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SECOND INTERNATIONAL CONFERENCE ON ELECTRON MICROSCOPY OF NANOSTRUCTURES

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Effect of concentration pigment particles on microstructure of the metal matrix copper composite coatings

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Copper electrodeposits are widely used for many engineering applications due to their physical, electrical and mechanical properties such as eco-friendly synthesis, corrosion resistance, excellent electrical and thermal conductivity, good chemical selectivity and mechanical features [1,2]. However the need for functional and decorative coatings motivates this research to explore possibilities of future develop the electrochemically synthesis of copper with incorporating pigments particles to produce copper matrix reinforced coatings with different surface appearance (color and brightness) or better mechanical properties [3]. This research focuses on the synthesis and characterization of composite coatings via electrochemical route with co-deposition pigments. For that reason, the effect of adding yellow green phosphorescent pigment on microstructural evaluation of the Cu/pigment composite systems has been investigated.

The copper coatings produced from the basic sulfate electrolyte without or with different content of phosphorescent pigment particles were characterized by Scanning Electron Microscope (SEM) and Atomic Force Microscope (AFM). Thin metal matrix composite coatings were prepared by galvanostatic electrodeposition technique with the assistance of magnetic stirring of electrolyte (DC/MS regime) on the brass substrate. The basic sulfate electrolyte consisted of: 240 g L^{-1} $CuSO_4 \cdot 5 H_2O$ in 60 g L^{-1} H_2SO_4. The particles of phosphorescent pigment (Sennelier Paint Pigment Phosphoyellow green, France) were added into the basic sulfate electrolyte. Five different particle concentrations were used: 0.25; 0.5; 1; 1.5 and 3 g particles in 100 ml basic electrolyte.

The morphology of the deposited copper coatings without and with pigment particles and cross-section analysis are given at Figure 1. Top surface and cross-section SEM images confirmed the co-deposition of pigment particles within the metal copper matrix throughout the entire coating thickness. It was also confirmed that the presence of particles in the sulfate electrolyte drastically changes the topography of the obtained coatings, via a change in micro roughness. The topographic analysis and micro roughness of coatings (according to an average absolute roughness parameter, R_a) were given at Figure 2. Roughness is evidently reduced to some critical concentration of pigment particles in the electrolyte (up to 1 g), and then increases due to a formation of agglomerates at higher concentrations of the particles. Therefore, the critical particle concentration in the electrolyte should be taken into account [4].

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[4] The authors acknowledge funding from the Ministry of Education, Science and Technological Development of Serbia (Grants No. 451-03-68/2022-14/200026 and 451-03-68/2022-14/200135).

