Atomic Layer Etching Using Thermal Reactions: ALD in Reverse

Atomic layer etching (ALE) is a thin film removal technique based on sequential, self-limiting surface reactions. ALE is the reverse of atomic layer deposition (ALD). This talk will present a new thermal approach to ALE based on sequential, self-limiting surface reactions. Examples will be presented for Al₂O₃ [1, 2] and HfO₂ [3] ALE. Using HF and Sn(acac)₂ as the reactants, Al₂O₃ and HfO₂ ALE are examined using quartz crystal microbalance, x-ray reflectivity and Fourier transform infrared spectroscopy measurements. These studies show that controlled, atomic layer removal of Al₂O₃ and HfO₂ is possible at temperatures from 150-250°C [1-3].

The ALE is achieved using sequential, self-limiting fluorination and ligand-exchange reactions. The surface reaction mechanism involves the formation of a metal fluoride surface layer from fluorination of the metal oxide by HF. The HF reactant also allows H₂O to leave as a reaction product. The Sn(acac)₂ reactant then accepts fluorine from the metal fluoride and donates acac to the metal fluoride in a ligand-exchange reaction. The donated acac ligand can produce Al(acac)₃ or Hf(acac)₄ as volatile reaction products from the metal fluoride. AlF(acac)₂ and HfF(acac)₃ may also be volatile reaction products.

This ALE reaction mechanism based on fluorination and ligand-exchange is applicable to other materials such as metal nitrides, metal arsenides and elemental metals. This mechanism also works with other metal precursors that accept fluorine, such as Al(CH₃)₃. The metal precursors introduce various ligands that may transfer during ligand-exchange. If the transferred ligands produce stable and volatile metal products, then the metal products may leave the surface and produce etching. Differences between stability and volatility of the possible reaction products can lead to selective ALE.


Tuesday, April 5, 2016
5326 Stevenson Center
3:10pm – 4:00pm
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Reception at 2:45pm.