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Microhardness of Boron Carbide Composites Reinforced with High Entropy Alloy: Statistical Analysis

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ABSTRACT

Introduction

Boron carbide (B_4C) is widely recognized as one of the most promising ceramic materials due to its high hardness, low density and chemical stability in aggressive environments. B_4C is used in many high demanding engineering fields such as tribological, refractory, nuclear or ballistic industry. However, worldwide research continues into improving its properties so that it can replace diamonds in different industrial applications. A recent strategy for improving its mechanical properties has been to incorporate high-entropy alloys (HEA) as reinforcement, taking advantage of the complexity of their multi-element configurations to induce synergies at the microstructural level. This paper presents a detailed statistical study of the microhardness of B_4C-based composites reinforced with different percentages of HEA and compares it with a monolithic B_4C sample manufactured under the same conditions. The objective is to quantify the variability of the mechanical response and establish significant trends associated with the reinforcement content.

Experimental

The experimental methodology was based on the preparation of five samples: monolithic B_4C and doped with 0.5%, 1%, 2%, and 3% by volume of HEA CoCrFeNiMo, synthesized by spark plasma sintering (SPS-7.40 MK-VII, SPS Syntex Inc., Saitama, Japan) at Istanbul Technical University (ITU). Afterwards, the samples were embedded, polished till mirror finish (tegraPol-11 system, Struers, Copenhagen, Denmark) and subjected to the different tests. Scanning Electron Microscope (FESEM JSM 7000 F, JEOL Ltd., Tokyo, Japan) was used for microstructural characterization and afterwards Vickers microhardness tests (FM-810 Microhardness Tester, Future Tech, Kawasaki, Japan) under a load of 2 kgf, with a minimum of 45 indentations performed in each case, according to the ISO 14577-1:2015 standard. The analysis focused on determining the mean hardness value, its standard deviation and the normal distribution.

Results and discussion

The results show a general trend toward increased average hardness with increasing HEA content, with the highest value being reached in the sample with 3%. Based on the SEM data, this behavior is attributed to the presence of HEA in the pores of the ceramic matrix, which acts as an effective reinforcement by restricting the propagation of microcracks and