

OR0104

Substrate effect on the dielectric constant of TiN films grown by plasma enhanced atomic layer deposition

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TiN films have gained much interest because of its low resistivity and compatibility with the materials used in semiconductor fabrication. TiN thin films have been applied to electrodes for DRAM capacitor and diffusion barrier for metalization. In recent, plasma enhanced atomic layer deposition (PEALD) has been employed to deposit the TiN films due to its excellent conformality, precise thickness control of nm, and reproducibility. The common method determining the thickness of TiN is measuring the sheet resistance with a 4-point probe. In addition to 4-point probe, spectroscopic ellipsometry (SE) is an effective and nondestructive method which is commonly used to measure the thickness and dielectric constant of thin films. As TiN film grown with an ALD is very sensitive to the substrate material, the dielectric properties of TiN varies with substrate. In this work, the optical properties of TiN were investigated with several substrates of oxide films.

A 20-nm TiN films were deposited on Si and ultra-thin SiO₂, Al₂O₃, HfO₂, and SiN substrates using TiCl₄ and NH₃ as precursors in the PEALD chamber. To get the precise dielectric constant, at first, the film thickness were evaluated with 4-point probe and high resolution TEM images. The dielectric constant were fitted with the combination of Lorentz oscillator and Drude model in the range of 1.5-5.0 eV. The dielectric function of TiN is varied with the substrate material, especially near 2.5 eV with a different peak feature. This difference is discussed with the physical and chemical properties of TiN and substrate: the surface roughness of both substrate and TiN film itself analyzed by AFM, the crystalline status of TiN measured by XRD, and the chemical state of TiN measured by XPS.

Keywords

PEALD

TiN

Dielectric function

Substrate