Research in Thermal Area Selective Atomic Layer Deposition and Atomic Layer Etching for Advanced Device Patterning

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Area-selective Atomic Layer Deposition (AS-ALD) is being exploitedby industrial and academic fields as promising mean for enabling the continuousdown scaling of transistor devices. Thermal TiO_2 ALD using $TiCl_4$and H_2O demonstrates surface selectivity between hydroxyl(Si-OH) andhydrogen terminated(Si-H) silicon surfaces. However, when a critical number of TiO_2ALD cycle is exceeded, significant amount of TiO_2 nuclei form onSi-H, which results in loss of the surface-dependent selectivity. We recentlyreported a thermal TiO_2 atomic layer etch (ALE) process consistingof thermodynamically favorable sequential reactions with WF_6 and BCl_3. To improve the surface-dependent selectivityof TiO_2, we investigated TiO_2 ALD with periodic etch-backsteps using the TiO_2 ALE process, thereby allowing > 5 nm of TiO_2selective deposition on Si-OH vs Si-H surfaces, as confirmed by transmissionelectron microscopy (TEM) and other techniques. Beyond metal oxide, we also discovered a process for thermal ALE oftungsten metal using O_2 and WF_6., and confirmed thereaction mechanisms using thermodynamic modeling. This presentation will focuson inherent differences in ALD precursor interactions with different substratematerials, and how selectivity in ALD and ALE surface reactions can be combinedand coupled to advance the challenges of area-selective deposition.