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Production of Nanocomposite Electrical Contact Materials Ag-SnO2, W-Cu and Cu-C in Thermal Plasma

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Abstract : Composite materials where metal matrix is reinforced by ceramic or metal particles are of great interest for use in the manufacturing of electrical contacts. Significant improvement of the composite physical and mechanical properties as well as increase of the performance parameters of composite-based products can be achieved if the nanoscale structure in the composite materials is obtained by using nanosized powders as starting components. The results of nanosized composite powders synthesis (Ag-SnO2, W-Cu and Cu-C) in the DC thermal plasma flows are presented in this paper. The investigations included the following processes: - Recondensation of micron powder mixture Ag + SnO2 in a nitrogen plasma; - The reduction of the oxide powders mixture (WO3 + CuO) in a hydrogen-nitrogen plasma; - Decomposition of the copper formate and copper acetate powders in nitrogen plasma. The calculations of equilibrium compositions of multicomponent systems Ag-Sn-O-N, W-Cu-O-H-N and Cu-O-C-H-N in the temperature range of 400-5000 K were carried to estimate basic process characteristics. Experimental studies of the processes were performed using a plasma reactor with a confined jet flow. The plasma jet net power was in the range of 2 - 13 kW, and the feedstock flow rate was up to 0.35 kg/h. The obtained powders were characterized by TEM, HR-TEM, SEM, EDS, ED-XRF, XRD, BET and QEA methods. Nanocomposite Ag-SnO2 (12 wt. %). Processing of the initial powder mixture (Ag-SnO2) in nitrogen thermal plasma stream allowed to produce nanopowders with a specific surface area up to 24 m2/g, consisting predominantly of particles with size less than 100 nm. According to XRD results, tin was present in the obtained products as SnO2 phase, and also as intermetallic phases AgxSn. Nanocomposite W-Cu (20 wt .%). Reduction of (WO3+CuO) mixture in the hydrogen-nitrogen plasma provides W-Cu nanopowder with particle sizes in the range of 10-150 nm. The particles have mainly spherical shape and structure tungsten core - copper shell. The thickness of the shell is about several nanometers, the shell is composed of copper and its oxides (Cu2O, CuO). The nanopowders had 1.5 wt. % oxygen impurity. Heat treatment in a hydrogen atmosphere allows to reduce the oxygen content to less than 0.1 wt. %. Nanocomposite Cu-C. Copper nanopowders were found as products of the starting copper compounds decomposition. The nanopowders primarily had a spherical shape with a particle size of less than 100 nm. The main phase was copper, with small amount of Cu2O and CuO oxides. Copper formate decomposition products had a specific surface area 2.5-7 m2/g and contained 0.15 - 4 wt. % carbon; and copper acetate decomposition products had the specific surface area 5-35 m2/g, and carbon content of 0.3 - 5 wt. %. Compacting of nanocomposites (sintering in hydrogen for Ag-SnO2 and electric spark sintering (SPS) for W-Cu) showed that the samples having a relative density of 97-98 % can be obtained with a submicron structure. The studies indicate the possibility of using high-intensity plasma processes to create new technologies to produce nanocomposite materials for electric contacts.

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