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The enhanced nucleation behavior of atomic-layer-deposited Ru film on porous low-*k* dielectrics by UV-O_3 treatment

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Copper interconnects require a barrier to prevent the diffusion of Cu into the adjacent dielectric, and physical vapor deposition (PVD) is most widely used to deposit metal barriers. However, at the 45 nm node or below, the step coverage provided by the PVD technique will not be at the proper level and the effective resistivity of the line will also increase. Atomic layer deposition (ALD), on the other hand, has the capability of producing ultra-thin films (of the order of a few nm) with further improved conformality. However, the ALD process also suffers from a poor nucleation problem at the initial stage of the film growth. We describe the deposition of ruthenium (Ru) films on porous low-*k* dielectrics by the ALD process. The effect of UV-O_3 treatment on the nucleation behavior of Ru film on low-*k* dielectrics was investigated. A continuous Ru film was not formed on the as-deposited or N_2-annealed low-*k* layer, but after the UV-O_3 treatment, full coverage with a continuous Ru layer was obtained. The enhanced nucleation behavior of Ru may be due to the increased chemisorption probability of the Ru precursor on the low-*k* film surface, which comes from a modified oxygen-based dense layer (SiO_x).

Accurate estimations of the thicknesses and density of the Ru films and SiO_x layer formed by the UV-O_3 treatments were acquired by the X-ray reflectivity (XRR) measurements. The microstructures of the films and the interface of the modified low-*k* and metal Ru layers were observed by transmission electron microscopy (TEM, JEOL, JEM-3000F).