A surface scientist's take on atomic layer deposition

Stacey F. Bent

Department of Chemical Engineering, Stanford University, Stanford, CA 94305 USA

With the growing interest in functional nanoscale materials for applications such as electronics, catalysts, and batteries, methods for fabricating materials with atomic-level control are becoming increasingly important. Atomic layer deposition (ALD) is a vapor-based method that provides excellent capabilities for depositing thin solid films, nanoparticles, and other nanoscale materials. Based on sequential, self-limiting vapor-surface reactions, ALD has become a popular nanofabrication tool because it provides exceptional conformality, thickness control at the angstrom level, and tunable film composition. This talk will describe research into the fundamental processes that drive ALD from the perspective of surface science. In one example, ALD of binary and ternary metal oxides using ozone as a counterreactant show unusual behavior implicating the importance of reactive oxygen species trapped at the subsurface in these ALD processes. In ALD of iron oxide by t-butylferrocene and ozone, for instance, growth per cycle of greater than one monolayer of Fe_2O_3 per cycle is observed and explained by the presence of excess oxygen stored near the surface of deposited films, and in the growth of ternary Ni-Al-O films, a large enhancement in Al uptake is attributed to subsurface nickel superoxide species after ozone exposure. In another example, we will describe an ALD process for growing stoichiometrically controlled, crystalline MoS_2 from $Mo(CO)_6$ and H_2S by taking advantage of surface desorption kinetics. The talk will provide insights into how surface science tools can help understand mechanisms of atomic layer deposition.