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Atomic Layer Electroless Deposition on Nanoporous Metals

Multimetallic materials in which an alloying element is present at or near the surface of a parent metal exhibit enhanced functional properties compared to parent metals alone. They have a wide range of applications in areas such as hydrogen storage, catalysis, and electrocatalysis. Examples include a dramatic increase in the oxygen reduction activity of Pt catalysts in the presence of subsurface alloy layers, Pd overlayers on Pt directing formic acid oxidation pathways to avoid surface-poisoning, and improved kinetics of hydrogen sorption by formation of surface and subsurface alloys. Further, the topology exhibited by nanoparticles and nanoporous metals (NPM) plays an important role in determining functional properties. Much effort has been made to develop approaches to synthesize multimetallic materials with well-controlled surface morphology and composition, but this remains a challenge, particularly at large scale, and when using high surface area powders and nanomaterials as substrates.

Atomic Layer Electroless Deposition (ALED) is a scalable approach to surface-modified metal powders in which deposition of adlayer elements on substrate metals is carried out. In this method, elements more noble than the surface hydrides of the substrate metal are deposited layer-by-layer in surface-limited fashion. The substrate is first charged with a controlled partial pressure of H_2 gas to chemically form a surface hydride. After terminating the flow of reagent gas, surface-limited reduction of an adlayer of a different metal is carried out by galvanic exchange of the surface hydride.

We report herein the results of ALED on NPM substrates that have been synthesized by chemical reduction of metal salts in the presence of a nonionic surfactant. ALED materials have been characterized by nitrogen porosimetry, X-ray photoelectron spectroscopy, electron microscopy and atomic absorption spectroscopy. Surfaces were further characterized by measuring the vibrational spectroscopy of adsorbates to probe fractional coverage of adlayer metals. We will also demonstrate strategies to alter adlayer morphology by controlling particle nucleation and growth rates during the ALED process.

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