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Properties of ultra-thin Cu films grown by high power pulsed magnetron sputtering

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Abstract

Because of the superior properties of copper, it has been of great interest as a conducting material to replace Al in device manufacturing and Ag in multilayer low-emission coatings. In this study, we investigated the influence of the pulsing frequency and the ion-to-atom ratio at direct-current (DC) and high power impulse magnetron sputtering on the structural, optical and electrical properties of Cu films of thickness less than 25 nm. The ratio of ion flux to deposited atom flux at the substrate was varied by changing the average discharge current density during the pulse from 26 to 1220 mA/cm^2 and pulse repetition rate from 0.5 to 5 kHz. Properties of nanometer-thick Cu films were found to be very sensitive to the ion-to-atom ratio. The Cu films were deposited with island-type growth. For the experimental conditions employed in the present study low-resistivity ultra-thin Cu films were obtained at moderate average discharge current density during the pulse (340 mA/cm^2), pulse frequency of 3 kHz and ion-to-atom ratio of 1.5. We also determined the critical thickness at which Cu films exhibit continuous growth as 5-6 nm. At this thickness films deposited under optimum conditions have resistivity of about 8 μΩ·cm, which is 8 times smaller than for films deposited by DC magnetron sputtering. This difference is due to the fact that films grown in DC regime have twice the concentration of oxygen atoms.

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