Self-Propagating High-Temperature Synthesis of Advanced Ceramic Composites

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ABSTRACT

Formation of advanced ceramic composites was investigated by self-propagating high-temperature synthesis (SHS) in this study. The combustion characteristics, including combustion wave propagation, flame-front velocity and combustion temperature, were derived from the image and data acquisition system. According to the calculated adiabatic combustion temperatures, experimental measurement of combustion velocity and temperature was verified. In addition, the dependence of nitridation percentage on experimental parameters was obtained. Finally, the product analysis by XRD and the microstructure observation by SEM were conducted. The first part of experiment used Boron Carbide (B4C), Titanium (Ti), Tantalum (Ta), Carbon Black (C) and Boron (B) as raw materials to produce TiB2-TiC, TiB-TiC, TiB2-SiC, TaB2-TaC and TaB-TaC. The experimental results showed that the combustion wave is steady and the reactant is viloent in the synthesis of TiB2-TiC and TiB2-SiC. The combustion velocity and temperature increased with TiB2 mole fraction from 20 to 66.67 mol%. XRD analyses indicated no intermediate products. When the reactants contained a small amount of Ni, the products had the Nitinols (Ni3Ti and NiTi) and TiB as well as remaining Ni. In the case of TaB2-TaC, the combustion wave was also steady, the combustion velocity was lower and combustion temperature was about 1400°C. The composition alalysis showed that in addition to TaB2 and TaC, there were two intermediates TaB and Ta5B6 when boron was added into the reactant. The second part of experiment was to fabricate (α+β)-SiAlON by Ytterbium Oxide (Yb2O3), Silicon (Si), Silicon Nitride (Si3N4), Silicon Oxide (SiO2) and Aluminum (Al). Furthermore, the molar ratio of Si：Si3N4 in the sample was equal to 2.5：1, 3：1 and 3.5：1, and two types (α and β) of Si3N4 were adopted. The experimental result showed that the combustion wave is abnormal because the reaction process has two reaction zones propagating in a spinning or chaotic mode. The spinning phenomenon was not obvious when the reactant used β-Si3N4 powder. The average velocity of the combustion wave is about 0.8-1.1 mm/s and the combustion temperature varies between 1200 and 1400 oC. When the content of α-Si3N4 powders increased in the sample, the amount of Si left unreacted increased. The sample nitridation was improved by increasing the content of Si3N4; i.e. by decreasing the molar ratio of Si to Si3N4. Additionally, the microstructure of (α+β)-SiAlON shows the rod- and plate-like grains, respectively.

Keywords : SHS, B4C, SiAlON; Si3N4; XRD, Flame propagation velocity; Nitridation percentage.

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