electrical and Thermal Conductors		AdvMatMfg	?	Argonne National Laboratory	3	3
Critical Material Recovery from Ores and Lean Sources	CMI	Sustain	Consortia	Oak Ridge National Laboratory	3	9
Critical Material Supply from Nontraditional Sources	LEEP-CRI	CritMats	Crosscutting	NUMiX Materials	3	9
Criticality, Life Cycles, Material Flows and Scenarios	CMI	Sustain	Consortia	Colorado School of Mines	3	9
Crosscutting Thermodynamic Properties of Critical Materials	CMI	CritMats	Consortia	Rutgers University	3	9
DC Data Center with High Frequency Isolation	PwrAmr	?	Consortia	Virginia Tech	3	9
Deep Learning-Augmented Flow Solver to Improve the Design of Gas-Turbine Engine	HPC4MFG	ProcessInt	Consortia	Raytheon Technologies Research Center (formerly UTRC)	3	9

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
Demonstration of a Medium Voltage Power Module for High Density Conversion	PwrAmr	Wide	Consortia	North Carolina State University - PREES Laboratory	3	9
Develop high performance atomically sharp tools for atomically precise manufacturing for a wide range of clean energy applications.		?	?	UCLA	3	9
Development of An Open Gate Dielectric Process for SiC MOSFET Manufacturing	PwrAmr	Wide	Consortia	Auburn University	3	9
Dielectric Materials for Capacitive Energy Storage	LEEP-CRI	AdvMatMfg	Crosscutting	Caporus Technologies	3	9
Direct Solid-State Conversion of Recyclable Metals into Nanoengineered Bulk Materials.		?	?	Southwire Company	3	9
DNA Strand Displacement Driven Molecular Additive Manufacturing		AddMfg	?	Dana-Faber Cancer Institue	3	3
Enhanced 2G HTS Wire Manufacturing Motor Applications	NGEM	?	Crosscutting	American Superconductor Corporation	3	3
Enhanced Separation of Critical Materials Structure and Properties of Ce-Strengthened Al Alloys	CMI	CritMats	Consortia	Idaho National Laboratory	3	9
Enhancing HDDR Powders	CMI	AdvMatMfg	Consortia	Oak Ridge National Laboratory	3	9
Fabrication Advanced Nanocarbon-Metal Composites		CompMats	?	University of Maryland	3	3
Finite Element Modelling of Magnetic and Electrochemical Systems	CMI	?	Consortia	CMI - Ames Laboratory	3	9
Freeze-dried biosensors for water quality and the energy-water nexus	LEEP-CRI	?	Crosscutting	Stemloop, Inc.	3	9
Friction Extrusion Feasibility Study	CMI	AdvMatMfg	Consortia	CMI - Ames Laboratory	3	9
Full-Stack Cross-Layer Quantum Optimization	LEEP-CRI	?	Crosscutting	Super.tech Labs, Inc.	3	9
Fully-Resolved DNS Simulation of Particulate Deposition for Aeroengine Combustor Applications	HPC4MFG	ProcessInt	Consortia	Raytheon Technologies Research Center (formerly UTRC)	3	9
Gliding Arc Plasma Reformer with Efficient Heat Recuperation		ProcessInt	?	Advanced Cooling Technologies, Inc.	3	3
Heterogeneous Sm-Co and Nd-Fe-B Magnets	CMI	CritMats	Consortia	CMI - Ames Laboratory	3	9
High Magnetic Field Processing of Permanent Magnet Materials	CMI	CritMats	Consortia	Oak Ridge National Laboratory	3	9
High Performance Computing for Improvement of Syngas Production Efficiency with OTM Technology	HPC4MFG	ProcessInt	Consortia	Praxair, Inc.	3	9

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
Highly Parallel Multi-Physics Multi-Scale Modeling Tool to Drive Smart Manufacturing in Casting	HPC4MFG	ProcessInt	Consortia	GE Global Research	3	9
High-Performance Computing to Increase Productivity of Secondary Lead Furnaces	HPC4MFG	ProcessInt	Consortia	Gopher Resource, Inc.	3	9
High-performance, Critical-element-free Permanent Magnets	CMI	CritMats	Consortia	CMI - Ames Laboratory	3	9
High-rate electron generation from organic waste	LEEP-IC	Sustain	Crosscutting	Electro-Active Technologies, Inc.	3	9
Hybrid Metal - Polymer Heat Exchangers for Waste Heat Recovery		WHRsys	?	University of Illinois - Urbana-Champaign	3	3
Hybrid Micro Converter	PwrAmr	?	Consortia	InnoCit, LLC	3	9
Infrared Imagers Using Colloidal Quantum Dots	LEEP-CRI	?	Crosscutting	QDIR, Inc.	3	9
Inks Enabling Energy Efficient Displays	LEEP-CRI	AdvMatMfg	Crosscutting	NanoPattern Technologies, Inc.	3	9
Integrated Computational Materials Engineering Tools for Optimizing Strength of Forged Al-Li Turbine Blades for Aircraft Engines	HPC4MFG	AdvMatMfg	Consortia	Lightweight Innovation for Tomorrow Consortium (LIFT)	3	9
Integrated hybrid silicon lasers	LEEP-CRI	?	Crosscutting	Iris Light Technologies, Inc.	3	9
Integrated Hydrogen Combustion with Ethylene Production		?	?	EcoCatalytic Inc.	3	9
Integrated Predictive Tools for Property Prediction and Alloy Design in Additive Manufacturing	HPC4MFG	AddMfg	Consortia	Raytheon Technologies Research Center (formerly UTRC)	3	9
Learning-Based Monitoring and Control for Optimizing Commercial Refrigeration	LEEP-IC	?	Crosscutting	Grid Fruit, LLC	3	9
Level-set Modeling Simulations of Chemical Vapor Infiltration for Ceramic Matrix Composites Manufacturing	HPC4MFG	CompMats	Consortia	Rolls-Royce Corporation	3	3
Li, Co & PGM Recovery from Li-ion Batteries & E-waste	CMI	Sustain	Consortia	Idaho National Laboratory	3	9
Li-ion Battery Disassembly, Remanufacturing, and Li & Co Recovery	CMI	Sustain	Consortia	Oak Ridge National Laboratory	3	9
Lithium Extraction and Conversion from Brines	CMI	CritMats	Consortia	Oak Ridge National Laboratory	3	9
Low Cost Modular Plasma System for Reforming NG		?	?	Rivis Inc.	3	9
Low Pressure Electrolytic Ammonia Production		ProcessInt	?	University of North Dakota	3	3

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
Low Temperature Chemical-Mediated Reduction of Rare Earth Elements	CMI	CritMats	Consortia	Idaho National Laboratory	3	9
Low Temperature Electrochemical Processing of Rare Earths Elements	CMI	CritMats	Consortia	Idaho National Laboratory	3	9
Low-Cost Titanium Alloy Production		?	Crosscutting	University of Utah	3	3
Low-Temperature Electrochemical Synthesis of Graphite	CMI	AdvMatMfg	Consortia	Oak Ridge National Laboratory	3	9
Machine Learning Materials Design	CMI	AdvMatMfg	Consortia	Lawrence Livermore National Laboratory	3	9
Materials for Organic Light Emitting Diodes	LEEP-CRI	AdvMatMfg	Crosscutting	Light and Charge Solutions, LLC	3	9
Melt Processing of Covetic Material		AdvMatMfg	?	National Energy Technology Laboratory	3	3
Metal (Cu, Al) CNT Composite Wires for Energy Efficient Motors	NGEM	?	Crosscutting	University of Central Florida	3	3
Mie photo sensors and arrays	LEEP-IC	?	Crosscutting	PixelEXX Systems, Inc.	3	9
Modeling and Simulation of the Manufacture of a Superior Fiber Optic Glass	HPC4MFG	AdvMatMfg	Consortia	Flawless Photonics, Inc.	3	9
Modeling Coating Flow and Dynamics During Drying	HPC4MFG	ProcessInt	Consortia	PPG Industries, Inc.	3	9
Modeling High Impulse Magnetron Sputtering (HiPIMS) plasma sources	HPC4MFG	ProcessInt	Consortia	Applied Materials, Inc.	3	9
Modeling of Non-equilibrium Plasma for Automotive Applications	HPC4MFG	AdvMatMfg	Consortia	Transient Plasma Systems, Inc.	3	9
Multi-Functional, High-Efficiency, High-Density, Medium Voltage SiC Based Asynchronous Microgrid Power Conditioning System Module	PwrAmr	Wide	Consortia	University Of Tennessee	3	9
Nanostructured coatings for direct water immersion cooling of server electronics	LEEP-IC	AdvMatMfg	Crosscutting	AquaQuant Laboratories	3	9
New In-Silico Molecular Design Methods for Improved Separations	CMI	AdvMatMfg	Consortia	CMI - Ames Laboratory	3	9
Non-equilibrium Molecular Simulations of Polymers under Flow: Saving Energy through Process Optimization	HPC4MFG	?	Consortia	Dow Chemical Company	3	9
On-demand and tunable curing of thermoset composites	LEEP-IC	?	Crosscutting	Actinic, LLC	3	9
One Step Hydrogen Generation Through Sorption Enhanced Reforming		?	?	Gas Technology Institute	3	3