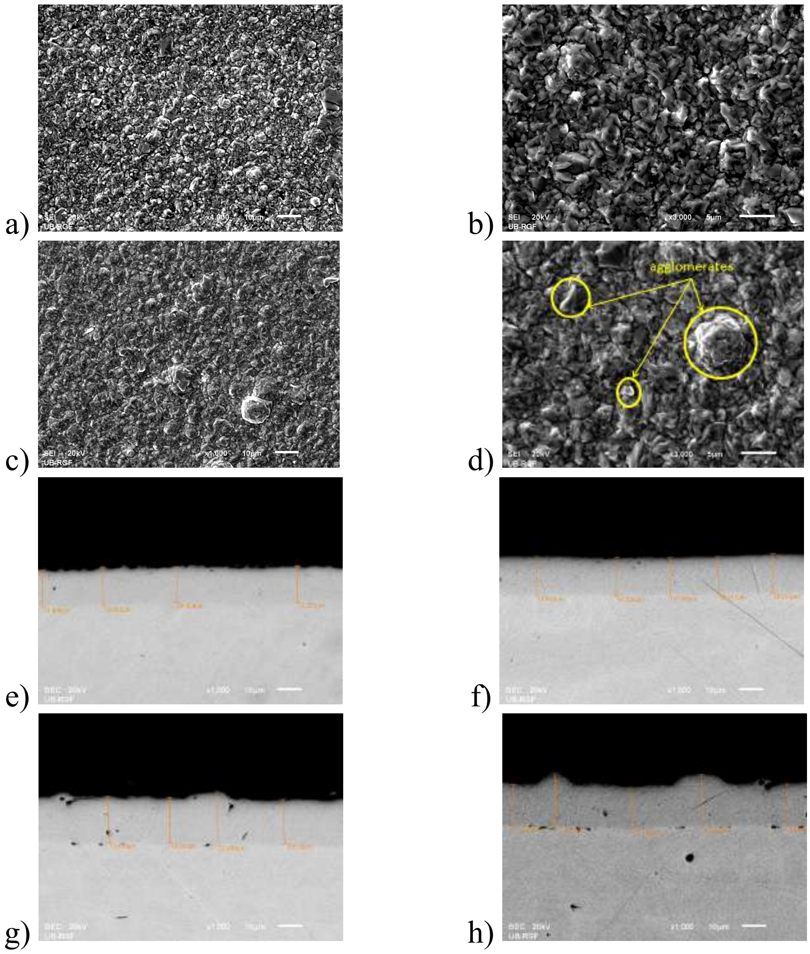

Figure 1. SEM micrographs on top side of Cu coatings: a) and b) without pigment particles, ×1000 (a) and ×3000 (b); c) and d) with 0.25 g pigment particles, ×1000 (c) and ×3000 (d). Cross-section views: e) Cu+0.25 g, f) Cu+1 g, g) Cu+1.5 g and h) Cu+3 g of pigment particles, ×1000. The particles are added to 100 mL the basic sulfate electrolyte.

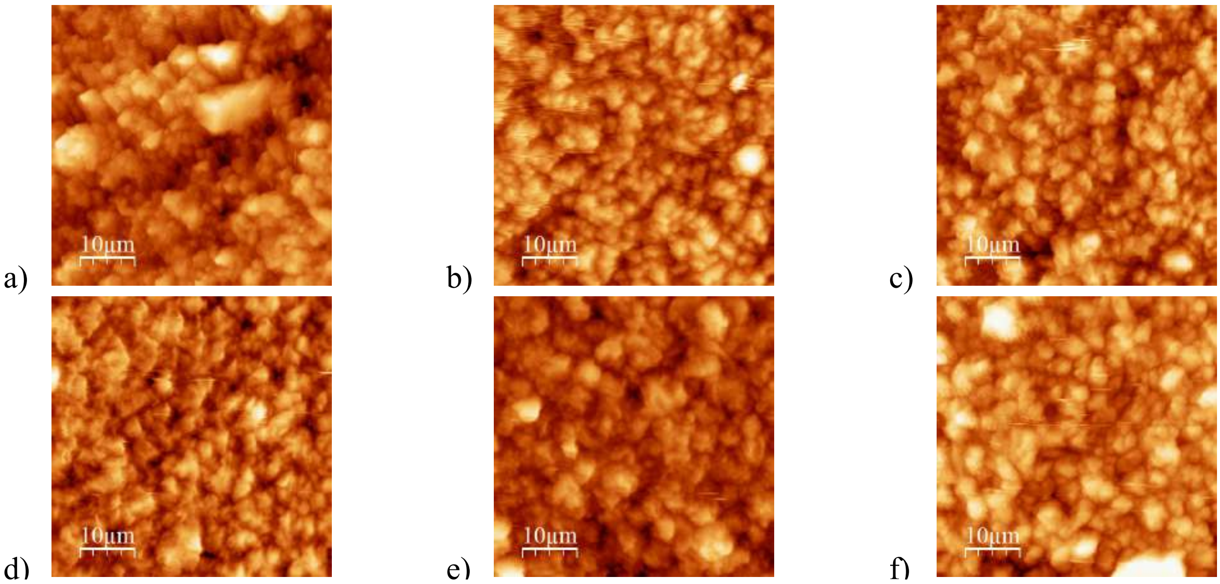

Figure 2. AFM analysis on top side of Cu coatings with included roughness values: a) without pigment particles (R_a = 280.8 nm), b) Cu+0.25 g (R_a = 246.1 nm), c) Cu+0.5 g (R_a = 221.7 nm), d) Cu+1.0 g (R_a = 213.6 nm), e) Cu+1.5 g (R_a = 230.3 nm) and f) Cu+3 g (R_a = 251.4 nm) of pigment particles. The particles are added to 100 mL the basic sulfate electrolyte.