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Characterization of copper-silicon nitride composite electrocoatings

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Abstract – Silicon nitride particles were incorporated to copper by co-electrodeposition in order to improve its mechanical resistance. Smooth composite deposits containing well-distributed silicon nitride particles were obtained. The microhardness of the composite coatings was higher than that of pure copper due to dispersion-strengthening and matrix grain refining and increased with the increase of incorporated Si_3N_4 particle content. The microhardness of both pure copper and composite coatings increased with an increase in cathodic current density due to copper matrix refinement. The composite coatings presented a higher mechanical resistance than pure copper coatings obtained under the same conditions but lower ductility.

Electrodeposition is widely used for the production of metallic coatings, such as copper, nickel, tin, chromium and noble metals electroplates. In order to improve some properties of these metallic coatings (hardness, wear resistance and corrosion resistance, for example), researches were developped incorporating particles of ceramic, metallic and polymeric materials to the electrodeposits [1-2]. The copper electroplates are widely used in engineering applications due to the high electrical and thermal conductivity of copper, good ductility and good corrosion resistance. Nevertheless, these coatings show low mechanical and wear resistance. In order to improve the mechanical properties copper-silicon nitride electrocomposites were produced from acidic sulfate bath containing 150 gL^{-1} $CuSO_4$ and 30 gL^{-1} H_2SO_4 at room temperature, where Si_3N_4 particles were maintained in suspension by magnetic stirring.

Smooth and well-crystallized composite deposits with good distribution of Si_3N_4 particles were obtained (Fig. 1). The Si_3N_4 particles inhibited the growth of the copper crystalites and the composite coatings have a copper matrix with smaller crystal sizes comparatively to the pure copper deposits (Figs 1b e 1c). In the other hand, copper grain size in both pure copper and composite coatings was finer when the current density increased, due to a higher crystal nucleation rate.

The incorporation of Si_3N_4 particles to copper did not affect the orientation of copper grains. In both types of deposits obtained using 10 and 20 mA cm^{-2}, the copper phase was clearly textured in the [110] direction, whereas for 30 and 40 mA cm^{-2} the copper matrix crystals were randomly oriented.

The microhardness of both pure copper and composite coatings increased with an increase in cathodic current density due to copper matrix refining. The microhardness of the composite coatings was higher than that of pure copper due to both dispersion-strengthening and matrix grain refining and increased with the increase of incorporated Si_3N_4 particle content (Fig. 2). The ultimate tensile strength of the composite coatings was higher than that of pure copper coatings obtained under the same conditions but their ductility was lower.

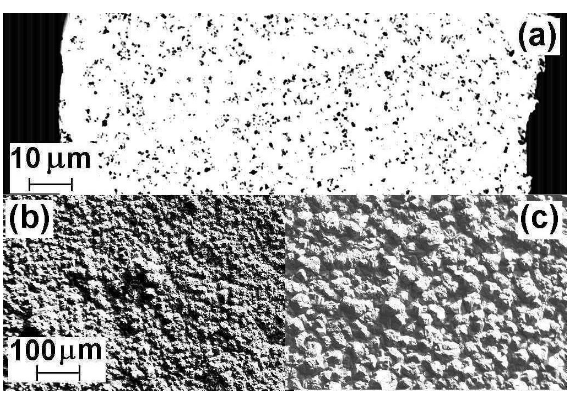

Figure 1: (a) SEM photograph of the cross-section of a Cu-Si_3N_4 composite; (b, c) surface morphology of Cu-Si_3N_4 composite and pure copper, respectively.

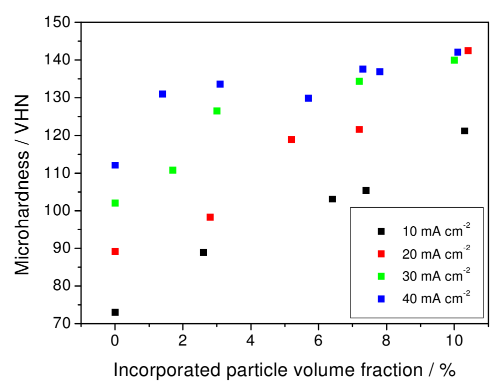

Figure 2: Microhardness of the Cu-Si_3N_4 composite coatings as a function of incorporated particle volume fraction and cathodic current density.

References

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