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
Open-Source Framework for Analysis and Design of Autothermal Chemical Processes		?	?	Iowa State University	3	3
Optimization of Alumina and Aluminum Fluoride Feeding in Advanced Aluminum Smelting Cells Using Large Eddy Simulation	HPC4MFG	ProcessInt	Consortia	Alcoa USA Corp	3	9
Optimization of Scrap Melting Using an Electric Arc in Steel Manufacturing	HPC4MFG	ProcessInt	Consortia	NLMK USA	3	9
Optimize performance of copper-based catalysts to convert carbon dioxide		ProcessInt	?	Lawrence Livermore National Laboratory	3	3
Optimizing Rotary Bell Atomiaztion	HPC4MFG	ProcessInt	Consortia	PPG Industries, Inc. of Pennsylvania (Allison Park)	3	3
Optimizing the Economic Performance of CMI Technologies	CMI	CritMats	Consortia	Purdue University	3	9
Passive Cooling Film Optimization	HPC4MFG	?	Consortia	3M Company	3	9
Powder Spreading Process Maps for Metal Additive Manufacturing	HPC4MFG	AddMfg	Consortia	GE Global Research	3	9
Powering the World with Silicon	LEEP-CRI	?	Crosscutting	SiMat EnerTech	3	9
Practical Reliable Exchange Spring Magnets (PRES-M)	CMI	CritMats	Consortia	Lawrence Livermore National Laboratory	3	9
Predicting Magnetic Anisotropy	CMI	CritMats	Consortia	CMI - Ames Laboratory	3	9
Predictive Tools for Customizing Heat Treatment of Additively Manufactured Aerospace Components	HPC4MFG	AddMfg	Consortia	Raytheon Technologies Research Center (formerly UTRC)	3	9
Production of Semi-Conducting Carbon Nanotubes via Resonant-Dielectrophoresis	LEEP-IC	AdvMatMfg	Crosscutting	American Nanotechnologies, Inc.	3	9
Pseudo-Spectral Method for Conjugate Heat Transfer Prediction of Impinging Flows Over Rough Surfaces	HPC4MFG	ProcessInt	Consortia	Raytheon Technologies Research Center (formerly UTRC)	3	9
Quantum Random Number Generation on a Chip	LEEP-CRI	?	Crosscutting	Axion Technologies LLC	3	9
Radiation Shielding Material Optimization	LEEP-IC	AdvMatMfg	Crosscutting	NeutroElectric (DBA Becq)	3	9
Rapid CFD Using Machine Learning Algorithms	HPC4MFG	?	Consortia	Guardian Industries	3	9
Rapid Synthesis and Characterization of Covetic Nanomaterials		AdvMatMfg	?	Oak Ridge National Laboratory	3	9
Recovery of Critical Materials as By-Products	CMI	Sustain	Consortia	Colorado School of Mines	3	9
Recovery of Critical Materials from Dilute Electronic Waste Streams	CMI	Sustain	Consortia	CMI - Ames Laboratory	3	9

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
Reduced Order Modeling and Performance Prediction for Steel Refining Ladle Processing via High Performance Computing	HPC4MFG	AdvMatMfg	Consortia	ArcelorMittal USA, LLC	3	9
Roadmaps for Technology Development	CMI	?	Consortia	Idaho National Laboratory	3	9
Robust Polymer Composite Membranes for Hydrogen Separation		?	Crosscutting	Los Alamos National Laboratory	3	3
Roll-to-Roll - Advanced Materials Manufacturing DOE Laboratory Consortium CRADA Projects		AdvMatMfg	?	Oak Ridge National Laboratory	3	3
Roll-to-Roll - PEM Fuel Cell Gas Diffusion Electrodes (GDE) with Ionomer Rich Surface Layer		AdvMatMfg	?	National Renewable Energy Laboratory	3	3
Roll-to-Roll Manufacturing of Highly Crystalline Thin-Film Semiconductor Substrates	LEEP-IC	AdvMatMfg	Crosscutting	Lux Semiconductors, LLC	3	9
Science-Enabling Diverse Value Chain Product from Al-Ce Alloys	CMI	AdvMatMfg	Consortia	Oak Ridge National Laboratory	3	9
Security for connected facilities and equipment	LEEP-IC	?	Crosscutting	Quantum Lock Technologies, LLC	3	9
Separation and Recovery of Dysprosium and Cobalt from E-Waste	CMI	Sustain	Consortia	Oak Ridge National Laboratory	3	9
Si-Al-Cr-Mn Alloy for High Specific Resistivity	NGEM	?	Crosscutting	AK Steel Corporation	3	3
SiC Active Harmonic Filter for Variable Frequency Drives	PwrAmr	?	Consortia	United Technologies Research Center	3	9
SiC Based Power Electronic Fan Driver for Class 8 Mild Hybrid Truck	PwrAmr	Wide	Consortia	Bendix Commerical Vehicle Systems, LLC	3	9
Simulation Tools for Characterizing Stress Distribution in Laser Welded Dissimilar Joints	HPC4MFG	ProcessInt	Consortia	General Motors Company	3	9
Simulation-driven optimization of non-Newtonian slurry atomizers for large-scale energy production	HPC4MFG	?	Consortia	Eastman Chemical Company	3	9
SmFeN as a Cost-Effective High Performance Magnet	CMI	CritMats	Consortia	CMI - Ames Laboratory	3	9
Spectral Radiative Modeling of Glass Furnaces	HPC4MFG	ProcessInt	Consortia	Saint-Gobain Ceramics & Plastics	3	9
Switchable Solvent Dewatering for Recovery of Critical Materials	CMI	Sustain	Consortia	Idaho National Laboratory	3	9
Topology Optimization of Fischer-Tropsch Reactor Design for Synthetic Fuel Production	HPC4MFG	ProcessInt	Consortia	OxEon Enery, LLC	3	9
Transition Metal Blocking Microporous Polymer Separators for Energy Dense and Long-Lived Li-Ion Batteries	SBIR I,II	?	?	Sepion Technologies of California	3	3

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
Ultra-High Efficiency SiC Modular UPS/Ultra-High Efficiency Full SiC-Based Modular UPS	PwrAmr	Wide	Consortia	ABB, Ltd	3	9
Ultra-High Temp Thermal Barrier Coating		?	?	Solar Turbines Incorporated	3	3
Ultrahigh-Efficiency Capacitive Devices for Continuous Water Desalination		?	Crosscutting	Mainstream Engineering	3	3
WBG Workshop Development and Teaching Modules for GaN Transistor Fabrication	PwrAmr	AdvMatMfg	Consortia	North Carolina State University	3	9
Enabling Technology For The Use Of Recycled Carbon Fibre Materials in Mobility Applications	IACMI	Sustain	Consortia	ELG Carbon Fibre Ltd (dba Gen 2 Carbon)	9	9
Impact of Research on Global Material Supply Chains	CMI	Sustain	Consortia	Idaho National Laboratory	9	9
Innovative Blade Finishing with Advanced Automated Technology	IACMI	CompMats	Consortia	DSM Engineering Materials - IACMI	9	9
Low Cost 3D Composites Additive Manufacturing	IACMI	AddMfg	Consortia	Impossible Objects, Inc.	9	9
Materials Characterization for Large Scale Additive Manufacturing	IACMI	AddMfg	Consortia	Techmer PM, LLC	9	9
Multiple Stream Low-Cost Recycling Method	IACMI	Sustain	Consortia	Greentex Solutions, LLC	9	9
NanoStitch® Format and Function Optimization for Multifunctional Composites	IACMI	AddMfg	Consortia	N12 Technologies, Inc.	9	9
Next Generation Co-Molding of Automotive Parts	IACMI	CompMats	Consortia	INEOS Composites US, LLC	9	9
Novel Preforms Enabling Effective Composite Joining	IACMI	CompMats	Consortia	Airbus Defence and Space North America	9	9
Process and Applications Development for Recycled Mixed-Stream Composites	IACMI	Sustain	Consortia	American Composites Manufacturing Association (ACMA)	9	9
Pultruded Textile Carbon Fiber (TCF) for Spar Caps (SC)	IACMI	CompMats	Consortia	Montefibre Carbon	9	9
Recycling Carbon Fiber Composite Aircraft Parts and Product Development from Reclaimed Fiber	IACMI	Sustain	Consortia	Universal Asset Management, Inc.	9	9
SMC Reinforced by Recycled or Textile Carbon Fibers	IACMI	Sustain	Consortia	IAMCI	9	9
Techno-Economic Wind Blade Manufacturing Model to Identify Opportunities for Cost Improvements	IACMI	CompMats	Consortia	University of Massachusetts - Lowell	9	9
Tooling for Composites with Washout Features Produced by Additive Manufacturing	IACMI	AddMfg	Consortia	Ability Composites, LLC	9	9

