Designing Superhard Materials: Rhenium Diboride

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Applications such as refractory and abrasive cutting and grinding require superhard materials, such as diamond or cubic boron nitride. Recent analysis in our laboratory has shown the potential of rhenium diboride (ReB_2) to be a metallic superhard material. To increase the hardness of ReB_2, solid solution and grain size hardening treatments were performed. Solid solution hardening was performed on ReB_2 by doping with 2%, 4%, and 10% TiB_2 as well as 2% Ti. Doping ReB_2 with 2% Ti increased the hardness by 14.4% at the lowest applied load of 0.49N while the addition of 2% TiB_2 increased the hardness (6.4% - 26.1%) over a load range of 0.49 to 2.9N. Higher concentrations of TiB_2 showed a minimal increase in hardness compared to pure ReB_2. Ball-milling was used to reduce the crystallite size of pure ReB_2 for grain size hardening; this method reduced the average crystallite size from approximately 50 nm to 20 nm as shown through peak broadening in x-ray diffraction patterns. Sintering and densification of ball-milled ReB_2 crystallites are currently underway and hold potential to dramatically increase the material hardness through grain size refinement.