Conductive composites based on copper- and nickel-containing powders deposited from solutions instead of silver pastes

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Conductive silver pastes and adhesives are used to produce electrical contacts and conductive elements in printed circuit boards, display panels, electrodes of capacitors, etc. [1]. Silver particles are the main conductive component in them providing high electrical conductivity and corrosion resistance. Due to high cost of silver, it is important to replace Ag with cheaper metals. The substitution of Ag with Cu is impossible because of the rapid copper oxidation in the air and a loss of electrical conductivity. Ni is significantly more resistant to corrosion, but has four times less electrical conductivity than Cu. The electrical conductivity of Zn and Ni has close values, but zinc loses its conductibility being covered with an oxide layer in the air. The purpose of this work was to obtain a conductive composite, which is a polymer matrix filled with copper or nickel-containing bimetallic ultrafine particles with a core–shell structure instead of silver powder.

Cu–Ni powder was synthesized by chemical deposition of nickel shell on copper particles for their corrosion protection. Zn–Cu and Zn–Ni powders were obtained by copper or nickel cementation with zinc powder [2]. Zn core performed the function of Cu or Ni cathodic protection against corrosion. In addition to the metal powder, thermally splitted graphite (TSG) was added to the polymer during the paste preparation. TSG plates arranged metal particles in a conductive frame. The resulting paste was applied to a glass surface in the form of strips 60−90 μm thick, simulating electrically conductive elements. The results of measuring their bulk resistivity are presented in the Table. The data show that polymers filled with only copper are non-conductive. The presence of Cu–Ni, Zn–Cu or Zn–Ni powders together with TSG in the polymer matrix provides a decrease of coatings' resistivity to about 3.6−5.1 kΩ·mm^2/m. Their resistance does not change during storage for six months or more.

Bulk resistivity (ρ_V) of metal−polymer composites

Filler	ρ_V, kΩ·mm^2/m
TSG	106
Cu	10^6
Cu + TSG	17.4
Cu–Ni (5 wt.% Ni) + TSG	3.7
Zn–Cu (98 wt.% Cu) + TSG	5.1
Zn–Ni (80 wt.% Ni) + TSG	3.6

References

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