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
100kW PV Inverter with Efficiency > 99% Operating in Interleaved Triangular Conduction Mode (iTCM)	PwrAmr	Wide	Consortia	Virginia Tech	No Response	9
100kW SiC Inverter for Electric Vehicle Traction Drive/Development of an Active Harmonic Filter using Interleaved SiC Inverter	PwrAmr	Wide	Consortia	North Carolina State University	No Response	9
1200V SiC Schottky Diode Commercialization and Production/Commercialization of 1700V SiC Schottky Diodes Manufactured at X-FAB Texas	PwrAmr	Wide	Consortia	Monolith Semiconductor Inc.	No Response	9
3D Direct Ink Writing with Graphene Aerogels	MDF	AddMfg	Consortia	Lawrence Livermore National Laboratory	No Response	9
3D printed trim-and-drill tool	MDF	AddMfg	Consortia	Boeing Company Research & Technology	No Response	9
3D Printing Aerospace-Grade Carbon Fiber	MDF	AddMfg	Consortia	Lawrence Livermore National Laboratory	No Response	9
3D Printing Enables Development of Cost-Effective Robotics	MDF	AddMfg	Consortia	Sandia National Laboratories	No Response	9
3D printing of 13m wind turbine blade mold	MDF	AddMfg	Consortia	Oak Ridge National Laboratory	No Response	9
3D printing turbine blades for high temperature gas turbine engines via EBM	MDF	AddMfg	Consortia	Oak Ridge National Laboratory	No Response	9
3D printing with bio-derived materials	MDF	AddMfg	Consortia	University of Maine	No Response	2
A Dynamic Techno-economic Systems Modeling Framework for U.S. Fiber Recycling	REMADE	Sustain	Consortia	Northwestern University	No Response	9
A NEW CLASS OF ULTRA-LOW-COST BATTERY	LEEP-CycRd	AdvMatMfg	Crosscutting	Noon Energy, Inc.	No Response	9
Accelerating Energy Technology Innovation at Cyclotron Rd.	LEEP-CycRd	?	Crosscutting	Lawrence Berkeley National Laboratory	No Response	3
ACCELERATING QUANTUM COMPUTING	LEEP-CycRd	?	Crosscutting	Bleximo	No Response	9
ACCELERATING THE FUTURE	LEEP-CycRd	?	Crosscutting	Astrileux	No Response	9

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
ACCESSIBLE MATERIAL ANALYSIS	LEEP-CycRd	AdvMatMfg	Crosscutting	NuSight Photonics	No Response	9
Additive Manufacturing of High Temperature Alloys for Energy Applications	MDF	AddMfg	Consortia	Brayton Energy	No Response	9
Adsorptive Nitrogen Rejection from Natural Gas	RAPID	?	Consortia	Praxair, Inc.	No Response	9
Advanced Diagnostics and Control for Furnaces, Fired Heaters and Boilers	EIP	?	Crosscutting	Yokogawa Corporation of America	No Response	1
Advanced Manufacturing Alpha Double Prime Iron Nitride FeNix (ADPIN)		?	?	FeNix Magnetics, Inc.	No Response	3
Advanced Manufacturing of High Performance Superconductor Wires for Next Generation Electric Machines	NGEM	AdvMatMfg	Crosscutting	University of Houston	No Response	2
Advanced Nanocomposite Membrane for Natural Gas Purification	RAPID	?	Consortia	University of Texas - Austin	No Response	9
Advanced reciprocating Engine Systems (ARES)	DE	?	Crosscutting	Cummins Alternative Fuel Program	No Response	1
Advanced Refrigerant-Based Cooling Technologies for Information & Communications Infrastructure	ARRA DC	?	Other Industries	Alcatel-Lucent Technologies (Bell Laboratories)	No Response	1
Aerodynamic Control Systems for Heavy Vehicles	LEEP-CRI	?	Crosscutting	Aeromutable Corporation	No Response	9
AFFORDABLE ENERGY STORAGE FOR A CLEANER GRID	LEEP-CycRd	?	Crosscutting	Antora Energy	No Response	9
AFFORDABLE HEATING AND COOLING FOR THE MASSES	LEEP-CycRd	?	Crosscutting	Treau, Inc. (dba Gradient)	No Response	9
AI FOR CLIMATE AND WEATHER RISK FORECASTING	LEEP-CycRd	?	Crosscutting	Terrafuse, Inc.	No Response	9
Alternative Carbon Fiber Precursors and Conversion Technologies		?	Crosscutting	Oak Ridge National Laboratory	No Response	3
AMO Program in Covetic Nanomaterials		?	?	Advanced Manufacturing Office - U.S. Dept. of Energy	No Response	9
AMO SBIR/STTR		?	Crosscutting	Advanced Manufacturing Office - U.S. Dept. of Energy	No Response	9

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
AMO SBIR/STTR Overview		?	Crosscutting	Advanced Manufacturing Office - U.S. Dept. of Energy	No Response	9
AMO Tech Assistance		?	Crosscutting	Advanced Manufacturing Office - U.S. Dept. of Energy	No Response	9
An Experimentally Verified Physical Properties Database for Sorbent Selection and Simulation	RAPID	?	Consortia	Georgia Institute of Technology	No Response	9
Application of HPC for Hot Rolling of Next Generation Steels	HPC4MFG	ProcessInt	Consortia	AK Steel Corporation	No Response	9
Assessment of the Impact of Single Stream Recycling on Paper Contamination in Recovery Facilities and Paper Mills	REMADE	Sustain	Consortia	University of Miami	No Response	9
Atomically Precise Metallo-Catalysts with Molecular Lego		AdvMatMfg	?	Temple University	No Response	3
Autothermal pyrolysis of lignocellulose wastes to sugars and other biobased products	RAPID	Sustain	Consortia	Iowa State University	No Response	9
BAAM system applications	MDF	AddMfg	Consortia	Oak Ridge National Laboratory	No Response	9
Bamboo Bio-composite Truck/Trailer Decking	IACMI	CompMats	Consortia	Resource Fiber	No Response	9
BESPOKE BACTERIA FOR BIOMANUFACTURING	LEEP-CycRd	?	Crosscutting	Microbyre, LLC	No Response	9
BETTER BATTERY DIAGNOSTICS	LEEP-CycRd	?	Crosscutting	Feasible	No Response	9
Big Area Additive Manufacturing (BAAM) Materials Development and Reinforcement with Advanced Composites	IACMI	AddMfg	Consortia	Local Motors Industries	No Response	9
BIO-CHEMICALS AND FUELS	LEEP-CycRd	?	Crosscutting	Visolis, Inc.	No Response	9
Bioleaching for Recovery of Recycled REE	CMI	Sustain	Consortia	Idaho National Laboratory	No Response	9
Biomass Boiler for Food Processing Applications	FoF	WHRsys	Other Industries	Burns & McDonnell Engineering Company, Inc.	No Response	1
BlackGold®: Erosion-Resistant Nanocoatings for Improved Energy Efficiency in Gas Turbine Engines	NM	AdvMatMfg	Crosscutting	MDS Coating Technologies Corporation	No Response	1

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
Boride-carbon Hybrid Technology Ultra-Wear and Corrosion Resistant Surfaces		MatHarsh	?	Michigan State University	No Response	9
Brackish and Wastewater Cleanup for Process Cooling		?	Crosscutting	TDA Research, Inc.	No Response	3
Buzzcell™: Powering Cell Phones with Fuel Cells Running on Renewable Fuels	I&I	?	Other Industries	Neah Power Systems, Inc.	No Response	1
Carbon fiber pre-preg recycling - automated preform manufacturing equipment	IACMI	CompMats	Consortia	Composite Recycling Technology Center (CRTC)	No Response	9
Carbon fiber Reinforced Polyolefin Body Panels	IACMI	CompMats	Consortia	Ford Motor Company	No Response	9
Catalytic Pulping of Wood	HPC4MFG	ProcessInt	Consortia	Agenda 2020 Technology Alliance	No Response	9
Characterization of Kevlar®-reinforced composites for predictive simulation	IACMI	CompMats	Consortia	DuPont de Nemours, Inc.	No Response	9
Chemical Recycling of Mixed Plastics and Valuable Metals in the Electronic Waste Using Solvent-Based Processing	REMADE	Sustain	Consortia	University of Massachusetts - Lowell	No Response	9
CHP Deployment Program		CHPsys	Crosscutting	Advanced Manufacturing Office - U.S. Dept. of Energy	No Response	9
CLEAN, AFFORDABLE COGENERATION OF HYDROGEN	LEEP-CycRd	?	Crosscutting	Brimstone Energy	No Response	9
Closing the Loop on Automotive Carbon Fiber Prepreg Manufacturing Scrap	IACMI	CompMats	Consortia	Vartega, Inc.	No Response	9
Combustion System to Replace Fossil Fuels in Lime Sludge Kilns		?	Forest Products	Houghton Cascade Holdings LLC	No Response	2
Composities Virtual Factory Hub (cvfHUB)	IACMI	CompMats	Consortia	Purdue University	No Response	9
Computation Study of Flow and Growth Inside Ammonothermal Gallium Nitride Reactor	HPC4MFG	AdvMatMfg	Consortia	Soraa Inc.	No Response	2
Computational Modeling of High Pressure Resin Transfer Molding (HP-RTM) for Automotive Structural Carbon Fiber (CF) Composites.	HPC4MFG	CompMats	Consortia	General Motors Company	No Response	2

