608g Plasma Treatment and Surface Analysis of Polyimide Films for an Electroless Copper Build-up Process

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Electroless copper plating on advanced dielectric materials is a key to the development of future semiconductor devices that require ever smaller features. Catalyst adsorption and adhesion between the dielectric material and the electroless copper layer must be improved in order to enable electroless copper plating. Hence, a detailed characterization of polyimide (PI) films following modifications by plasma treatment and subsequent electroless copper deposition has been undertaken. NH3 and Ar plasma treatments have been successfully used to achieve morphological and chemical modification of the PI surface so that electroless copper plating can occur. The adhesion strength of the electroless copper to the PI surface was measured and correlated with the plasma-induced modifications of the PI surface. The NH3 plasma causes primarily chemical changes to the PI surface through creation of nitrogen moieties on the surface. The Ar plasma treatment, on the other hand, brings about mainly physical changes to the surface (i.e. surface roughening). The combined-plasma treatment (Ar plasma followed by NH3 plasma) combines the desirable chemical and physical effects of each treatment, yielding a PI surface with higher roughness for physical anchoring of the copper and surface bonding sites (nitrogen and oxygen sites) for enhanced chemical bonding and catalyst adsorption. The adhesion strength of the electroless copper to the PI correlated well to the surface modifications and plasma treatment conditions. The effect of plasma treatments on catalyst adsorption was also examined. A direct relationship has been observed between surface palladium concentration and the abundance of the -N=C< sites on the surface. This suggests that the nitrogen radicals created during the NH3 plasma are incorporated into the surface and serve as bonding sites for the palladium. For the first time, a specific bonding configuration on the PI surface is shown to promote adsorption of palladium, which in turn promotes covalent bonding with Cu.