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Mechanical features of copper coatings electrodeposited by the pulsating current (PC) regime on Si(111) substrate

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Mechanical features of the Cu coatings produced by the pulsating current (PC) regime on Si(111) substrate have been investigated. The Cu coatings were electrodeposited by varying duty cycle (15–50 %) and keeping the current density amplitude constant (100 mA cm^{-2}), and by keeping duty cycle constant (50 %) but varying the current density amplitude value (80–120 mA cm^{-2}). The scanning electron microscopy (SEM) and optical microscopy (OM) techniques showed that morphology of the coatings changed with increasing the duty cycle from those with large and well defined grains to uniform and compact fine-grained coatings. The Vickers microindentation technique was used for an examination of hardness applying the Chen-Gao (C-G) composite hardness model and indentation creep features of the Cu coatings. The obtained values of hardness for the Cu coatings on Si(111) in the 0.9069–1.5079 GPa range indicated the successful implementation of the C-G model for this „soft film on hard substrate“ composite system. The obtained stress exponents ranging from 2.79 to 5.29 indicated that creep mechanism changed from grain boundary sliding to both dislocation climbs and dislocation creep with decreasing duty cycle values. The maximum hardness and minimum stress exponent was obtained for the fine-grained Cu coating produced with a duty cycle of 50 % and the current density amplitude of 100 mA cm^{-2}, indicating that its plastic deformation during microindentation was primarily caused by grain boundary sliding. Optimization of process formation and mechanical features of the Cu coatings was made using Response Surface Methodology (RSM), and error of 3.2 % showed a good agreement between predicted and measured values.

Keywords: copper; pulsating current (PC); hardness; stress exponent; response surface methodology (RSM).

FULL TEXT