

Fundamental Insights into the Kinetics and Growth of Electrodeposited Palladium Nanocrystallites

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Abstract

Kinetics of the electrodeposition process and growth mechanism of three-dimensionally grown palladium particles (Figure 1a) have been studied. In the present system, kinetics of electrodeposition of palladium followed a parabolic growth law which indicates involvement of instantaneous nucleation and subsequent three-dimensional growth (Figure 1b). It was also observed that the nucleation density of palladium electrodeposits was a function of the nature of the electrode substrate. The structure, morphology, texture, chemical state and composition of the electrodeposited palladium particles have been characterized (Figures 2a and 2b) using scanning electron microscopy (SEM), Transmission Electron Microscopy, X-ray Photoelectron Spectroscopy, Electron Backscattered Diffraction (EBSD) and Orientation Impinging Microscopy (OIM). The growth of the palladium nuclei situated at the grain interior was found to be more than that at the grain boundaries on steel substrate. These micron-sized palladium particles consisted of a number of nanocrystallites (Figure 3). The surface morphology of the electrodeposited palladium particles was uneven due to the preferential growth of such nanocrystallites in certain crystallographic directions. The results of the present investigation indicate that the growth of the palladium electrodeposits was limited by the diffusivity of bulky palladium tetra-chloro-square planar complex from bulk solution to near the electrode surface. Such understanding will enable us to design novel catalysts, hydrogen sensors and storage materials.

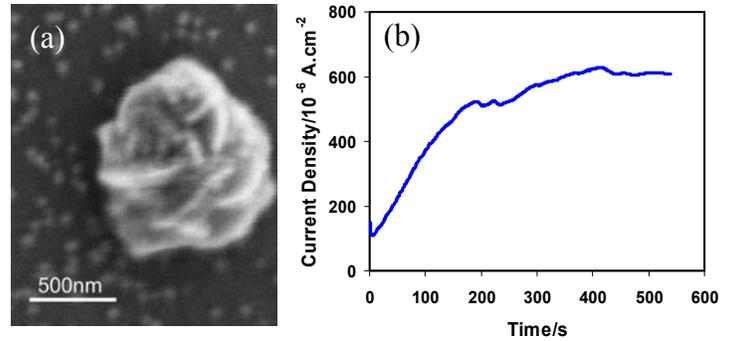


Figure 1: a. SEM micrograph of Pd electrodeposits on AISI 316 stainless steel substrate at 300 mV. b. corresponding current density vs. time plot of electrodeposition

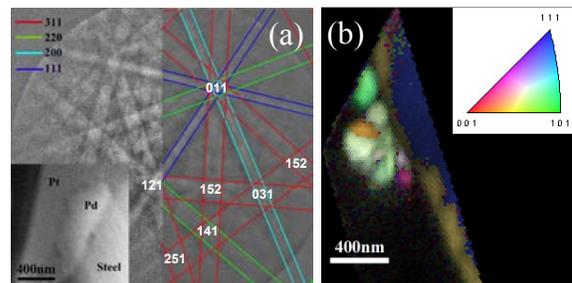


Figure 2: a. EBSD (Kikuchi) pattern showing the various lattice planes in color with their zone axis taken from the Pd particles as shown in left bottom inset. b. OIM image of the Pd crystallites along with the single stereographic triangle.

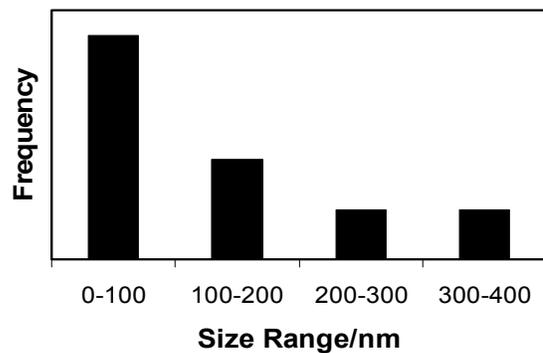


Figure 3: Particle size distribution of palladium nanocrystallites obtained from OIM data