Electric field engineering to induce flash sintering in a spark plasma sintering furnace

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Traditionally, electric current sintering techniques (ECAS) are divided into electric discharge sintering (EDS) and resistive sintering (RS). Both techniques depends on electric nature of die; (i) EDS is carried out with an electric insulator die to sinter electric conductor ceramics, (ii) RS is carried out with an electric conductor die to sinter conductor or non-conductor ceramics, such as spark plasma sintering (SPS). The design of a new mold, which concentrates the electric current through the specimen bulk (EDS) or throughout specimen surface (RS) depending on electric nature of specimen, has allowed the fabrication of dense ZrB_2, $MoSi_2$, $ZrB_2/MoSi_2$ composites, Al_2O_3 and 3Y-TZP among other ceramic systems in less than one minute. Energy consumption is from 1 to 7% compared to SPS with heating rates higher than 3000 ºC/min and maximum working temperature of ~2700 ºC.

Flash sintering could be considered a transition to an EDS process at certain temperature under an electric field intense enough. However, some resistive heating is required to reach the transition temperature. Electric fields during conventional SPS are not high enough to induce flash sintering in ionic-conductor or semiconductor ceramic materials. However, electric fields under this new mold design are stronger than in conventional SPS and could be tailored to induce flash sintering in a SPS furnace. This approach and the feasibility of inducing flash sintering in a SPS furnace will be discussed.