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
Computational Modeling of Industrial Rolling Processes Incorporating Microstructure Evolution to Minimize Rework Energy Losses	HPC4MFG	?	Consortia	Arconic Inc.	No Response	9
Computational Modeling of Multi-Strand Aluminum DC Vertical Casting Processes Incorporating Cast Structure and Thermal Treatment Effects Contributing to Rework Energy Losses	HPC4MFG	ProcessInt	Consortia	Arconic Inc.	No Response	3
Condition Assessment of Used Electronics	REMADE	Sustain	Consortia	Rochester Institute of Technology	No Response	9
CONVERTING OCEAN WAVES INTO ELECTRICITY	LEEP-CycRd	?	Crosscutting	CalWave	No Response	9
Cross-Industry Utilization of Ground Tire Rubber for Energy Efficient Pavements	REMADE	Sustain	Consortia	Iowa State University	No Response	9
Cupola Furnace Process Model		ProcessInt	Metal Casting	American Foundry Society	No Response	2
Curriculum Development on Modeling, Simulation, and Design of Wide Band Gap Semiconductor Devices	PwrAmr	Wide	Consortia	Florida State University	No Response	9
Data Modeling for Machine Learning and Data-Centric Analytics for Smart Aerospace Additive Manufacturing	CESMII	AddMfg	Consortia	Honeywell International, Inc.	No Response	9
Data-Driven Design Decision Support for Re-X of High-Value Components in Industrial and Agricultural Equipment	REMADE	Sustain	Consortia	Iowa State University	No Response	9
DB-LN Series Burner: Fuel-Flexible Combustion System for Refinery and Chemical Plant Process Heaters	FF ARRA	ProcessInt	Chemicals	Zeeco, Inc.	No Response	1
Demineralization of Carbon Black Derived from End-of-Life Tires	REMADE	Sustain	Consortia	University of Utah	No Response	9
DEMOCRATIZING MICRO- AND NANOFABRICATION	LEEP-CycRd	AdvMatMfg	Crosscutting	Inchfab	No Response	9
Demonstrating microstructure control in additively manufactured nickel-base superalloys via EBM	MDF	AddMfg	Consortia	Oak Ridge National Laboratory	No Response	9
Deployment of FlexCHP System		CHPsys	?	Gas Technology Institute	No Response	3
Design for Remanufacturing	REMADE	Sustain	Consortia	Rochester Institute of Technology	No Response	9

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
Determining Material, Environmental and Economic Efficiency of Sorting and Recycling Mixed Flexible Packaging and Plastic Wrap	REMADE	Sustain	Consortia	American Chemistry Council (ACC)	No Response	9
Developing a BPD-Free Room Temperature AI Implant and Activation Anneal Process for P-Wells in SiC MOSFETS	PwrAmr	Wide	Consortia	Naval Research Laboratory	No Response	9
Developing high performance computing model of vapor transition through advanced membranes for applications in 7AC Liquid Desiccant Air Conditioners	HPC4MFG	?	Consortia	7AC Technologies	No Response	3
Development and Demonstration of Novel Thermal Technologies for Enhanced Air-Side and Two-Phase Performance of CPI-Relevant Heat Exchangers	RAPID	WHRsys	Consortia	Georgia Institute of Technology	No Response	9
Development and Deployment of a Wide Bandgap Medium-voltage Electric Vehicle Fast Charger/Next Generation 350kW Three-Phase Medium Voltage, High-Efficiency EV Fast Charger	PwrAmr	Wide	Consortia	North Carolina State University	No Response	9
Development and Validation of Simulation Capability for the High Capacity Production of Carbon Fiber	HPC4MFG	CompMats	Consortia	Harper International Corporation	No Response	9
Development of a Castable High Strength Secondary Aluminum Alloy from Recycled Wrought Aluminum Scrap	REMADE	Sustain	Consortia	University of Illinois - Urbana-Champaign	No Response	9
Development of a lower cost, high-volume, commercially available precursor for lower cost carbon fiber and automotive and wind blade applications	IACMI	CompMats	Consortia	Dralon GmbH	No Response	9
Development of a soot-free engine for heavy-duty applications	LEEP-CRI	ProcessInt	Crosscutting	ClearFlame Engines, Inc.	No Response	9
Development of a Static Induction Transistor	PwrAmr	Wide	Consortia	UC - Davis	No Response	9
Development of a Transformational Micro-Cooling Technology for High-Pressure Die Casting using High-Performance Computing	HPC4MFG	AdvMatMfg	Consortia	Shiloh Industries of Ohio	No Response	9
Development of an Industrially Relevant RE-SOLAR Design Framework	REMADE	Sustain	Consortia	University of Pittsburgh	No Response	9
Development of Automotive Grade Carbon Fiber Composite Performance Standards to Reduce Costs and Drive Mainstream, High Volume Vehicle Production with CFRP	IACMI	CompMats	Consortia	American Chemistry Council (ACC)	No Response	9

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
Development of Complete Documentation on Fabrication of GaN HEMTs (600V-1.1KV)	PwrAmr	Wide	Consortia	UC - Davis	No Response	9
Development of Large Scale Extrusion Deposition for Structural Applications	IACMI	CompMats	Consortia	Local Motors Industries	No Response	9
Development of Manufacturable Gen 3 6.5kV/100mOhm SiC MOSFET and Establish HTRB, HTGB, and TDDB Reliability Qualification	PwrAmr	Wide	Consortia	Wolfspeed, Inc.	No Response	9
Development of New Cost-Effective Methods for Removing Trace Contaminants in Recycled Metals	REMADE	Sustain	Consortia	Ohio State University	No Response	9
Development of Non-destructive Evaluation/Non-destructive Testing (NDE/NDT) Tools for High-Volume, High-Speed Inspection of CFRP Structures in Automotive Manufacturing	IACMI	CompMats	Consortia	American Chemistry Council (ACC)	No Response	9
Development of rCF thermoplastic non-woven prepreg for automotive class A body panels via compression molding	IACMI	CompMats	Consortia	BASF Corporation	No Response	9
Development of Reduced Glass Furnace Model to Optimize Process Operation	HPC4MFG	ProcessInt	Consortia	PPG Industries, Inc. of Pennsylvania (Monroeville)	No Response	9
Digital Through-the-Earth Communication™ System		?	Mining	Vital Alert Communications, Inc.	No Response	1
Dimensional Stability of Low-Cost Thermoplastic Composite Molds	IACMI	CompMats	Consortia	ESI North America	No Response	9
Diode-based Additive Manufacturing (DiAM)	MDF	AddMfg	Consortia	Lawrence Livermore National Laboratory	No Response	9
Discontinuous Aligned Carbon Fiber Intermediates for Automotive and Related Applications	IACMI	CompMats	Consortia	Neenah Paper	No Response	9
Documentation of Design and Process of GaN Power Devices	PwrAmr	Wide	Consortia	Rensselaer Polytechnic Institute	No Response	9
Drivetrains for small wind power	LEEP-CRI	?	Crosscutting	Accelerate Wind, LLC	No Response	9
Dynamic Intensification of Chemical Processes	RAPID	ProcessInt	Consortia	University of Texas - Austin	No Response	9
Economizer Based Data Center Liquid Cooling with Advanced Metal Interfaces	ARRA DC	?	Other Industries	IBM TJ Watston Research Center	No Response	2

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
Efficient Chemicals Production via Chemical Looping	RAPID	?	Consortia	University of Delaware	No Response	9
Efficient One-Step Electrolytic Recycling of Low-Grade and Post-Consumer Magnesium Scrap		Sustain	?	Metal Oxygen Seperation Technologies, Inc. (MOxST)	No Response	9
Electrodeionization for Product Purification		?	Chemicals	Argonne National Laboratory	No Response	2
EMI Mitigation and Containment in SiC-Based Modular UPS for Commercial Applications	PwrAmr	Wide	Consortia	Virginia Tech	No Response	9
EMPOWERING GEOTHERMAL ENERGY	LEEP-CycRd	?	Crosscutting	Fervo Energy	No Response	9
EMPOWERING NEXT-GENERATION HIGH-SPEED COMMUNICATIONS	LEEP-CycRd	?	Crosscutting	SkyGig, LLC	No Response	9
Enable High Voltage 6.5kV & 10kV Power Module Commercialization and Manufacturing	PwrAmr	Wide	Consortia	Wolfspeed, Inc.	No Response	9
ENABLING 1000X IMPROVEMENTS IN COMPUTING	LEEP-CycRd	?	Crosscutting	Aligned Carbon	No Response	9
Enabling Composite Processing through the OEM Assembly Line	IACMI	CompMats	Consortia	PPG Industries, Inc.	No Response	9
Enabling Efficient Additive Manufacturing of Titanium Alloys	MDF	AddMfg	Consortia	Ames Laboratory	No Response	9
ENABLING TOMORROW'S DEVICES	LEEP-CycRd	?	Crosscutting	Laminera, LLC	No Response	9
Energy Efficient Manufacturing of Steel Slabs with the Application of High Performance Computing (HPC) and Machine Learning	HPC4MFG	AdvMatMfg	Consortia	ArcelorMittal USA, LLC	No Response	9
Energy Efficient Separations of Olefins and Paraffins through a membrane	RAPID	?	Consortia	Compact Membrane Systems, Inc.	No Response	9
Energy Efficient Thermoplastic Composite Manufacturing		CompMats	?	Boeing Company Research & Technology	No Response	2
Energy Management Systems for Subtractive and Additive Precision Manufacturing	CESMII	AddMfg	Consortia	University of Connecticut	No Response	9

