Plasma-Polymerized Toluene Films for Corrosion Inhibition in Microelectronic Devices

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1. Introduction

In view of decreasing dimensions in microelectronic devices, the question of how to protect effectively the multilevel interconnections from corrosion becomes more and more important. Generally, the corrosion failure of electronic devices is mainly related to interconnect metals such as copper forming porous oxide layers on the surface and the increased use of newly developed polymers as interlayer dielectrics in microelectronic devices. In this paper plasma-polymerized toluene films were considered as a possible candidate for an interlayer dielectric for multilevel metallization of ultra large scale integrated (ULSI) semiconductor devices.

2. Experiment

The protective abilities of plasma-polymerized toluene films as a function of RF power and deposition temperature in a 3.5 wt.% NaCl solution were examined by electrochemical methods and FT-IR analyses. Polarization measurements of the electrodes, both bare and covered with toluene films, were carried out potentiodynamically at room temperature. A perturbation AC potential of amplitude 10 mV was applied over the frequency range 100 kHz to 1 mHz. All potentials recorded in this paper were referred to the saturated calomel electrode (SCE), and the counter electrode was a high-purity graphite rod.

3. Results

The protective efficiency of the film increased with increasing RF power and deposition temperature, which induced the higher degree of cross-linking in the film.

All the studied systems showed two time constants in the impedance spectra, implying that all toluene-

coated samples formed the conductive paths in the film due to the penetration of corrosive species such as Cl^- ions as well as water uptake. Especially, an increase of R_{po} and a decrease of C_c reflect the decrease of pathways through the film for the electrolyte to reach the copper substrate. An increase of R_{ct} and a decrease of C_{dl} represent a decrease of the reactive area (A_d). From the results of FT-IR analyses, toluene films with increasing RF power and deposition temperature had the higher degree of cross-linking. The better corrosion protection for copper coated with toluene films with increasing RF power and deposition temperature is based on the densely-packed and tightly-interconnected films because of the higher degree of cross-linking in the film.