Winter 3-9-2016

Engineering of lightweight ceramic composites by spark plasma sintering

Oleg Vasylkiv
Nanyang Technological University, Singapore, ovasylkiv@ntu.edu.sg

ENGINEERING OF LIGHTWEIGHT CERAMIC COMPOSITES BY SPARK PLASMA SINTERING

Dmytro Demirskyi, Temasek Laboratories, Nanyang Technological University, 50 Nanyang Avenue, 639798 Singapore
Hanna Borodianska, National Institute for Materials Science, 1-2-1 Sengen, Tsukuba, Ibaraki 305-0047, Japan
Yoshio Sakka, National Institute for Materials Science, 1-2-1 Sengen, Tsukuba, Ibaraki 305-0047, Japan
Oleg Vasylkiv, National Institute for Materials Science, 1-2-1 Sengen, Tsukuba, Ibaraki 305-0047, Japan; Temasek Laboratories, Nanyang Technological University, 50 Nanyang Avenue, 639798 Singapore, Oleg.VASYLKIV@nims.go.jp, OVasylkiv@ntu.edu.sg

Key Words: spark plasma sintering, reaction-driven consolidation, boron carbide, mechanical properties, high-temperature strength .

It is well recognised that value of porosity and grain size influences mechanical properties such as fracture toughness, elastic modulus and strength dramatically. Boron carbide (B_4C), as well as other lightweight ceramics like TiB_2, B_6O requires high consolidation temperatures owing to its poor sinterability. Therefore such decrease of ceramics properties becomes a materials processing issue since during consolidation process on the final stage of sintering (either pressure-assisted or pressureless one) grain growth starts. To overcome this problem, various metallic and non-metallic binders are used to obtain dense borides. However, the presence of a metallic binder is not desirable for high-temperature structural applications. We propose that reaction-driven consolidation by means of spark plasma sintering (SPS) at temperatures exceeding 1800 °C as an alternative method for fabrication of high-temperature lightweight ceramic composites.
This work summarizes recent activity on processing of lightweight ceramics based on boron carbide, boron suboxide and titanium diboride in the respect to mechanical properties: such as hardness, fracture toughness and room and high-temperature strength. Application of various techniques for powders preparation and consolidation by SPS is thoroughly discussed in respect to obtained lightweight ceramic composites properties. A thorough discussion of high-temperature properties for these ceramic composites is also provided.