

The effects of TiC network microstructure on the mechanical properties of spark plasma sintered Al₂O₃

Umut Savaci¹, Salih Cagri Ozer¹, Eren Can¹, Yiğit Berkcan Harmankaya¹, Servet Turan^{1,2}
¹Eskisehir Technical University, Department of Materials Science and Engineering, Eskisehir, Turkey, ²Ceramic Research Center, Eskisehir, Turkey

Background incl. aims

Al₂O₃-based composite materials are widely used for cutting tool applications due to their high strength, hardness and wear resistance. Despite these ideal mechanical properties, having low fracture toughness values and brittleness present problems during application. This study aimed to improve both the hardness and fracture toughness of Al₂O₃ simultaneously by taking advantage of different mechanisms with TiC network structures. Hardness was aimed to be increased by introducing the TiC secondary phase with high hardness throughout the Al₂O₃ matrix. On the other hand, fracture toughness was aimed to be improved by promoting crack deflection mechanisms by the formed network structure.

Methods

Al₂O₃ ceramics with TiC network microstructures were produced by the spark plasma sintering (SPS) technique by coating the Al₂O₃ granules with 2-10 vol.% TiC powders, utilizing a simple dry coating method. The sintering process was carried out at a minimum of 1400°C dependent on the TiC content. The effects of various amounts of TiC addition and differing sintering temperatures on the microstructural and mechanical properties of Al₂O₃ were observed by scanning electron microscopy techniques as well as mechanical testing.

Results

Network structures of TiC were formed successfully around the Al₂O₃ matrix during the SPS process, resulting in simultaneous improvement of hardness and fracture toughness. Present TiC and Al₂O₃ phases were confirmed by the X-ray diffraction analysis. The fracture toughness of Al₂O₃ was improved by crack deflection and bridging mechanisms induced by the introduction of the network structure, as observed by the microstructural investigations. In addition, Vickers microhardness values of the samples were found to be increased with increasing volume fraction of TiC.

Conclusion

As a conclusion, in this study, mechanical properties of the Al₂O₃ ceramics were successfully improved by the formation of TiC network around Al₂O₃ granules. Electron microscopy studies revealed the formation of the continuous network around the matrix and microstructural features such as grain size, and porosity as well as toughening mechanisms. This study was supported by Eskişehir Technical University Scientific Research Projects Commission under grant no 23ADP195

Keywords:

Al₂O₃, TiC, Network, SPS, Properties