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
Energy-Efficient Material Processing through Automated Process Monitoring and Controls	CESMII	AdvMatMfg	Consortia	Virginia Tech	No Response	9
Energy-Savings' Model for the Heat Treatment of Aluminum Castings		ProcessInt	Crosscutting	Worcester Polytechnic Institute	No Response	2
Engineered Osmosis for Energy-Efficient Separations: Optimizing Waste Heat Utilization		WHRsys	?	Oasys Water, Inc.	No Response	9
Environmentally Friendly Coolant System		?	?	Cool Clean Technologies, Inc.	No Response	9
Epoxy/Silicon Potting Material Removal for Greater Recovery of Circuit Boards	REMADE	Sustain	Consortia	Rochester Institute of Technology	No Response	9
Evaluation of Logistics Systems for the Collection, Preprocessing and Production of Secondary Feedstocks from E-waste	REMADE	Sustain	Consortia	Idaho National Laboratory	No Response	9
EXTREME ENZYMES FOR INDUSTRY	LEEP-CycRd	AdvMatMfg	Crosscutting	CinderBio	No Response	9
Fabrication of High Quality NaA Zeolite Membranes via a Novel Plate & Frame Configuration for Molecular-scale Mixture Separations	SBIR I,II	?	?	Engi-Mat	No Response	9
Factory 4.0 Educational Toolkit	CESMII	?	Consortia	Pennsylvania State University	No Response	9
Flexible Combined Heat and Power (CHP) System with Low NOx, CO, and VOC Emissions	DE	CHPsys	Crosscutting	Gas Technology Institute	No Response	2
Flexible Hybrid Friction Stir Joining Technology	EIP	?	Crosscutting	Oak Ridge National Laboratory	No Response	1
Formation of RAPID Center for Process Modeling	RAPID	?	Consortia	Texas Tech University	No Response	9
FROM ATOMS TO APPAREL	LEEP-CycRd	?	Crosscutting	Funxion Wear, Inc.	No Response	9
Fuel Flexible, Low Emissions Catalytic Combustor for Opportunity Fuel Applications	FF	?	Crosscutting	Precision Combustion, Inc.	No Response	2
Fuel-Flexible Microturbine and Gasifier System for CHP		?	Crosscutting	Capstone Turbine Corporation	No Response	2

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
Fully Integrated High Speed Megawatt Class Motor and High Frequency Variable Speed Drive System	NGEM	?	Crosscutting	Clemson University	No Response	3
FUNCTIONAL 3D PRINTING	LEEP-CycRd	AddMfg	Crosscutting	polySpectra, Inc.	No Response	9
Graphene-enhanced electrodes	LEEP-CRI	AdvMatMfg	Crosscutting	Volexion, Inc.	No Response	9
GREEN ENZYMES FOR CHEMICAL MANUFACTURING	LEEP-CycRd	?	Crosscutting	Aralez Bio	No Response	9
HARVESTING VALUE FROM AGRICULTURAL WASTE	LEEP-CycRd	Sustain	Crosscutting	Takachar, Inc.	No Response	9
High Efficiency Waste Heat Harvesting Using Thermal Oscillators		WHRsys	?	University of Pennsylvania	No Response	3
High Fidelity Physics-based Model Driven Process Parameter Selection for LPBF Additive Manufactured Metallic Aerospace Components.	HPC4MFG	AddMfg	Consortia	United Technologies Research Center	No Response	9
High Performance Computational Modeling of Synthetic Jet Actuators for Increased Freight Efficiency in the Transportation Industry	HPC4MFG	?	Consortia	Actasys, Inc. of New York	No Response	9
High Power Industrial Ultraviolet Curing System		Wide	?	SolidUV, Inc.	No Response	2
High Purity Ethanol without Distillation: Carbon nanotube Enabled Ethanol Dewatering	RAPID	?	Consortia	Frauhofer USA Center for Energy Innovation	No Response	9
High Speed Laser Cladding for Hard Surface Replacement	REMADE	Sustain	Consortia	Rochester Institute of Technology	No Response	9
High Speed Layup and Forming of Automotive Composite Components	IACMI	CompMats	Consortia	DURA Automotive Systems	No Response	9
High Speed/Low Effluent Process for Ethanol	I&I	?	Other Industries	Bio-Process Innovation, Inc.	No Response	2
High Throughput Rare Earth Magnets Recycling System	CMI?	Sustain	Consortia	CMI - Ames Laboratory	No Response	9
High-Density, High-Efficiency Adapter with Improved Manufacturability	PwrAmr	Wide	Consortia	Navitas Semiconductor, Inc.	No Response	9

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
High-Efficiency Microturbine with Integral Heat Recovery		CHPsys	Crosscutting	Capstone Turbine Corporation	No Response	2
High-Efficiency Thermoelectric Materials/Devices for Industrial Process Refrigeration and Waste Heat Recovery		AdvMatMfg	Crosscutting	Aegis Technology Inc.	No Response	2
High-Efficiency, Wide-Band Three-Phase Rectifiers and Adaptive Rectifier Management	ARRA DC	Wide	Other Industries	GE Power Controls (Lineage Power Corporation)	No Response	1
High-Frequency GaN Power Converter	PwrAmr	Wide	Consortia	Lockheed Martin Corporation	No Response	9
High-Intensity Plasma Glass Melter		ProcessInt	Glass	Zybek Advanced Product	No Response	2
Highly Efficient Conical Air Gap Axial Motor Using Soft Magnetic Composites and Grain-Oriented Electrical Steel	NGEM	?	Crosscutting	Regal Beloit Corporation	No Response	2
Highy-Scalable FEA Simulation for Efficient Paper Fiber Structure	HPC4MFG	ProcessInt	Consortia	Procter & Gamble of Ohio	No Response	9
Hot Strip Mill Simulation Model	HPC4MFG	ProcessInt	Consortia	United States Steel Corporation (USS Corp)	No Response	9
HPC4Mfg to Optimize Phase Transformations During Flash Processing	HPC4MFG	AdvMatMfg	Consortia	SFP Works, LLC (dba Flash® Bainite)	No Response	9
HTGB, Thermal Shock, ESD, Body Diode, & H3TRB Qualification of Gen3 3.3kV/45 mΩ & 10 kV/350 mΩ SiC MOSFETs	PwrAmr	Wide	Consortia	Wolfspeed, Inc.	No Response	9
Hybrid Additively Manufactured Tooling for Large Composite Structures	IACMI	CompMats	Consortia	Airbus Defence and Space North America	No Response	9
Hydrate-Free Concrete: A Low Energy, CO2-Negative Solution		?	?	Solidia Technologies, Inc.	No Response	1
Hydrogen Generation for Refineries		?	?	TDA Research, Inc.	No Response	9
Identifying strategies to maximize benefit of fiber recovery through systems quantification – Massachusetts Institute of Technology (MIT), The American Forest & Paper Association (AF&PA), WestRock, Graphic Packaging	REMADE	Sustain	Consortia	Massachusetts Institute of Technology	No Response	9
Improving the Manufacturability, Performance, and Durability of Microporous Polymer Membrane Separators for Li–S Batteries using First Principles Computer Simulations	HPC4MFG	AdvMatMfg	Consortia	Sepion Technologies of California	No Response	9

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
Increased Efficiency Low Temperature Drying Process	HPC4MFG	ProcessInt	Consortia	ZoomEssence, Inc.	No Response	9
Increasing Melt Efficiency and Secondary Alloy Usage in Aluminum Die Casting	REMADE	Sustain	Consortia	Ohio State University	No Response	9
Induction Consolidation/Molding of Thermoplastic Composites Using Smart Susceptors		CompMats	Crosscutting	The Boeing Company	No Response	1
Industrial Scale Demonstration of Smart Manufacturing (SM) Achieving Transformational Energy Productivity Gains		?	?	University Of Texas - Austin	No Response	9
INDUSTRIAL-SCALE MANUFACTURING OF NANOMATERIALS	LEEP-CycRd	AdvMatMfg	Crosscutting	Photia, Inc.	No Response	9
Inferential Modeling for Driving Out Energy Waste	CESMII	Sustain	Consortia	ThinkIQ	No Response	9
Injection Overmolding of Continuous Fiber Preforms	IACMI	CompMats	Consortia	Airbus Defence and Space North America	No Response	9
Innovative Cold Plasma Jet Surface Treatment_Starfire		?	?	Starfire Industries, LLC	No Response	9
In-situ, Nondestructive Evaluation of In-flight Particle Dynamics and Intrinsic Properties for Thermal Spray Repairs	REMADE	Sustain	Consortia	Iowa State University	No Response	9
Integrated 15kV SiC VSD and High-Speed MW Motor for Gas Compression Systems	NGEM	?	Crosscutting	Eaton Corporation	No Response	3
Integrated Die Casting Process for Large Thin-Wall Magnesium Applications		?	Metal Casting	General Motors Company	No Response	2
Integrated Electric Drive with HV2 Modular Electric Machine and SiC Based Power Converters	NGEM	?	Crosscutting	Ohio State University	No Response	3
Integrated Intelligent Gate Driver and Interface System for Medium Voltage Applications	PwrAmr	Wide	Consortia	North Carolina State University	No Response	9
Intensified Commercial Scale Production of Dispersants	RAPID	?	Consortia	University of Pittsburgh	No Response	9
Intensified Microwave Reactor Technology	RAPID	ProcessInt	Consortia	University of Delaware	No Response	9
Ion Implementation Processes in AIN for Wide Bandgap Semiconductor Power Devices	SBIR	Wide	Crosscutting	Adroit Materials	No Response	3

