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Spark Plasma Sintering/Synthesis of Alumina-Graphene Composites

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Abstract : Nanocrystalline materials in powder condition can be manufactured by a number of different methods, however manufacture of composite materials product in the same nanocrystalline state is still a problem because the processes of compaction and synthesis of nanocrystalline powders go with intensive growth of particles – the process which promotes formation of pieces in an ordinary crystalline state instead of being crystallized in the desirable nanocrystalline state. To date spark plasma sintering (SPS) has been considered as the most promising and energy efficient method for producing dense bodies of composite materials. An advantage of the SPS method in comparison with other methods is mainly low temperature and short time of the sintering procedure. That finally gives an opportunity to obtain dense material with nanocrystalline structure. Graphene has recently garnered significant interest as a reinforcing phase in composite materials because of its excellent electrical, thermal and mechanical properties. Graphene nanoplatelets (GNPs) in particular have attracted much interest as reinforcements for ceramic matrix composites (mostly in Al2O3, Si3N4, TiO2, ZrB2 a. c.). SPS has been shown to fully densify a variety of ceramic systems effectively including Al2O3 and often with improvements in mechanical and functional behavior. Alumina consolidated by SPS has been shown to have superior hardness, fracture toughness, plasticity and optical translucency compared to conventionally processed alumina. Knowledge of how GNPs influence sintering behavior is important to effectively process and manufacture process. In this study, the effects of GNPs on the SPS processing of Al2O3 are investigated by systematically varying sintering temperature, holding time and pressure. Our experiments showed that SPS process is also appropriate for the synthesis of nanocrystalline powders of alumina-graphene composites. Depending on the size of the molds, it is possible to obtain different amount of nanopowders. Investigation of the structure, physical-chemical, mechanical and performance properties of the elaborated composite materials was performed. The results of this study provide a fundamental understanding of the effects of GNP on sintering behavior, thereby providing a foundation for future optimization of the processing of these promising nanocomposite systems.

Keywords : alumina oxide, ceramic matrix composites, graphene nanoplatelets, spark-plasma sintering
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