THERMAL PROPERTIES OF ZIRCONIUM DIBORIDE CERAMICS

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This presentation will focus on the thermal conductivity of zirconium diboride ceramics. Previous reports of thermal conductivity values for ZrB_2 vary from as low as about 30 W/m•K to over 100 W/m•K without any direct evidence to identify the reasons for the variations. Our group systematically investigated the effects of transition metal impurities, which led to the discovery that the size of the dissolved impurity species was directly related to the decrease in thermal conductivity. Analysis of the electron contribution to thermal conductivity utilizing the Wiedemann-Franz methodology led to the conclusion that both the phonon and electron contributions were affected by dissolved metallic impurities. Further, the effects of some transition metals including Ti and Y were masked by other impurities in ceramics produced from commercial ZrB_2 powders.

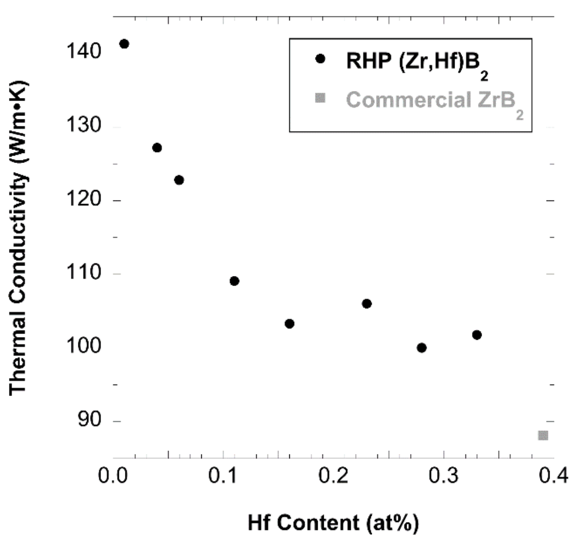

Figure 1 – Thermal conductivity as a function of Hf content in ZrB_2 ceramics prepared by reactive hot pressing (RHP) or by hot pressing of commercial ZrB_2 powder.

Based on these studies, reactive hot pressing (RHP) was used to produce a series of ZrB_2 ceramics with controlled additions of Hf. The typical natural abundance of Hf in Zr-bearing ores is on the order of 0.5 wt%, but Hf is removed for nuclear applications due to its neutron absorption. Thermal conductivities as high as ~140 W/m•K were achieved when Hf content was reduced due to increases in both thermal diffusivity and heat capacity with decreasing Hf content. Additional increases in thermal conductivity were achieved by controlling the B isotope content of the ZrB_2 ceramics.

The presentation will conclude with discussion of the remaining research challenges related to the thermal properties of diboride ceramics.