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Spark and plasma aided densification mechanisms during spark plasma sintering of ceramic powders

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Spark plasma sintering (SPS) currently used for rapid and full densification of ceramic particles assisted by a pulsed dc current passed through the powder compact. Our investigations with different ceramic powders (LiF, NiO, and YAG) as model systems discovered local melting of the particle and nano-particle surfaces, confirming the formation of spark and plasma during the SPS. However, spark and plasma form at certain material and process conditions. The ceramic yield stress and its electrical conductivity, and their temperature dependence mainly determine the conditions at which spark and plasma will take place in a given non-conducting granular compact. We introduce the conditions for plasma formation in soft deformable and hard non-deformable ceramic powders as model systems, through the Plastic Deformation-Plasma Formation Temperature Windows Diagrams. The different behavior at different oxide systems depend on the material properties, and the pressure and its application regime. These conditions also determine the nano- micro-structure evolution during the sintering by grain growth via grain-rotation and grain sliding.