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Review

on the thesis for Doctor of Science Degree in Specialty 05.02.01, Materials Science at Institute for Problems in Materials Science, NAS of Ukraine, Kyiv, 2018. Title: **"Features of consolidation, formation of the structure and properties of ceramic materials in the processes of spark-plasma sintering"** (manuscript), by: ***Borodianska Hanna Yu.***

This work been devoted to the solving the scientific and technological problems related to preparation of dense bulk nanostructured ceramics with different types of conductivity and a different nature of the chemical bonding. The work approaches the possibility of structure control and further of physical functional properties by applying the powerful unconventional methods of spark plasma/flash sintering on presynthesized nanopowders and on nanodisperse products. Ceramics with nanograins can show improved or novel functionality, hence, they are of much interest for different applications, but to obtain such materials is not trivial and the degree of complexity is high. In this respect, physical and chemical processes that occur during sintering are studied and the accumulated knowledge allows achieving the proposed tasks and goals.

Design of technology with precise control of processing parameters (temperature, pressure, etc.) applied on powders with established morpho-structural and compositional features led to fabrication of sintered high quality ceramics within reactive or non-reactive approaches. Grains and grain boundary control made it possible to establish complex correlations between raw materials, processing and functional properties. This is essential to guarantee the reproduction of results in practice.

The production of materials with a bulk density close to theoretical values, where the grain size is less than 100 nm was demostrated by using SPS in its flash mode. The key to this result is high-rate sintering under pressure, which created the conditions for separation of consolidation and grain growth processes. The potential and advantages of SPS-technique for preparation of different ceramics with grains in the nanosize range (<100 nm) are emphasized. Than it shows the results of the SPS-development for sintering of nanodispersed oxide powders with ionic (oxygen-ion) type of conductivity. Materials are zirconia doped with yttrium oxide (YSZ) and cerium oxide doped with gadolinium oxide (CGO). The choice of zirconia-stabilized yttrium oxide as a model material in the class of oxide ceramics for investigating the patterns of pores-sealing during SPS is due to availability of "quasi"-monocrystalline particles of this material in various sizes and shapes.

Also author studied the nanopowders sintering in the mode of thermal runaway – "flash"-SPS. It is shown that an almost instantaneous sintering to high densities of 3Y–TZP nanopowder occurs. It is confirmed that despite a number of shortcomings, "flash" sintering can dramatically reduce sintering time from hours in traditional sintering or from tens of minutes in typical SPS to dozens of seconds. The method of consolidation of nanopowder by "flash"-SPS, supresses the grain growth resulting in formation of materials with unique nanostructures. High localization of heating and short processing time may also promote specific features and properties. "flash"-SPS sintering of nanopowders is successfully demonstrated for the first time.

Very promising methodology of reactive SPS of unique B_aC_b–(B_xO_y/BN) composite with a nanolamellar B_xO_y/BN 3D-grain boundary framework is developed. The 3D-grain boundary framework B_xO_y/BN is the result of reactions of N_2 with the initial boron carbide powder (B_4C covered by B_2O_3 grains). The nanocomposites B_aC_b–(B_xO_y/BN) exhibit bending strength of up to 800 MPa in the temperature range from 25 to 1600 °C. The complex relation between SPS conditions, consolidation mechanisms, features of boron carbide ceramics and static and dynamic mechanical properties of consolidated ceramics has been analyzed. The possibility of controlling the dynamic mechanical properties as tested by Split Hopkinson Pressure Bar (SHPB) method by optimization of the reactive SPS conditions is attempted. A significant five times improvement of the dynamic toughness of massive boron carbide ceramics from ~6 to ~30 MJ/m^2 was obtained. Such bulk ceramic parts expected to be applied in constructions, and for lightweight protection.

Sure the DSc thesis of Borodiansca Hanna "Features of consolidation, formation of the structure and properties of ceramic materials in the processes of spark-plasma sintering" and all her 37 published papers are the high quality scientific work established on the highest scientific level and will be useful for further scientific and technological application. Dr. Hanna Borodianska is definitely eligible to be awarded of Doctor of Science degree on specialty 05.02.01 – Material Science .

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