The Synthesis and Mechanical Properties of Nanostructured Plasma Formed W-HfC Bulk Components

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To broaden the useful range and thermomechanical application of tungsten-based alloys, some certain characteristic qualities of the high temperature material could be modified using theories of nanotechnology and metallurgical principles. Tungsten possesses the highest melting point and a small coefficient of thermal expansion, which leads to applications in environments wherein high temperature mechanical deformation is the primary mode for material failure. Some composites, such as TiC, have been added into the tungsten matrix in successful attempts to further strengthen the high temperature resilience of the material, whereas tungsten has a tendency of low strength at rising temperatures [1]. A synthesis method has been developed and applied that enables the production of bulk components through the plasma forming method, rapid solidification under vacuum, and subsequent mechanical removal of the solid part from the substrate of the deposition mandrel [2]. For the purpose of bringing a reinforcing element that would provide a higher strength in the highest temperature regions, a nanoscale reinforcement of halfnium carbide particles has been shown to increase the mechanical functionality of the bulk components. To ensure the proper path and velocity of the nanoreinforcements in the plasma arc, the halfnium carbide was agglomerated to raise the mean particle diameter using the process of spray drying (figure 1). The starting powder, the agglomerate powder, and the final bulk component is analyzed using scanning electron microscopy, transmission electron microscopy, and nanoindentation. Transmission electron microscopy reveals the retention of nanostructure in the dispersed larger tungsten matrix (see figure 2, 3). There is a presence of microstructured defects, including fault lines that would raise the inherent strength of the material. The component was also investigated using nanoindentation.

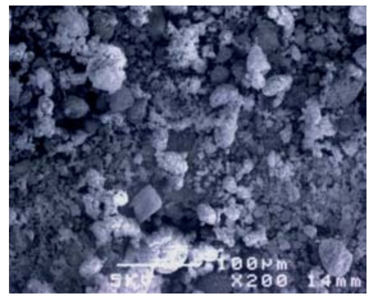

Figure 1. Spray dried agglomerated W-HfC powder with mean diameter of > 10 μm viewed in SEM.

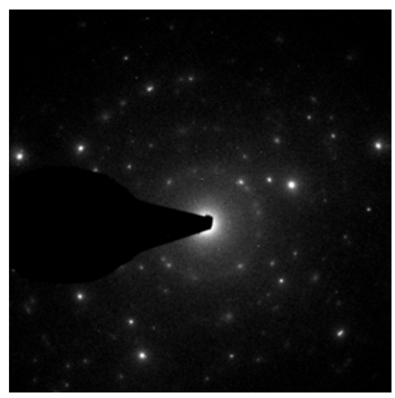

Figure 2. SAED elicits nano-polycrystalline ring structure.

Figure 3. TEM micrograph showing stressed regions and defects.

References

1. Song, Gui-Ming, et al. Thermomechanical properties of TiC particle-reinforced tungsten composites for high temperature applications. *International Journal of Refractory Metals & Hard Materials*, 2003.
2. McKechnie, T. and A. Agarwal. Spray-forming Aluminum Structures. *Advanced Materials and Processes*, 2000.