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
Lab Embedded Entrepreneurship Programs		?	Crosscutting	Advanced Manufacturing Office - U.S. Dept. of Energy	No Response	9
Large Scale Metal Additive Manufacturing	MDF	AddMfg	Consortia	Lincoln Electric Company	No Response	2
LIGHTEnUP Tool & Analysis Framework		?	?	Advanced Manufacturing Office - U.S. Dept. of Energy	No Response	9
Low Cost Ceramic-Matrix Composites		CompMats	?	United Technologies Research Center	No Response	3
Low Cost, High Volume, Carbon Fiber Precursor for Plasma Oxidation	IACMI	CompMats	Consortia	RMX Technologies	No Response	9
Low Emission Diesel Engines		?	Chemicals	Compact Membrane Systems, Inc.	No Response	2
Low Energy Low Cost Production of Ethylene by Low Temperature Oxidative Coupling of Methane		?	?	Siluria Technologies	No Response	2
Low-Cost Basalt Fiber for Automotive Applications	IACMI	CompMats	Consortia	Michelman, Inc.	No Response	9
Low-Cost Microchannel Heat Exchangers		WHRsys	Crosscutting	Altex Technologies Corporation	No Response	2
Low-Cost Process for the Manufacture of Titanium Heat Exchanger Components for Desalination	SBIR I&II	WHRsys	Crosscutting	Materials and Electrochemical Research Corporation (MER) dba ATS-MER, LLC	No Response	2
Low-Cost Production of InGaN for Next-Generation Photovoltaic Devices		?	Crosscutting	Structured Materials Industries Inc.	No Response	9
Low-Cost, High-Value Metal Recovery from Electronic Waste to Increase Recycling and Reduce Environmental Impact	REMADE	Sustain	Consortia	University of Utah	No Response	9
LucidPipe™: Spherical Reaction Hydraulic Turbine	I&I	?	Other Industries	Lucid Energy, Inc.	No Response	1
Machining Elimination through Application of Thread Forming Fasteners in Net-Shaped Cast Holes		?	?	United States Council for Automotive Research, LLC	No Response	9
Magnetocaloric Generator for Waste Heat Energy Recovery	SBIR I, II	?	Crosscutting	Aqwest LLC	No Response	2
Management Technology for Energy Efficiency in Data Centers and Telecommunications Facilities	ARRA DC	?	Other Industries	IBM TJ Watston Research Center	No Response	1

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
Manufacturing Supply Chain Development for the STARS Technology Modular Solar-Thermochemical Conversion Platform	RAPID	Sustain	Consortia	Oregon State University	No Response	9
Mapping the Material Base for REMADE	REMADE	Sustain	Consortia	Yale University	No Response	9
Mass Market SiC Solid-State Circuit Breaker Development	PwrAmr	Wide	Consortia	Atom Power, Inc.	No Response	9
Material Characterizations and Sorting Specifications That Can Allow the Development of Advanced Tire Constructions with High Incorporation of Recovered Rubber Materials	REMADE	Sustain	Consortia	Michelin North America, Inc.	No Response	9
Materials Development and Advanced Process Simulation for Additive Manufacturing (AM) with Fiber-Reinforced Thermoplastics	IACMI	CompMats	Consortia	DuPont de Nemours, Inc.	No Response	9
Materials Flows through Industry (MFI) Tool		?	Crosscutting	Advanced Manufacturing Office - U.S. Dept. of Energy	No Response	9
Medium Voltage Gate Drive with Comprehensive Protection Functions	PwrAmr	Wide	Consortia	Ohio State University	No Response	9
Membraneless Water Desalination System		?	Chemicals	Reactive Innovations	No Response	3
MEMBRANES FOR THE 21st CENTURY	LEEP-CycRd	?	Crosscutting	Sepion Technologies, Inc.	No Response	9
Method of 3D Printing Lightweight Ceramic-Metal	MDF	AddMfg	Consortia	The ExOne Company	No Response	9
Microchannel Magnetic Coolers with Negative Magnetocaloric Effect		?	Crosscutting	Materials and Electrochemical Research Corporation (MER) dba ATS-MER, LLC	No Response	2
Microfibrous Entrapped Sorbents for High Throughput Modular Process Intensified Gas Separation and Ion Exchange	RAPID	ProcessInt	Consortia	IntraMicron, Inc.	No Response	9
Microstructure prediction in additively manufactured metal parts can help qualify parts	HPC4MFG	ProcessInt	Consortia	Eaton Corporation	No Response	9
Microwave Catalysis for Process Intensified Modular Production of Value-Added Chemicals from Natural Gas	RAPID	ProcessInt	Consortia	West Virginia University	No Response	9
Microwave Enhanced Direct Cracking of Hydrocarbon Feedstock for Production of Ethylene and Propylene		ProcessInt	?	Ceralink, Inc.	No Response	9

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
Minimization of Spatter during Direct Metal Laser Melting (DMLM) Additive Manufacturing Process using ALE3D Coupled with Experiments	HPC4MFG	AddMfg	Consortia	GE Global Research	No Response	9
MOBILE MAGNETOMETERS FOR TODAY'S NEEDS	LEEP-CycRd	?	Crosscutting	Sonera Magnetics, Inc.	No Response	9
Modular Catalytic Desulfurization Units for Sour Gas Sweetening	RAPID	?	Consortia	IntraMicron, Inc.	No Response	9
Modular Conversion of Stranded Ethane to Liquid Fuels	RAPID	?	Consortia	North Carolina State University	No Response	9
Modular Mechanical Vapor Compression-Membrane Distillation (MVC-MD) for Treatment of High TDS Produced Water	RAPID	?	Consortia	Texas Tech University	No Response	9
Molecular Modeling to Increase Kraft Pulp Yield	HPC4MFG	ProcessInt	Consortia	Alliance for Pulp & Paper Technoloy Innovation	No Response	9
Multiphase Microchannel Separator	RAPID	?	Consortia	Oregon State University	No Response	9
Multi-physics Modeling Continuous Liquid Interface Production for Additive Mfg	HPC4MFG	AddMfg	Consortia	Carbon Inc.	No Response	9
Multiple Process Tooling	IACMI	?	Consortia	Valley Enterprises, Inc. (Gemini Group)	No Response	9
Multiscale Modeling of Microstructure Evolution During Rapid Solidification for Additive Manufacturing.	HPC4MFG	?	Consortia	Arconic Inc.	No Response	3
Nanocatalysts for Diesel Engine Emissions Remediation		AdvMatMfg	Crosscutting	Oak Ridge National Laboratory	No Response	2
Nanocomposite Coatings for Life Extension in Zinc Pot Rolls		?	Steel	MesoCoat, Inc.	No Response	2
Nanometal-Interconnected Carbon Conductors for Advanced Electric Machines	NGEM	?	Crosscutting	Rochester Institute of Technology	No Response	3
NANOMYTE® SuperCN: High Temperature Resistant Superhydrophobic Nanocomposite Coating	SBIR I,II	AdvMatMfg	Crosscutting	NEI Corporation	No Response	1
Nanopowder Manufacturing via Cost-Effective, Low-Carbon Footprint Process	SBIR I,II NM	AdvMatMfg	Crosscutting	nGimat, LLC	No Response	1

