In Situ Characterization of Plasma-Assisted Pt ALD on W ALD Adhesion Layers with Spectroscopic Ellipsometry

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Platinum is an excellent catalyst for many applications. The high cost of Pt requires that Pt be used as efficiently as possible. For the oxygen reduction reaction in H_2 fuel cells, experiments show that a continuous Pt film is 5-10 times more active per Pt surface atom than a 3 nm Pt nanoparticle. Consequently, understanding the process conditions under which thin continuous films of Pt can be deposited is critical.

Pt has a high surface energy of ~2.5 J/m and does not readily wet most substrates which typically have much lower surface energies. Pt nanoparticles are generally formed during Pt atomic layer deposition (ALD) on oxide substrates. A continuous Pt film is possible only after the coalescence of the Pt nanoparticles. The result is a thick Pt film and the inefficient use of Pt resulting from the thickness.

One possible route to obtain a continuous and ultrathin Pt film is to deposit on an adhesion layer that has a higher surface energy than Pt. In this case, the Pt should wet the adhesion layer because the deposited Pt film will lower the surface energy. One material that has a higher surface energy than nearly all other metals, including Pt, is W. The surface energy of W is ~3.5 J/m.

In situ spectroscopic ellipsometry (SE) allowed for the characterization of Pt ALD nucleation on W ALD adhesion layers. *In situ* measurements of nucleation during plasma-assisted ALD provided rapid feedback on the process variables including plasma power, plasma exposure time and the process gas mixture. *Ex situ* characterization with X-ray photoelectron spectroscopy and X-ray reflectivity was used to verify the SE models employed during *in situ* monitoring of the nucleation of plasma-assisted Pt ALD.