EFFECTS OF TRANSITION METALS ON THERMAL PROPERTIES OF ZrB_2

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Nominally phase pure zirconium diboride ceramics were synthesized to study their intrinsic thermal properties. Ceramics for this study were synthesized by reaction hot pressing of reactor grade ZrH_2 and B to minimize impurities commonly found in commercial powders such as the natural abundance (1-4 wt%) of Hf. Starting powders contained <200 ppm Hf. Previous results showed that Hf impurities present in quantities comparable to commercial powders masked the effect of other transition metal additions. For example, additions of 3 at% Ti and Y had no apparent effect on thermal conductivity of ceramics produced from commercial ZrB_2. Lowering the Hf content to 0.4 at% increased thermal conductivity from ~90 W/m•K for ZrB_2 ceramics prepared from commercial powders to ~100 W/m•K for low-Hf content ZrB_2 at 25 °C. Lowering the Hf content also increased the thermal conductivity at 2000°C from ~70 W/m•K to ~80 W/m•K. For the low Hf ZrB_2, adding 3 at% TiB_2 decreased thermal conductivity ~15 W/m•K at 25°C while adding 3 at% MoB_2 decreased thermal conductivity ~45 W/m•K at 25°C.

For the present study, transition metals such as Hf, Ti, Y, Ta, and W were added individually to nominally phase pure ZrB_2 to study the effects on thermal diffusivity, thermal conductivity and heat capacity at temperatures from 25°C to 2000°C. These properties will be compared to values obtained for ceramics prepared from commercial ZrB_2 powders, which contained the natural abundance of Hf.

Most previous reports have relied on heat capacity values from the NIST-JANAF thermodynamic tables to calculate thermal conductivity of ZrB_2 ceramics. However, the heat capacity of ZrB_2 with low Hf content was approximately 10% greater than widely accepted values. Due to this difference, heat capacity will be measured for each composition, and these values will be used to calculate thermal conductivity.

The intrinsic thermal properties of ZrB_2 will be discussed as well as the effect of transition metal additions on the thermal properties of ZrB_2 with low and naturally abundant quantities of Hf.