Winter 3-9-2016

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Recommended Citation

[1] S. Grasso, Y. Sakka, G. Maizza, Sci. Tech. Adv. Mater., 10(2009) 053001

DEVELOPMENT OF ELECTRIC CURRENT ACTIVATED/ASSISTED SINTERING (ECAS/SPS)

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Key Words: SPS, temperature simulation, advanced ceramics, nanocomposite.

The electric current activated/assisted sintering (ECAS) is an ever growing class of versatile techniques for sintering particulate materials. ECAS was pioneered by Bloxam in 1906. As illustrated in Fig. 1, ECAS development is emblematic of its technological and scientific importance. Nowadays, most of the scientific attention is focused on the Spark Plasma Sintering (SPS) technology originated in 1966 by Dr. Inoue [1]. Essentially, SPS exploits the same punch/die system concept as the more familiar hot pressing (HP) process. The powder is placed in the die and subsequently pressed between two counter-sliding punches. Mechanical loading is normally uniaxial. SPS and HP differ significantly in the heating mode. Specifically, in HP an array of heating elements indirectly heats the punch/powder/die assembly by radiation and eventually by convection and/or conduction. The powder heating rate is controlled by the rate of radiation and/or convection and conduction. Conversely, in SPS, the punches transfer the electricity and Joule heat directly to the powder. As the supplied current density can be very large, the heating rate in the powder can approach 10^6 Ks^{-1}. The short sintering time, SPS is particularly suitable for: (a) preserving initial powder grain size or nanostructure, (b) consolidating amorphous materials, (c) improving bonding strength between particles and (d) controlling phase reactions or decomposition (in the case of composites).

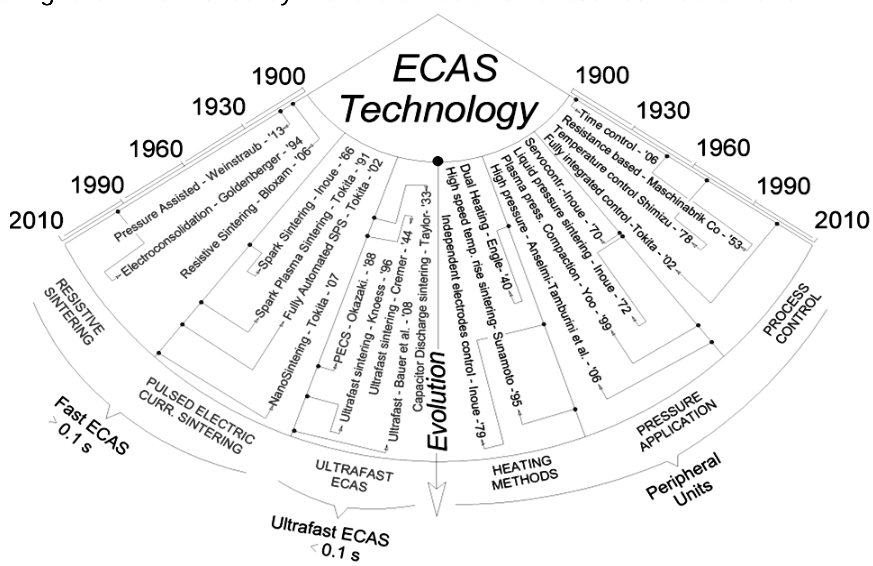

Fig. 1 Diagram tracing the evolution of ECAS technology over the past 110 years. The main patents corresponding to milestones in basic ECAS and peripheral units, are specified on the left- and right-hand sides, respectively.

In the SPS process, the measured temperature is not directly related to the sintering temperature. The combined experimental and FEM simulation analysis permitted to obtain the optimum process and mold design which permitted to have direct control of the final microstructure. The electric conductivity of the material plays a fundamental role on the current and temperature distribution inside the sample. The SPS method was successfully applied to electric conductive ceramics such as pure WC, WC-diamond, semiconductors, and low electrical conductive ceramics such as transparent alumina.
Here we will summarize future direction and problems in both fundamental research and industrialization of the SPS technology.

References:

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Acknowledgement: This study was partially supported by Grant-in-Aid for Scientific Research B from Japan Society for the Promotion of Science (JSPS).