Self-limiting Surface Reactions for Atomic-level Control of Materials Processing

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ALE and ALD have in common that their defining characteristic is a self-limiting transformation of the surface in each cycle. This leads to the well-known advantages of the techniques - uniformity, conformality and digital control of thickness etched/deposited. In this tutorial we will examine how the chemical interaction between a gas and a surface can be either self-limiting or continuous. Looking at how this depends on process conditions (temperature or pressure) gives a straightforward way to understand the process window and account for the etch/growth rate. The simple procedure for estimating etch/growth rates from surface coverage will be presented. We will discuss the various potential sources of self-limiting chemistry, such as the concentration of substrate sites, availability of co-reagent fragments, exposure of gaseous reagent and diffusion along the surface. Examples will be given from both acid-base and redox-based chemical mechanisms of ALE and ALD.