PECVD-Ti/TiNx Barrier with Multilayered Amorphous Structure and High Thermal Stability for Copper Metallization

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Abstract

Ultrathin (10 nm) Ti films with an amorphous structure were deposited by low temperature (<500°C) plasma enhanced chemical vapor deposition (PECVD) using TiCl4 and H2 as reactants. Ammonia plasma was further employed topost-treat the PECVD-Ti barrier layer to improve barrier properties. An amorphous TiNx layer forms on the surface of the PECVD-Ti layer after ammonia plasma post-treatment. The resulting films have a multilayered amorphous Ti/TiNx structure. Furthermore, the effective resistivity of resulting Ti/TiNx film reduces to 122 μΩ cm. Improved barrier capability against Cu diffusion is found for the Ti/TiNxbarrier layer because the Cu/TiNx /Ti/n+-p junction diodes retain low leakage current densities even after annealing at 500°C for 1 h. Ti/TiNx barrier layers present lengthened grain structures to effectively impede Cu diffusion, thus acting as much more effective barriers than are conventional Ti and TiN films.