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Understanding the Bonding Mechanisms of Directly Sputtered Copper Thin Film on an Alumina Substrate

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Abstract

The evaluation of bonding mechanisms between magnetron sputtered copper (Cu) thin films and a ceramic substrate was carried out using polycrystalline and monocrystalline alumina (Al_2O_3) substrates with different surface roughness. Three different bonding mechanisms, *viz*, surface adsorption, mechanical interlocking, and diffusion bonding have been assessed. A tensile test was applied to measure the interfacial adhesion strength between the Cu films and the Al_2O_3 substrate. The contribution to the interfacial adhesion from each of the bonding mechanisms was elucidated based on the adhesion strength. Without special surface pre-treatment, physical adsorption is the main factor for the film adhesion, contributing ~5.9 MPa adhesion strength between this directly sputtered Cu film and a flat Al_2O_3 substrate. For substrates with surface roughness around 350 - 500 nm, mechanical interlocking enhances the film adhesion up to 18.6 % compared to the flat surface. Post-deposition annealing at 300 °C has increased adhesion strength by 18 %, and diffusion bonding may be operative.