1. Introduction

B₄C based ceramics exhibits many attractive properties for structural materials such as high melting point, low density, good chemical stability, high wear resistance, and high hardness, which enables them to be used for wear resistant parts, light weight armor, and cutting tool [1-4]. However, B₄C-based ceramics have some major problems such as low strength and fracture toughness compared with other competitive engineering ceramics such as Si₃N₄ and SiC. Furthermore, B₄C-based ceramics have very poor sinterability due to its low self diffusion coefficient. Many researches have been performed to improve the mechanical properties as well as sinterability of B₄C-based ceramics [3-12]. The studies reveal that it would be a challenge to achieve both improvements in sinterability and mechanical properties. Therefore, in this study, reactive sintering process was performed to prepare fully dense B₄C-based ceramic composites by adding SiC and TiC into B₄C matrix at a relatively low temperature. The effect of adding SiC and TiC on sinterability and mechanical properties of B₄C-based ceramic composites was investigated.

2. Experimental and Results

In this study, B₄C, TiC, and SiC powder were used as starting materials. B₄C, SiC, and TiC powder were mixed with a composition of B₄C : SiC : TiC = 50~75 : 20 : 5~30 in wt. % using SPEX™ mill for 10 min in Ar atmosphere. B₄C-based ceramic composites were fabricated by hot pressing at the temperature range of 1950 °C under 40 MPa for 0.5 h in Ar atmosphere. After the fabrication process, phase identifications of fabricated B₄C-based ceramic composites were done by X-ray diffraction (XRD) method with Cu-k radiation. The polished surface of fabricated B₄C-based ceramic composites was electrochemically etched in 20% HNO₃ solution, and then examined by scanning electron microscope (SEM). The three-point bending tests were performed to measure the toughness by single edge notched beam method of B₄C-based ceramic composites specimen with dimensions of about 3 x 4 x 25 mm.

Fig.1 shows XRD patterns of fabricated B₄C-based ceramic composites by hot pressing. The crystalline phases in B₄C-based ceramic composites comprise B₄C, TiB₂, SiC and graphite. The newly formed TiB₂ and graphite was embedded both inside grain and at grain boundary of B₄C. The mechanical properties of reaction synthesized B₄C-TiB₂-SiC-graphite composites were more enhanced compared to those of monolithic B₄C.

Keywords : B₄C, composite, reaction synthesis, mechanical property
materials, intensities of XRD peaks for TiB₂ and graphite increases as shown in Fig. 1. Fig. 2 shows the SEM microstructures of fabricated B₄C-based ceramic composites. SiC and newly formed phases were relatively well distributed inside B₄C grain as well as along the B₄C grain boundaries. With increase TiC content, newly formed phases and SiC dispersions formed another interconnected matrix along with B₄C matrix. From the EDS analysis, dispersions as shown in Fig. 3(c), the gray colored and white colored phase were identified as SiC and newly formed TiB₂ phase, respectively. Fig. 3 shows the flexural strength and fracture toughness of B₄C-based ceramic composites fabricated in this study.

![Fig. 2. SEM microstructures of B₄C composites by hot pressing of (a) 75 w/o B₄C:20 w/o SiC:5 w/o TiC, (b) 70 w/o B₄C: 20 w/o SiC: 10 w/o TiC, and (c) back scattered SEM microstructure of (b).](image)

3. Summary

In this study, B₄C-TiB₂-SiC-graphite composites were synthesized by reactive hot pressing using B₄C, TiC and SiC powder as starting materials. The mechanical properties of reaction synthesized B₄C-TiB₂-SiC–graphite composites fabricated in this study showed significant improvements compared to those of monolithic B₄C and other B₄C-based ceramic composites reported in the previous studies. The flexural strength and fracture toughness of these in-situ B₄C synthesized composites were 400-570 MPa and 6-9.5 MPa m⁻¹/², respectively. The enhanced fracture toughness of B₄C based ceramic composites are considered to be due to the severe crack deflection at the phase boundary between B₄C matrix and dispersions consisting of SiC and TiB₂, which occur by residual stress from the difference in thermal expansion coefficients of B₄C, SiC, and TiB₂ upon cooling from the fabrication temperature.

4. References