

Electrodeposition of Ni/SiC Nano-Composites for Environmentally-Friendly Coatings

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Chromium and cadmium-based composites that are widely used in the aerospace industry for wear and corrosion-resistant coatings have been planning to be restricted due to environmental regulations. Ni/SiC composites are studied extensively as alternative coatings due to their high hardness, anti-corrosion and anti-wear properties (1). Electrocodeposition of Ni and SiC for the production of these composites has the advantage of low cost and operating temperature. High and uniform SiC incorporation into the deposit, which is crucial for enhanced mechanical and tribological properties, depends strongly on the stability of the ceramic particles in the plating electrolyte (2). Cationic dispersants are commonly studied in literature for the stabilization of SiC particles in the electrolyte since these additives not only improve the dispersion but also increase the affinity of the particles to the cathode by resulting in more positively charged SiC particles (3). The size of the ceramic particle plays a crucial role in Ni/SiC co-deposition. Previous studies show that nano-composites have lower SiC fraction in the deposit compared to micro-composites for the same plating conditions (1). However incorporation of nano-particles result in superior mechanical and tribological film properties (1).

An important consideration in Ni/SiC co-deposition is that the additives that improve the dispersion of the particles may also impact the electrodeposition significantly. In this study, co-deposition of nano-SiC particles with Ni from a Watts solution in the presence of a cationic polymer, polyethyleneimine (PEI 60000) is described. The effect of PEI 60000 on both electrodeposition kinetics and SiC incorporation is investigated for Ni/SiC nano-composites. In addition, a particle-preparation method to obtain high SiC dispersion and incorporation without decreasing the current efficiency is developed.

Figure 1 shows the effect of particle size on the SiC fraction in the deposit for additive-free Watts solution. It can be seen that when there is no PEI in the plating bath, SiC volume fraction of the nano-composite is much lower than the micro-composite. The effect of PEI 60000 concentration on the SiC incorporation is shown in Figure 2 for nanoparticles. It is apparent from the figure that the addition of PEI results in a significant increase in the SiC vol% in the deposit especially at concentrations of 500 and 1000 ppm. However, when the current efficiencies are measured it is seen that current efficiency decreases to 32% at 1000 ppm PEI. Therefore the best result is obtained for PEI 60000 concentration of

500 ppm. The SiC vol% increases to 11.45 vol% from 1.69 vol% without a decrease in the current efficiency. In addition, dispersion of the SiC particles in the electrolyte is improved.

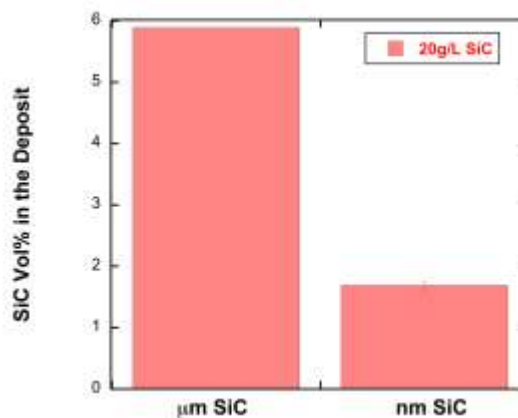


Figure 1. Effect of particle size on SiC vol% in the deposit for Watts solution containing 20 g/L SiC (1 µm or 45-55 nm particles) at a current density of -50 mA cm^{-2} and rotation speed of 100 rpm.

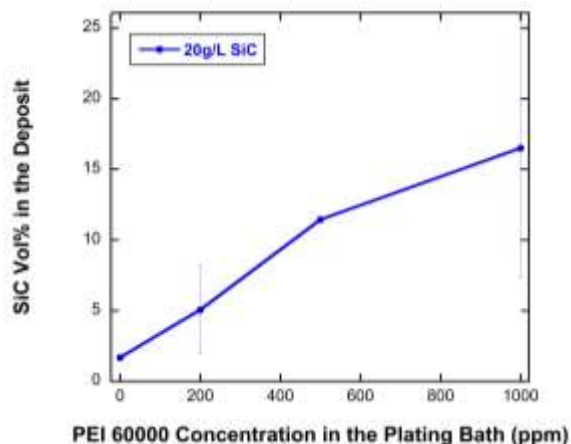


Figure 2. Effect of PEI 60000 concentration on the SiC vol% in the deposit for Watts solution containing 20 g/L SiC (45-55 nm) at a current density of -50 mA cm^{-2} and rotation speed of 100 rpm.

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References

1. E. A. Pavlatou, M. Stroumbouli, P. Gyftou and N. Spyrellis, *Journal of Applied Electrochemistry*, **36**, 385 (2006).
2. M. Srivastava, V. K. William Grips and K. S. Rajam, *Materials Letters*, **62**, 3487 (2008).
3. N. K. Shrestha, I. Miwa and T. Saji, *Journal of the Electrochemical Society*, **148**, C106 (2001).