Pacific Northwest
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PNNL-36782

Titanium Electroplating from Deep Eutectic Solvent Ethaline

Progress Report

September 2024

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U.S. DEPARTMENT OF ENERGY

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Abstract

This fiscal year we investigated the kinetic mechanism of electroplating of titanium on stainless steel substrates, as well as the influence of additives on the brightness and smoothness of this plating, as related to the FY24 LD-TCF proposal.

Acknowledgments

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Figures

1.0 Introduction

This fiscal year we investigated the kinetic mechanism of electroplating of titanium on stainless steel substrates, as well as the influence of additives on the brightness and smoothness of this plating, as related to the FY24 LD-TCF proposal.

2.0 Results

We have found that additives such as brightness and levelers, commonly used in aqueous electroplating baths, influence the electrodeposition of titanium from Deep eutectic solvent (DES) baths. Metal deposits obtained from the bath containing small molecules were noticeably brighter and smoother, as evidenced by reflectance spectroscopy. This result agrees with the common approach utilized in the aqueous electroplating of metals for decorative purposes. The near-mirror coating has been achieved, as seen in Figure 1

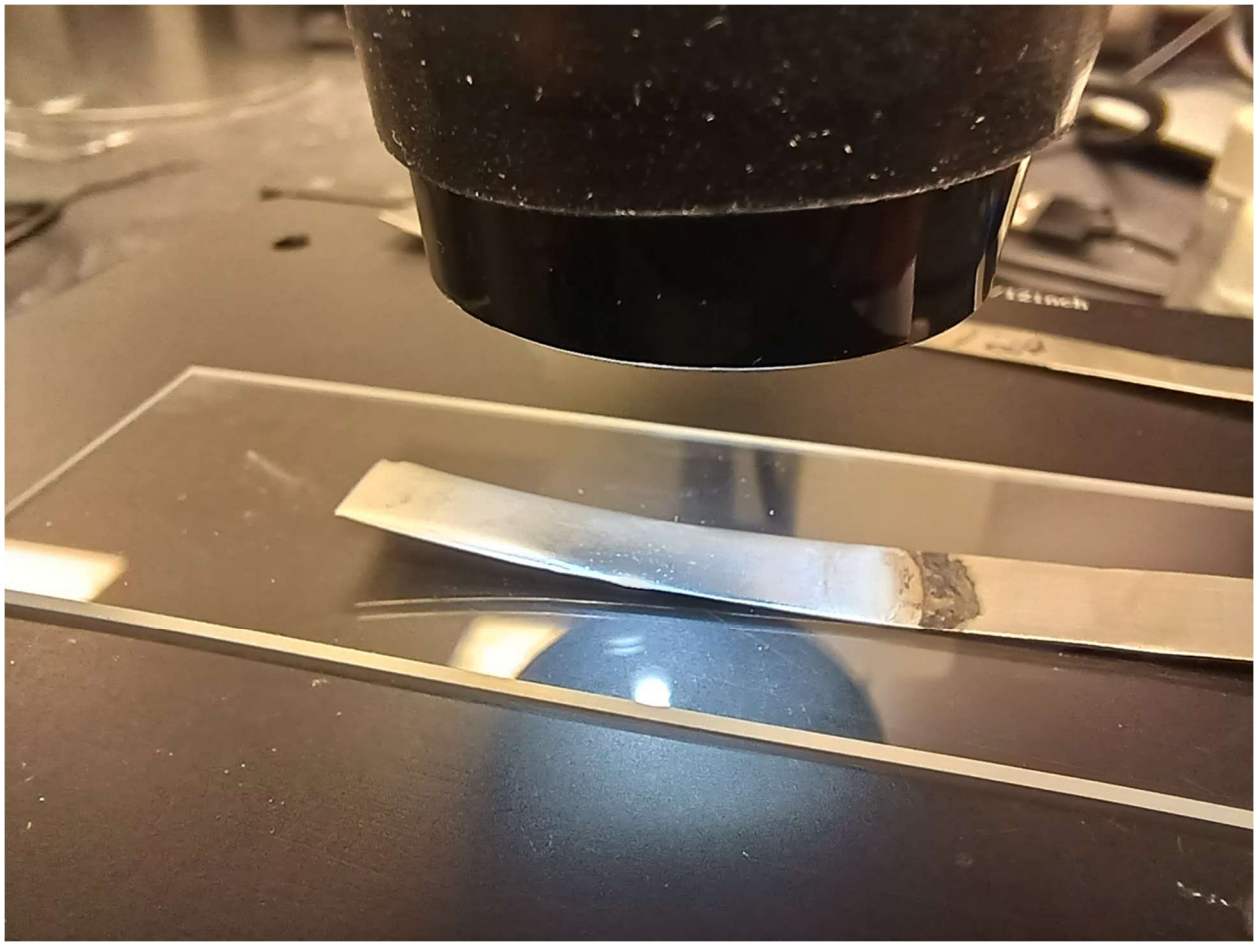

Figure 1 Image of the strip of 316 stainless steel coated with 3 microns thick of near-mirror finish titanium.

We have also investigated kinetic aspects of electrodeposition of Ti from DES and have found that the growth of the Ti deposit depends on the temperature of the plating bath.

3.0 Methods

The methods are pending patenting and publication in a peer-reviewed journal, (L. Hubbard et al., 2020; L. R. Hubbard et al., 2023)

4.0 Conclusions

Based on the observation in our studies, we also deduced that the mechanism of deposition of Ti can be affected. The mechanism proceeds through the initial formation of “islands” and then changes to layer-by-layer growth. The interaction of Ti ions with a surface is modified in the deposition bath. Additives may change the mechanism of the “native” Ti electrodeposition by lowering the energy barrier by the formation of various Ti-containing species.

5.0 References

Hubbard, L., Arendt, C., & Webster, R. (2020). *COMPOSITION AND METHOD EMBODIMENTS FOR PLATING METAL COATINGS*. https://patents.google.com/patent/US20200378027A1/en

Hubbard, L. R., Arendt, C., & Webster, R. (2023). *US Patent 11,613,825 Composition and method embodiments for plating metal coatings* (Patent No. 11613825). https://scholar.google.com/citations?view_op=view_citation&hl=en&user=N8zp-X8AAAAJ&citation_for_view=N8zp-X8AAAAJ:eQOLeE2rZwMC

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