PRESSURE-LESS RAPID HEATING OF NANOPARTICLE COMPACTS BY INFRARED HEAT TRANSFER

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Rapid sintering is nowadays a domain of novel methods such as spark plasma sintering (SPS) or flash sintering. These methods deal with special heating source and, therefore, it is difficult to describe obtained results by conventional pressure-less sintering mechanisms. Pressure-less SPS demonstrated possibility of extremely fast densification and grain growth without mechanical pressure and electrical current passing through the sample[1]. However, impact of pulsing electromagnetic field remains unclear. Recently, we have presented specially designed pressure-less rapid sintering furnace, which allows heating rates on level of hundreds degrees per minute[2]. Experimental data were used for numerical calculations of conduction/convection of heat transfer. Obtained results reveal that the maximum temperature in the sample cannot reach temperature necessary for the observed sintering if only heating by conduction and convection is considered. Our results indicate that during rapid sintering of low thermally conductive materials (yttria stabilized zirconia) radiation heat transfer is dominant in both the conventional rapid sintering and SPS. The rapid heating furnace was used for rapid sintering of nanoparticle powder compacts of yttria-stabilized zirconia by the radiation heat transfer. Green bodies were prepared by cold isostatic pressing (CIP) at various pressures providing various porosity of samples before sintering. Consequently, samples were pressure-less sintered in air at a heating rate of $100°\ C{\cdot}min^{-1}$ up to the 1500°C with 1 minute dwell. Scanning electron microscopy, mercury intrusion porosimetry, and Archimedes technique were used to characterize the microstructure and to determine the density of the green and sintered bodies. Contrary to expectations based on classical sintering models, our results reveal opposite dependence of the green- and sintered densities on the CIP pressure. Since the whole sintering process does not exceed 10 min, to propose what processes are responsible for observed results, our attention is focused on the radiation heat transfer from furnace heating elements into the ceramics. Our arguments are supported by numerical calculations of the electromagnetic field enhancement in/between particles[3]. Obtained results indicate an important role of nano features on energy absorption during rapid heating of ceramic materials.

References

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