Nanocomposites and nanomaterials

Features of Ni/NiO Nanopowder Synthesis by Thermal Decomposition of Nickel Acetate Amines

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Nickel powders are widely used as electrode materials in multilayered ceramic capacitors. Tendency of ceramic and electrode layers thinning to 100 – 200 nm that is used for increasing of capacitor dielectric capacity leads to necessity of powders size decreasing to 10 – 20 nm. Thus, development of technology of Ni nanopowders obtaining with particle size of 20 nm and less and minimal impurities content is of great importance.

Ni/NiO nanopowders with different metal and oxide phase ratio have been prepared by using thermal de-composition of nickel acetate ammine complexes which contain various ammonia concentrations at the temperature range 300 – 500 ºC in air.

Thermal decomposition of nickel ammine complexes occurred with formation of crystalline hydroxide-containing and amorphous carbonate-containing precursors. Decomposition of ammonia-hydroxide and ammonia-carbonate precursors occurred with formation of different pore size 3.7 and 3.3 nm correspondently. Decomposition process occurred in three stages: 1) Ni primary forming from nickel ammine-hydroxide complexes, 2) decomposing of residual nickel-containing precursors to NiO and 3) after reducing of NiO to Ni by NH_3 and organic residuals. These stages were accompanied with exchanging of powders pore structure and agglomerate sizes. The most optimal condition for Ni/NiO nanopowder obtaining by thermal decomposition of nickel acetate ammines were considered NH_3 concentration in initial complex of 6.5 – 9 and 6.5 – 8 mol/mol Ni^{2+} at annealing times 60 and 30 min at 350 and 400 °C correspondently. The minimal free and fixed carbon concentrations were observed for powder obtained by decomposition during 60 min at 350 °C. Mean crystallite size of Ni depended on temperature only. In the temperature range from 350 to 500 °C the crystallite size of Ni has grown from 50 to 55 nm. Mean crystallite size of NiO depended on temperature and ammonia content. In the temperature range from 350 to 500 °C the crystallite size of NiO has grown from 5 to 25 nm. Increasing of NH_3 content from 3.6 to 14.4 mol/mol Ni led to decreasing NiO crystallite size from 8 – 10 to 5 nm.