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
Nanostructured Ferritic Alloys: Improving Manufacturing Energy Efficiency and Performance for High-Temperature Applications		?	?	GE Global Research	No Response	9
Nanostructured Superhydrophobic Coatings		AdvMatMfg	Crosscutting	Velox Flow LLC,	No Response	2
Near Net Shape Manufacturing of New, Low-Cost Titanium Powders	EIP	?	Crosscutting	Oak Ridge National Laboratory	No Response	1
New Approaches to Improve Deinking Flotation to Increase the Availability of High-Quality, Low-Cost Recycle Paper Fibers	REMADE	Sustain	Consortia	Virginia Tech	No Response	9
New Generation of Miniaturized, High-Efficiency Heat Exchangers	MDF	?	Consortia	University of Maryland	No Response	9
New High-Temperature, Low-Cost Ceramic Media for Natural Gas Combustion Burners		ProcessInt	?	3M Company	No Response	9
New Qualification Framework for Additive Manufacturing	MDF	AddMfg	Consortia	United States Air Force	No Response	9
New Silica-Alumina-Based Cementitious Material Using Coal Refuse		AdvMatMfg	?	University of the Pacific	No Response	9
Next Generation Nonwovens Manufacturing based on Model-driven Simulation Machine Learning Approach	HPC4MFG	CompMats	Consortia	3M Company	No Response	9
No Heat Spray Drying Technology	SBIR I,II	?	Crosscutting	ZoomEssence, Inc.	No Response	1
Non-Destructive In-process Assessment of Thermal Spray Repairs	REMADE	Sustain	Consortia	Rochester Institute of Technology	No Response	9
Novel 3D Printing Method to Fabricate Bonded Magnets of Complex Shape	CMI	AddMfg	Consortia	Momentum Technologies, Inc.	No Response	9
Novel Membrane for Olefin/Paraffin Separation	SBIR I,II	ProcessInt	Chemicals	Compact Membrane Systems, Inc.	No Response	2
Novel Refractory Materials for High-Temperature, High-Alkaline Environments	IMF	MatHarsh	Crosscutting	MINTEQ International Inc.	No Response	1
Novel Steels for High-Temperature Carburizing		?	Steel	Caterpillar Inc.	No Response	9
Optimization Modeling for Advanced Syngas to Olefins Reactive Systems	RAPID	?	Consortia	Carnegie Mellon University	No Response	9

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
Optimized Carbon Fiber Production to Enable High Volume Manufacturing of Lightweight Automotive Components	IACMI	CompMats	Consortia	Ford Motor Company	No Response	9
Optimized Resins and Sizings for Vinyl Ester/Carbon Fiber Composites	IACMI	CompMats	Consortia	INEOS Composites US, LLC	No Response	9
PAINTABLE OPTICAL COATINGS	LEEP-CycRd	AdvMatMfg	Crosscutting	Cypris Materials	No Response	9
Para-xylene Selective Membrane Reactor	RAPID	?	Consortia	University of Minnesota	No Response	9
partially 3D printed excavator	MDF	AddMfg	Consortia	Oak Ridge National Laboratory	No Response	9
Performance Prediction for Non-standard Non-Crimped Fabrics	IACMI	CompMats	Consortia	Chomarat North America	No Response	9
Photothermal Solar Cell	SBIR I,II	?	Crosscutting	Aquaneers, Inc.	No Response	3
Plastics, Fibers, and Solvents from Biosynthetically Derived Organic Acids	SBIR I,II	?	Other Industries	BioAmber, Inc.	No Response	1
Platform Technology for Atomically Precise Manufacturing		AdvMatMfg	?	University of Texas - Dallas	No Response	2
Portable thermophotovoltaic power generator	LEEP-CRI	?	Crosscutting	Mesodyne, Inc.	No Response	9
Powder Synthesis and Alloy Design for Additive Manufacturing		AddMfg	?	Ames Laboratory	No Response	2
Powering the Next-Gen Internet of Things	LEEP-CycRd	?	Crosscutting	ActiveMEMS	No Response	9
POWER-PLANT-ON-A-CHIP	LEEP-CycRd	?	Crosscutting	Spark Thermionics, Inc	No Response	9
Predictive Modeling of Polyurethane Foam Processes to Optimize Performance, Reduce Waste, and Design Processes	HPC4MFG	?	Consortia	Dow Chemical Company	No Response	9
Preparation of Mesophase Pitch Feedstock for Carbon Fiber	IACMI	CompMats	Consortia	Advanced Carbon Products, LLC	No Response	9
Process Innovations 2G HTS Wire Manufacturing	NGEM	?	Crosscutting	Superconductor Technologies, Inc.	No Response	2

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
Process Intensification through Multifunctional Reactor Engineering		ProcessInt	Chemicals	CB&I Lummus	No Response	2
Process Map for Tailoring Microstructure in Direct Metal Laser Melting (DMLM) additive Manufacturing Process	HPC4MFG	AddMfg	Consortia	GE Global Research	No Response	3
Production of zero-defect (ZD) slabs through the implementation of Smart Manufacturing technologies in steel continuous casting	CESMII	AdvMatMfg	Consortia	ArcelorMittal USA, LLC	No Response	9
Production Scale Up of Nanoparticle-Based Lubricant Additives	SBIR I,II	AdvMatMfg	Crosscutting	NanoMech, LLC	No Response	1
Project AMIE	MDF	?	Consortia	Oak Ridge National Laboratory	No Response	9
Purification Process for Purified Terephthalic Acid (PTA) Production		ProcessInt	Chemicals	GTC Technology, Inc.	No Response	2
Pushing the State of the Art in Steel Recycling through Innovation in Scrap Sorting and Impurity Removal	REMADE	Sustain	Consortia	Colorado School of Mines	No Response	9
Quantitative Non-Destructive Evaluation of Fatigue Damage Based on Multi-Sensor Fusion	REMADE	Sustain	Consortia	University of Illinois - Urbana-Champaign	No Response	9
Rapid Carbon Fiber Prepreg Molding Technology for Automobile Structural Parts	IACMI	CompMats	Consortia	Toray Composite Materials America, Inc.	No Response	9
RAPID MCPI - Energy Efficient Technology for Metals Separation	RAPID	?	Consortia	University of Alabama	No Response	9
RAPID Reaction Software Ecosystem	RAPID	?	Consortia	University of Delaware	No Response	9
Rapid Sorting of Scrap Metals with Solid State Device	REMADE	Sustain	Consortia	University of Utah	No Response	9
Rational Design Platform for Electrochemical Synthesis		?	?	Lawrence Livermore National Laboratory	No Response	9
REALTIME ADAPTIVE MACHINE LEARNING	LEEP-CycRd	?	Crosscutting	Dauntless.io	No Response	9
Reclaimed Carbon Fiber Reinforced Automotive Part using 3-DEP preforms and preform tooling using reclaimed carbon fiber and MDF's Additive Manufacturing Process	IACMI	CompMats	Consortia	Massachusetts Institute of Technology	No Response	9

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
RECYCLING CARBON DIOXIDE	LEEP-CycRd	Sustain	Crosscutting	OPUS 12 (dba Twelve)	No Response	9
Recycling Technologies (R&D 100 2018)	IACMI	?	Consortia	CHZ Technologies	No Response	9
REDEFINING ILLUMINATION	LEEP-CycRd	?	Crosscutting	Helux	No Response	9
Reduced Rare Earth Content High Performance Magnets	CMI	CritMats	Consortia	CMI - Ames Laboratory	No Response	9
Reduction of CO2 Emissions Through Lightweight Body Panels	IACMI	CompMats	Consortia	Volkswagen Group of America	No Response	9
Reduction of Metal Oxide to Metal Using Ionic Liquids		ProcessInt	?	University of Alabama	No Response	3
Reinforced Recycled Polymer Composites	REMADE	Sustain	Consortia	Oklahoma State University	No Response	9
Reliability Benchmarking of Lateral GaN Power HEMTs on Si Substrates and Assessment of GaN/Si Epitaxy	PwrAmr	Wide	Consortia	Rensselaer Polytechnic Institute	No Response	9
Remaining Life Determination	REMADE	Sustain	Consortia	Rochester Institute of Technology	No Response	9
RESHAPING THE PLASTICS INDUSTRY	LEEP-CycRd	CompMats	Crosscutting	Mallinda, Inc.	No Response	9
Resistively Graded Insulation System for Converter-Fed Motors	NGEM	?	Crosscutting	GE Global Research	No Response	9
RETHINK COOLING	LEEP-CycRd	?	Crosscutting	Nelumbo, Inc.	No Response	9
Robust Membranes For Black Liquor Concentration	RAPID	?	Consortia	Georgia Institute of Technology	No Response	9
SAFE AND RELIABLE LITHIUM METAL BATTERIES	LEEP-CycRd	AdvMatMfg	Crosscutting	Cuberg	No Response	9
Scalable High Shear Catalyzed Depolymerization of Multilayer Plastic Packaging	REMADE	Sustain	Consortia	University of Massachusetts - Lowell	No Response	9
Scale-Up of Next Generation Nano-Enhanced Composite Materials for Longer-Lasting Consumer Goods	IACMI	CompMats	Consortia	N12 Technologies, Inc.	No Response	9

