

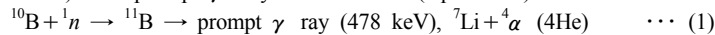
PT-3

New Boron Compound, Silicon Boride Ceramics for Capturing Thermal Neutrons (Possibility of the material application for nuclear power generation)

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As you know, boron compounds, borax ($\text{Na}_2\text{B}_4\text{O}_7 \cdot 8\text{H}_2\text{O}$) etc. were known thousands of years ago. As for natural boron, it has two naturally occurring and stable isotopes, boron 11 (^{11}B) and boron 10 (^{10}B). The neutron absorption ^{10}B is included about 19~20% with 80~81% ^{11}B . Boron is similar to carbon in its capability to form stable covalently bonded molecular networks. The mass difference results in a wide range of β values between the ^{11}B and ^{10}B . The ^{10}B isotope, stable with 5 neutrons is excellent at capturing thermal neutrons. For example, it is possible to decrease a thermal neutron required for the nuclear reaction of uranium 235 (^{235}U). If ^{10}B absorbs a neutron (1_0n), it will change to $^7\text{Li} + ^4\alpha$ (α ray, like ^4He) with prompt γ ray from ^{11}B ^{11}B (equation 1).



If about 1% boron is added to stainless steel, it is known that a neutron shielding effect will be 3 times the boron free steel. Enriched boron or ^{10}B is used in both radiation shielding and in boron neutron capture therapy. Then, ^{10}B is used for reactivity control and in emergency shutdown systems in nuclear reactors. Furthermore, boron carbide, B_4C , is used as the charge of a nuclear fission reaction control rod material and neutron cover material for nuclear reactors. The B_4C powder of natural B composition is used as a charge of a control material of a boiling water reactor (BWR) which occupies commercial power reactors in nuclear power generation. The B_4C sintered body which adjusted ^{10}B concentration is used as a charge of a control material of the fast breeder reactor (FBR) currently developed aiming at establishment of a nuclear fuel cycle. In this study for new boron compound, silicon boride ceramics for capturing thermal neutrons, preparation and characterization of both silicon tetraboride (SiB_4) and silicon hexaboride (SiB_6) and ceramics produced by sintering were investigated in order to determine the suitability of this material for nuclear power generation. The relative density increased with increasing sintering temperature. With a sintering temperature of 1,923 K, a sintered body having a relative density of more than 99% was obtained. The Vickers hardness increased with increasing sintering temperature. The best result was a Vickers hardness of 28 GPa for the SiB_6 sintered at 1,923K for 1 h. The high temperature Vickers hardness of the SiB_6 sintered body changed from 28 to 12 GPa in the temperature range of room temperature to 1,273 K. The thermal conductivity of the SiB_6 sintered body changed from 9.1 to 2.4 W/mK in the range of room temperature to 1,273 K.

Keywords: Silicon boride ceramics, Thermal neutrons, Control rod