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Akhtar, S.S., Waqar, T., Hakeem, A.S., Arif, A.F.M., Al-Athel, K.S.

Design and development of hybrid Al2O3 based composites with toughening and self-lubricating second-phase inclusions
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Abstract
Polycrystalline ceramics, such as alumina (Al2O3), are brittle and they generally wear by fracture mechanism, which limits their potential in tribological applications. In the present work, computational design tools are used to develop hybrid Al2O3 composites reinforced with best combinations of toughening and self-lubricating second-phase particles for cutting tool inserts in dry machining applications. A mean-field homogenization approach and J-integral based fracture toughness models are employed to predict the effective structural properties (such as elastic modulus and fracture toughness) and related to the intrinsic attributes of second- phase inclusions in Al2O3 matrix. Silicon carbide (SiC), boron nitride (cBN and hBN), zirconia (ZrO2), graphite, titanium dioxide (TiO2), and titanium carbide (TiC) were found the most suitable candidates to be added in Al2O3 matrix as individual or hybrid combinations. A series of samples including standalone Al2O3, single inclusion composites (Al2O3/SiC, Al2O3/cBN) and hybrid composites (Al2O3/SiC/cBN, Al2O3/SiC/TiO2 and Al2O3/SiC/graphite) are sintered by Spark Plasma Sintering (SPS) for validation purpose. Properties of the sintered composites are measured and compared with the proposed computational material design. Composition and phase transformation of the sintered samples are studied using X-ray diffraction (XRD) and Raman spectroscopy, while their morphology is studied using Field Emission Scanning Electron Microscope (FESEM). The presented nontraditional material design approach is found to significantly reduce experimental time and cost of materials in developing toughened and anti-friction ceramic composites. © 2019 by the authors.

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