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Electrical consolidation under pressure for Al_2O_3 and WC nanodisperse powders

ABSTRACT. The features of hot pressing by the method of electrical consolidation under pressure of nanodispersed powders of two types of materials—electrically conductive (WC) and nonconductive (Al_2O_3)—are considered. WC powder with a particle size of <2 μm and α-Al_2O_3 powder with a particle size of <0.1 μm were used. The heating rate varied from 50 to 500 °C min^{-1}. Sintering was carried out in an electric field engendered by a direct current lead to the vacuum processing chamber, implementing the well known field-assisted sintering technique (FAST) with spark plasma sintering (SPS) on the original installation with longitudinal-axial pressing of the chamber contents. With rapid heating, the density of the sintered powders was 99% after 2 min exposure under a pressure of 40 MPa, reached at 1200 °C for Al_2O_3 and 1650 °C for WC. Grain size did not change significantly. Intensive compaction and minimal grain growth in each of these materials are caused by the combined effect of electric current and mechanical pressure, which favourably changes the mass transfer pattern, its intensity, uniformity and dispersion of the consolidated grain structure compared to conventional sintering, in which large grain growth is typical for both materials. The direct action of the electric current contributes to removal of impurities (contaminants from the surface) of the particles, activates their surface, changes the transboundary structure, provides direct physical contact between the grains, ensures cleanliness and flexibility of their boundaries, increases sensitivity to heat, intensifies their compaction, and alleviates the inevitable problem of shrinkage. High-speed electric heating of powders reduces the time of coalescence of grain boundaries, inhibits their growth and ultimately leads to the formation of fine homogeneous structures of high functionality.

Keywords: fine grain structure, high-speed electric heating, nanopowder, refractory ceramics, sintering

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