EFFECT OF ABSORBED POWER ON DENSIFICATION AND GRAIN GROWTH DURING RAPID MICROWAVE SINTERING

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Rapid microwave sintering with intense volumetric energy release results in enhanced densification governed by the physical mechanisms similar to flash sintering [1]. In this paper we report the results of the recent rapid microwave sintering studies accomplished on ZnO-based varistor ceramics [2], $BaTiO_3$ and $SrTiO_3$-based dielectric ceramic materials [3, 4], and CeO_2-based ceramics for solid electrolyte applications. The volumetrically absorbed microwave power was varied in the experiments by using a wide range of heating rates (10 – 300 °C/min) and comparing direct and susceptor-assisted microwave heating.

Microwave sintering of the samples was carried out in the workchamber of the gyrotron system for high-temperature microwave processing of materials with a maximum output power of 5 kW [5]. The microwave power was regulated automatically in accordance with the predefined temperature-time schedule. The shrinkage of the samples was monitored *in situ* in some experiments using optical dilatometry.

The development of thermal instability was detected in the experiments with direct microwave heating by a sudden decrease or stall in the automatically regulated power during continued heating at a constant rate. It was followed by an onset of densification, which generally occurred at a lower temperature compared to susceptor-assisted heating. A detailed analysis accomplished on Bi_2O_3-doped ZnO samples [6] has shown that the effective high-frequency electric conductivity increases by a factor of 3 to 5 during the instability development. It can be assumed that the simultaneously occurring increase in microwave absorption and onset of densification are manifestations of the formation of a highly absorptive grain-boundary phase with enhanced transport properties.

The microstructural studies have revealed abnormal grain growth in the samples, often intensified in the case of direct microwave heating. In a study with $BaTiO_3$ ceramics it has been demonstrated that the transformation from fine-grain to coarse-grain microstructure spreads out from the core of the sample towards its periphery, which is associated with the non-uniform temperature distribution existing under volumetric microwave heating [3]. The impedance spectroscopy measurements suggest that the properties of grain boundaries, such as the effective width and/or dielectric constant, may be influenced by the density of the volumetrically absorbed microwave power.

The ceramic samples obtained in rapid microwave sintering regimes without an isothermal hold had a final density of 95 – 96 % of the theoretical value. The functional properties of the materials exhibit correlation with the microstructure and therefore can be tailored by selecting the microwave processing regimes.

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