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Introduction to Plasma-based Atomic-Layer Processes for Modern Semiconductor Device Fabrication

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Abstract

As the sizes of semiconductor devices continue to diminish and are now approaching atomic scales, the downsizing of transistors following Moore's law is bound to end in the near future. However, the continuing market demand for higher performance and lower energy consumption of large-scale integrated (LSI) circuits has driven invention of new device technologies such as three-dimensional (3D) device structures and devices based on non-silicon materials. Manufacturing of these non-conventional devices also poses new challenges for processing technologies. One of the latest processing technologies that are considered crucial in modern semiconductor technologies is Atomic-Layer Processes (ALPs), which typically refers to Atomic Layer Deposition (ALD) and Atomic Layer Etching (ALE). In these processes, deposition or etching processes take place layer by layer in atomic sclae. For example, in plasma-based ALE of SiO2 films, deposition of a few-angstrom deep fluorocarbon (FC) layer on a SiO2 film and a subsequent application of low-energy Ar+ ions to the fluorocarbon-deposited SiO2 film causes sub-mono-layer etching of the SiO2 surface. By repeating these steps, a layer-by-layer etching of SiO2 can be achieved selectively over other materials such as Si. Despite their low throughput, ALPs are now widely welcomed in industry as they typically allow highly uniform processes over a large area with atomic-scale accuracy. In this lecture, after a brief introduction of plasma processing in general, basics of ALPs will be discussed and latest research results for experimental and computational studies on ALE processes will be presented.

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