Atomic Layer Modulation for Compositionally Controlled RuZnO Films as Diffusion Barriers for Cu Interconnects

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Atomic layer modulation (ALM) was employed as an ALD-based process strategy to enable compound thin-film formation with precise compositional control. In ALM, multiple metal precursors are sequentially introduced within a single ALD cycle, followed by a common reactant step, allowing atomic-scale mixing of multi-component systems while retaining the precise thickness control, excellent uniformity, and cycle-to-cycle reproducibility characteristic of ALD processes. Based on this capability, RuZnO thin films were synthesized and investigated as diffusion barrier layers for Cu interconnects. RuZnO was selected to combine the favorable properties of Ru, such as thermal stability and a short electron mean free path, with the ability of ZnO to enhance adhesion at dielectric interfaces through zinc silicate formation, thereby integrating diffusion suppression and interfacial stability within a single layer. RuZnO films were deposited using tricarbonyl(trimethylenemethane)ruthenium [$Ru(TMM)(CO)_3$] and diethylzinc (DEZ) as precursors, and O_2 as a reactant. The Ru–Zn–O composition was systematically varied by controlling the ALM process's various parameters. The structural properties, thickness uniformity, and compositional distribution of the ALM-grown films were analyzed using XRD, XRR, RBS, and TEM. The results confirm the formation of homogeneous RuZnO layers over a range of compositions, indicating effective atomic-scale mixing achieved within the ALM cycle. Based on these results, compositionally controlled RuZnO films grown by ALM are discussed as diffusion barrier layers for Cu interconnects, and the detailed results will be presented at the conference.

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