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
Screenable Water-Based Pressure Sensitive Adhesives		?	Forest Products	Franklin International-Franklin Adhesives & Polymers	No Response	2
Self-Healing Polymeric Coatings	SBIR I,II	AdvMatMfg	Crosscutting	NEI Corporation	No Response	1
SiC Channel Mobility Enhancement	PwrAmr	Wide	Consortia	North Carolina State University	No Response	9
SiC Commercial PV Inverter	PwrAmr	Wide	Consortia	Florida State University	No Response	9
SiC Device-based Small Commercial PV Inverter/SiC Device based Commercial Hybrid PV Inverter with Li-ion Battery Integration	PwrAmr	Wide	Consortia	Toshiba International Corporation	No Response	9
SiC enabled High-Frequency Medium Voltage Drive for High-Speed Motors	NGEM	Wide	Crosscutting	GE Global Research	No Response	3
SiC Power Device Commercial Foundry Development	PwrAmr	Wide	Consortia	X-FAB Texas, Inc	No Response	9
Simulation Sensitivity Studies	IACMI	?	Consortia	Composites Design Studio	No Response	9
Single Step Manufacturing of Low Catalyst Loading Electrolyzer MEAs	STTR	?	Other Industries	Proton Energy Systems, Inc.	No Response	3
Smart Composite Overwrapped Pressure Vessels (SCOPV) with Integrated Health Monitoring	IACMI	CompMats	Consortia	Steelhead Composites	No Response	9
Smart Connected Workers in Advanced Manufacturing	CESMII	AdvMatMfg	Consortia	UC - Irvine	No Response	9
Smart Manufacturing for Chemical Processing: Energy Efficient Operation of Air Separation Unit	CESMII	AdvMatMfg	Consortia	Texas A&M	No Response	9
Smart Manufacturing of Cement	CESMII	AdvMatMfg	Consortia	University of Louisville	No Response	9
Smart Manufacturing Workforce Development Model	CESMII	?	Consortia	El Camino Community College	No Response	9
SmartDiagnostics®: Predictive Maintenance Wireless Monitoring	S&C SBIR I,II	?	Crosscutting	KCF Technologies, Inc.	No Response	1

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
Software Tools RFI and SEE Action		?	Crosscutting	Advanced Manufacturing Office - U.S. Dept. of Energy	No Response	2
Solvent Recovery by Pervaporation	ARRA SBIR I,II	Sustain	Chemicals	Compact Membrane Systems, Inc.	No Response	1
Submerged Combustion Melting		?	Glass	Gas Technology Institute	No Response	2
Sugars-To-Bioproducts Scalable Platform Technology	RAPID	?	Consortia	University of Delaware	No Response	9
SulfaTrap™: Novel Sorbent to Clean Biogas for Fuel Cell Combined Heat and Power	SBIR I,II	?	Other Industries	SulfaTrap, Inc.	No Response	1
Suntuitive™: Sunlight-Responsive Thermochromic Window Systems	I&I	AdvMatMfg	Crosscutting	Pleotint, LLC	No Response	1
Surface Roughness Effects from Additive Manufacturing in High Efficiency Power Generation Combustion Systems	HPC4MFG	?	Consortia	GE Global Research	No Response	3
Sustainable Manufacturing via Process Modeling and Manufacturing-Informed Design	S	Sustain	Crosscutting	Third Wave Systems, Inc.	No Response	1
SUSTAINABLE SEPARATIONS	LEEP-CycRd	?	Crosscutting	Mosaic Materials, Inc.	No Response	9
Synopsis – Synthesis of Operable Process Intensification	RAPID	ProcessInt	Consortia	Texas A&M	No Response	9
System for Utilizing Waste Heat to Power Water Purification		WHRsys	Crosscutting	RTI International	No Response	3
Systems Analysis for PET and Olefin Polymers in a Global Circular Economy	REMADE	Sustain	Consortia	Michigan Technological University	No Response	9
Tailored Fiber Placement for Complex Preforms	IACMI	?	Consortia	Airbus Defence and Space North America	No Response	9
Task Asynchronous Microgrid Power Conditioning System (MicroGrid PCS) Connector to MicroGrid	PwrAmr	?	Consortia	North Carolina State University	No Response	9
Techno-Economic Wind Blade Manufacturing Model to Identify Opportunities for Cost Improvements	IACMI	CompMats	Consortia	University of Massachusetts - Lowell	No Response	9
Terrestrial Neutron Induced Reliability Concerns in Very High Voltage Silicon Carbide Power Devices	PwrAmr	Wide	Consortia	CoolCAD Electronics, LLC	No Response	9

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
Textile Carbon Fiber Packaging and Non-Crimp Fabric Production	IACMI	CompMats	Consortia	McCoy Machinery	No Response	9
THE NEXT SOLAR EVOLUTION	LEEP-CycRd	?	Crosscutting	Tandem PV	No Response	9
The Virtual Blast Furnace: An Integrated High Performance Computing	HPC4MFG	ProcessInt	Consortia	Steel Manufacturing Simulation and Visualization Consortium (SMSVC)	No Response	3
Thermal Instability in the Manufacturing of Wind Turbine Blade Spar Caps	IACMI	CompMats	Consortia	TPI Composites	No Response	9
Thermolyzer: Controlled Pyrolysis, A robust, scalable composite recycling technology	IACMI	CompMats	Consortia	American Composites Manufacturing Association (ACMA)	No Response	9
Thermoneutral Propane Dehydrogenation via a Solid Oxide Membrane Reactor	RAPID	?	Consortia	University of Michigan	No Response	9
Thermoplastic Composite Compressed Gas Storage (CGS) Tanks	IACMI	CompMats	Consortia	DuPont de Nemours, Inc.	No Response	9
Thermoplastic Composite Development for Wind Turbine Blades	IACMI	CompMats	Consortia	TPI Composites	No Response	9
Thermoplastic Composites Part Manufacturing Enabling High Volumes, Low Cost, Reduced Weight with Design Flexibility	IACMI	CompMats	Consortia	DuPont de Nemours, Inc.	No Response	9
Thermoplastic Thermal Welding	IACMI	CompMats	Consortia	Arkema, Inc.	No Response	9
Three-Way Catalytic Distillation to Renewable Surfactants via Triglycerides	RAPID	?	Consortia	University of Minnesota	No Response	9
Tidal Energy Systems		?	Other Industries	Verdant Power, Inc.	No Response	2
Training of a Neural Network Reduced-order Model for Glass Furnace Operations	HPC4MFG	ProcessInt	Consortia	Vitro Flat Glass, LLC	No Response	9
TURBOCHARGING BIOMANUFACTURING	LEEP-CycRd	?	Crosscutting	Tierra Biosciences, Inc.	No Response	9
Turbocompression Cooling System for Waste Heat Recovery		WHRsys	?	Colorado State University	No Response	2

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
Ultra Low Energy, Low Cost Industrial Nanomembrane Manufacturing for Desalination, Water Purification and Remediation	SBIR I, II	AdvMatMfg	?	Covalent, LLC	No Response	3
Ultra-Clean Transient Turbine Combustor	HPC4MFG	ProcessInt	Consortia	VAST Power Systems, Inc.	No Response	9
Ultra-Compact Imaging Technology	LEEP-CycRd	?	Crosscutting	Synopic, Inc.	No Response	9
Ultra-Efficient Combined Heat, Hydrogen, and Power (CHHP) System		CHPsys	Crosscutting	FuelCell Energy, Inc.	No Response	2
Ultra-Fast Boriding in High-Temperature Materials Processing Industries		AdvMatMfg	Crosscutting	Argonne National Laboratory	No Response	2
Ultra-High Efficiency and Ultra-Low Emissions Crosscutting Combustion Technology for Manufacturing Industries		?	?	University of Michigan	No Response	9
Use of Microwave for Energy-Efficient Heating in High-Temperature Brazing		?	?	GE Global Research	No Response	9
Use of Power Ultrasound for Nonthermal, Nonequilibrium Separation of Ethanol/Water Solutions	RAPID	?	Consortia	University of Illinois -Urbana-Champaign	No Response	9
Using directed energy deposition to repair Cummins engine	MDF	?	Consortia	Oak Ridge National Laboratory	No Response	9
Utilizing HPC to Model the E-Iron Nugget Process	HPC4MFG	ProcessInt	Consortia	Purdue University - Northwest	No Response	9
Vertical Axis Wind Turbine with Thermoplastic Composite Blades	IACMI	CompMats	Consortia	Steelhead Composites	No Response	9
VFT iHPC App	HPC4MFG	?	Consortia	Ohio Supercomputer Center (OSC)	No Response	9
Waste Heat Recovery and Recycling in Thermal Separation Processes		WHRsys	?	FMC Corporation	No Response	9
Waste Heat-to-Power Using Scroll Expander for Organic Rankine Bottoming Cycle		WHRsys	Crosscutting	TIAX LLC	No Response	3
Wear-Resistant Surface Technologies		MatHarsh	?	Argonne National Laboratory	No Response	3

ProjectTitle	Funding Type	Constell	SubProgram	Organization	Current Status	Previous Status
Wind Turbine Blade Recycling	IACMI	Sustain	Consortia	National Renewable Energy Laboratory	No Response	9
X-Rays Help Identify and Avoid Flaws in Laser Metal Deposition	MDF	?	Consortia	SLAC National Accelerator Laboratory	No Response	9
Yahoo! Compute Coop - Next Generation Passive Cooling Design for Data Centers	ARRA DC	?	Other Industries	Yahoo! Inc.	No Response	1
Zero-Emission Mechanical Seal		?	Crosscutting	Louisiana State University	No Response	2
ZERO-EMISSION, FLEXIBLE, AND EFFICIENT POWER	LEEP-CycRd	?	Crosscutting	Noble Thermodynamic Sysytems, Inc.	No Response	9

U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

For more information, visit: www.energy.gov/eere/amo/advanced-manufacturing-office

DOE/PNNL-32114