Impact of electroplating parameters on palladium hydride phases and hydrogen desorption dynamics

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Significance and Relevance

The study explores the formation of palladium hydrides during electroplating, finding that current density and deposit thickness influence hydrogen content and phase stability. XRD analysis revealed that β-PdH_x predominates at low current densities, while α-PdH_x is favored at high currents. Pulsed and reverse currents significantly altered the deposit morphology and hydrogen retention. Compact deposits, retained hydrogen in the β-phase even after 24 hours, showing potential for hydrogen storage. These results provide a new approach to palladium hydride phase control for specific uses such as the energy field.

Preferred and 2nd choice for the topic: H_2 storage and transportation, green H_2 production, hydrogen vectors; circular economy

Preferred presentation: Poster

Introduction and Motivations

The study investigates palladium electroplating, widely used in decorative and industrial applications due to its corrosion resistance and aesthetic properties[1,2]. Challenges such as hydrogen-induced microfractures and phase transitions (α-β) impact deposit quality and limit practical uses[3]. Understanding the influence of deposition parameters on hydrogen incorporation and phase stability could improve both decorative and hydrogen storage applications[4]. Additionally, β-PdH_x offers potential for solid-state hydrogen storage, a safer alternative to compressed gas[5]. This motivates optimizing electroplating techniques to tailor palladium deposits for specific functional and aesthetic requirements.

Materials and Methods

The study used a commercial palladium-iron (PdFe) electroplating bath containing proprietary additives and 3 g/L $Pd(NH_3)_2(NO_2)_2$. Brass substrates were electrodeposited with palladium under direct (DC), pulsed (PC), and reverse pulsed currents (PRC) across varying current densities and thicknesses. X-ray diffraction (XRD) identified palladium hydride phases and their desorption over time, while scanning electron microscopy (SEM) and atomic force microscopy (AFM) analyzed deposit morphology. X-ray fluorescence (XRF) measured thickness, and colorimetric analysis assessed surface gloss and hydrogen-related changes.

Results and Discussion

The study investigated the impact of electrodeposition parameters on palladium (Pd) deposits, focusing on hydrogen absorption and desorption. The X-ray diffraction (XRD) analysis revealed two palladium hydride phases, β-PdH_x and α-PdH_x, with the β-phase (hydrogen-rich) forming at lower current densities and the α-phase (hydrogen-poor) at higher current densities. The desorption rate of hydrogen from the Pd deposits was studied over time, showing a transition from β to α phase, depending on current density and thickness. Scanning electron microscopy (SEM) and atomic force microscopy (AFM) revealed morphological differences in the deposits.

The findings provide valuable insights into controlling palladium hydride formation for hydrogen storage and electroplating applications. The ability to modulate the hydrogen content and desorption rate by adjusting the deposition parameters opens the door for optimizing palladium-based deposits in both decorative and energy storage sectors.

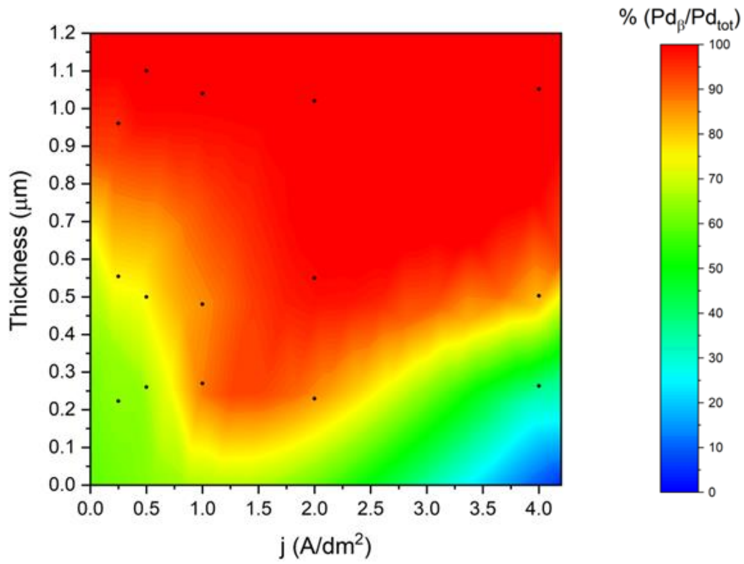

Figure 1 β-PdH_x percentages obtained on DC samples after 10 minutes after the end of deposition. The black dots represent the samples.

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