Densification Behavior of BN-added UO_2

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1. Introduction

Boron is commercially used as a neutron absorber fuel. A neutron absorber fuel is burned out or depleted during reactor operation. Westinghouse have been produced the Integral Fuel Burnable Absorber (IFBA) which is enriched UO_2 fuel pellets with a thin coating of zirconium diboride (ZrB_2) on the outer surface. Standard sintered fuel pellets are sputter coated with ZrB_2. It is known that IFBA fuel can incur 20% to 30% additional fabrication costs. [1]

Boron-dispersed UO_2 fuel pellet made by the conventional pressing and sintering process of a powder mixture of UO_2 and B compound might be more cost-effective than IFBAs. M. G. Andrew et al. [2] tried to sinter boron-dispersed UO_2 green pellet. However, they reported that boron-dispersed UO_2 fuel pellet is very difficult to be fabricated with a sufficient level of boron retention and high sintered density (greater than 90 % of theoretical density) because of the volatilization of boron oxide.

We have investigated the densification behavior of mixtures of UO_2 and various boron compounds, such as B_4C, BN, TiB_2, ZrB_2, SiB_6, and HfB_2. Boron compounds seemed to act as a sintering additive for UO_2 at a certain low temperature range. [3-5]

In this study, the densification behavior of BN-added UO_2 pellet has been investigated by sintering green pellets of a mixture of UO_2 powder and BN powder in H_2 atmosphere.

2. Experimental

ADU route UO_2 powder and 70 nanometer-sized BN powder were used for sample preparation. UO_2 powder and BN powder were mixed and crushed in a ball mill for 24 h using an ethanol medium. A dried powder mixture was granulated with a 30 mesh sieve. The granules were mixed with a 0.3 wt% of zinc stearate in a tumbling mixer for 30 min. The compaction was conducted in a single acting press under about 3 ton/ cm^2. Green pellets were sintered at 1100 °C and 1400 °C for 1 to 4 h in a H_2 atmosphere. The sintered density was measured by a water immersion method. Microstructures were observed using an optical microscope after polishing the cross-section of the sintered pellet up to a 1 μm diamond polish. Residual boron content in the sintered pellets was measured by Prompt Gamma Activation Analysis (PGAA) at HANARO.

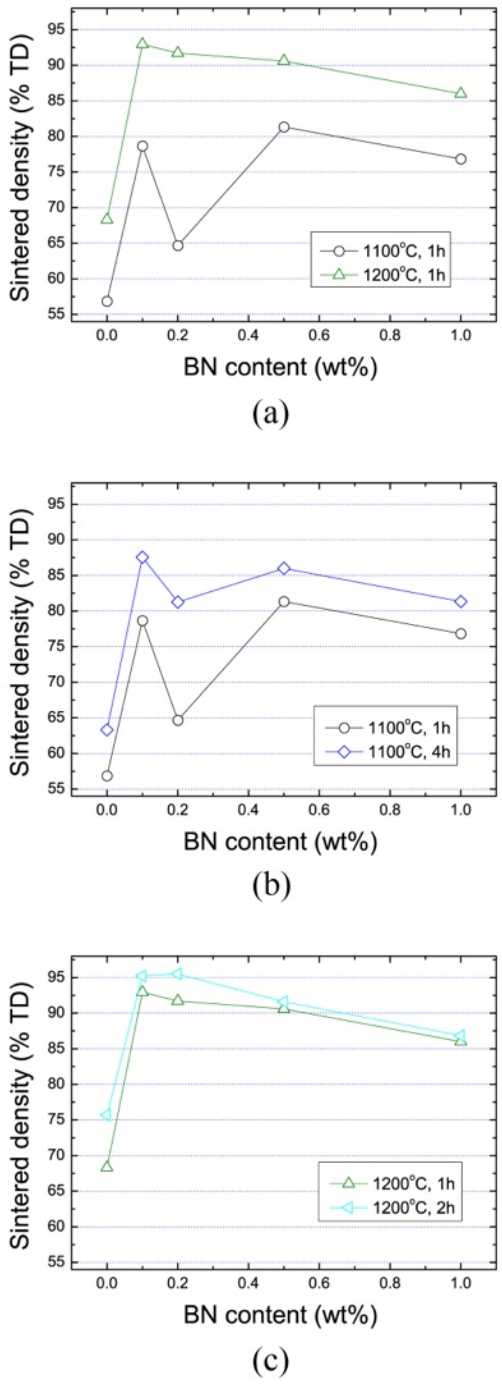

Fig. 1. Sintered densities of BN containing UO_2 pellets with various BN contents.

3. Results

Measured sintered densities of sintered pellets with various initial BN contents were represented in Fig. 1 according to the sintering temperature and time. It appears that the densification of BN-added UO_2 pellet is significantly enhanced compared with that of pure UO_2 pellet. Even an addition of 0.1 wt% BN considerably increases the sintered density, and then the sintered seems to gradually decrease with increasing the BN addition. It might be attributed to the volatilization of excess boron oxide. BN-added UO_2 pellet can be densified up to about 95 % of theoretical density at 1200 °C for more than 1 h in a H_2 atmosphere.

4. Conclusions

A high density BN-added UO_2 pellet can be fabricated after sintering at 1200 °C for more than 1 h in a H_2 atmosphere. The sintered density of BN-added UO_2 pellet can be increased up to about 95 %TD. Enhanced densification behavior of BN-added UO_2 pellet might be attributed to fast material transfer through the boron oxide liquid phase which is formed by the decomposition of BN. An appropriate amount of boron compound seemed to have an effect on the densification enhancement of UO_2 pellet during sintering at a certain low sintering temperature in a H_2 atmosphere.

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