Recent Progress of Spark Plasma Sintering (SPS) Method and Industrial use of Functionally Graded Materials (FGMs)

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Abstract

The growth of the advanced functional and structural materials industry, whether for applications of Functionally graded materials (FGMs), nano-phase materials, or other new materials must provide the end user with economic value and quality that justifies the commercial cost. The FGMs will always cost more than metallic or ceramic, monolithic or composite alternative materials because of the inherent cost of manufacturing method. Potentials for an industrial use of FGMs are hampered by the lack of an infrastructure for high volume manufacturing facilities at times. In order to overcome those existing issues, the low cost production systems are also desired.

Since two and half decades ago, Spark Plasma Sintering (SPS) method is of great interest to the powder and powder metallurgy industry and material researchers of academia for both product manufacturing and advanced material research and development. The SPS features to provide a rapid sintering as one of remarkable advantage of SPS technique with microstructure controlled sintering. Structurally tailoring effect in SPS processing was verified in the consolidation of nano-Al2O3, CeO2, WC, SiC and others. Therefore, it is generally well known that the SPS is an advanced processing technology to produce a homogenous highly dense nano-structural sintered compact in a shorter time than with conventional processes at a lower temperature. Functionally Graded Materials (FGMs), fine ceramics, composite materials, new wear-resistant materials, thermo-electric semiconductors and Bio materials are also recognized good effective applications.

This unique technique was originally invented in Japan as “Spark Sintering (SS)” in the early 1960s. Today, a number of SPSed products for different industries including FGMs are now being realized in Japan. Hardness gradient WC/Co system FGMs for stamping die tools and WC/Ni system weldable FGMs for extruding machine screw tools have practically been applied in the tooling industries. The SPS application has been getting into the industry use product stage through the scientific academia and/or R&D proto-type materials fabrication level such as in the field of molds and dies industry, cutting tools industry, electronics industry and automotive industry. The SPS has a high potential to be a major FGMs manufacturing method in the various industries provided the developments necessary, therefore, is now challenging both high-value added small scale and mass-production area to apply a newly developed Fifth generation SPS systems and processes.

Firstly, in my talk, a brief historical review on progress of SPS technology is given and the applicable fields and systems are exemplified. Then, present development and future prospects of SPS on research and industrialization activities will be introduced. The lecture is focused on industrialization of FGMs by SPS technology.

Keywords:
Spark Plasma Sintering, SPS, wear-resistant materials, WC/Co FGMs, nano powder, Industrialization