Reliability of Multistacked Tantalum-based Structure as the Barrier Film in Ultralarge Scale Integrated Metallization

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Abstract

Diffusion barrier properties of Ta films with and without plasma treatments have been investigated in the study. The nitrogen-incorporated Ta films were prepared by NH3 plasma treatment or reactive sputtering. Barrier properties were evaluated by sheet resistance, X-ray diffraction, transmission electron microscopy, X-ray photoelectron spectroscopy and reverse-biased junction leakage current. An amorphous-like TaNx layer was formed on Ta barrier film after plasma treatments. The thickness of the amorphous TaNx layer is about 3 nm and NH3 plasma-treated Ta films (TaNx/Ta) possess lower resistivity and smaller grain sizes. The Cu/TaNx/Ta(10 nm)/Si remained stable after annealing at 750°C for 1 h. NH3 plasma-treated Ta films (TaNx/Ta) possess better thermal stability than Ta and TaN films. It is attributed to the formation of a new amorphous layer on the surface of Ta film after the plasma treatments. For thermal stability of Cu/Ta(-N)/n+-p diodes, Cu/Ta/n+-p and Cu/TaN/n+-p junction diodes resulted in large reverse-bias junction leakage current after annealing at 500 and 525°C, respectively. On the other hand, TaNx/Ta diffusion barriers will improve the integrity of Cu/Ta(-N)/n+-p junction diodes to 650°C.