Interfacial Structure of Si_3N_4/SiC Nanocomposites by High Resolution Electron Microscopy

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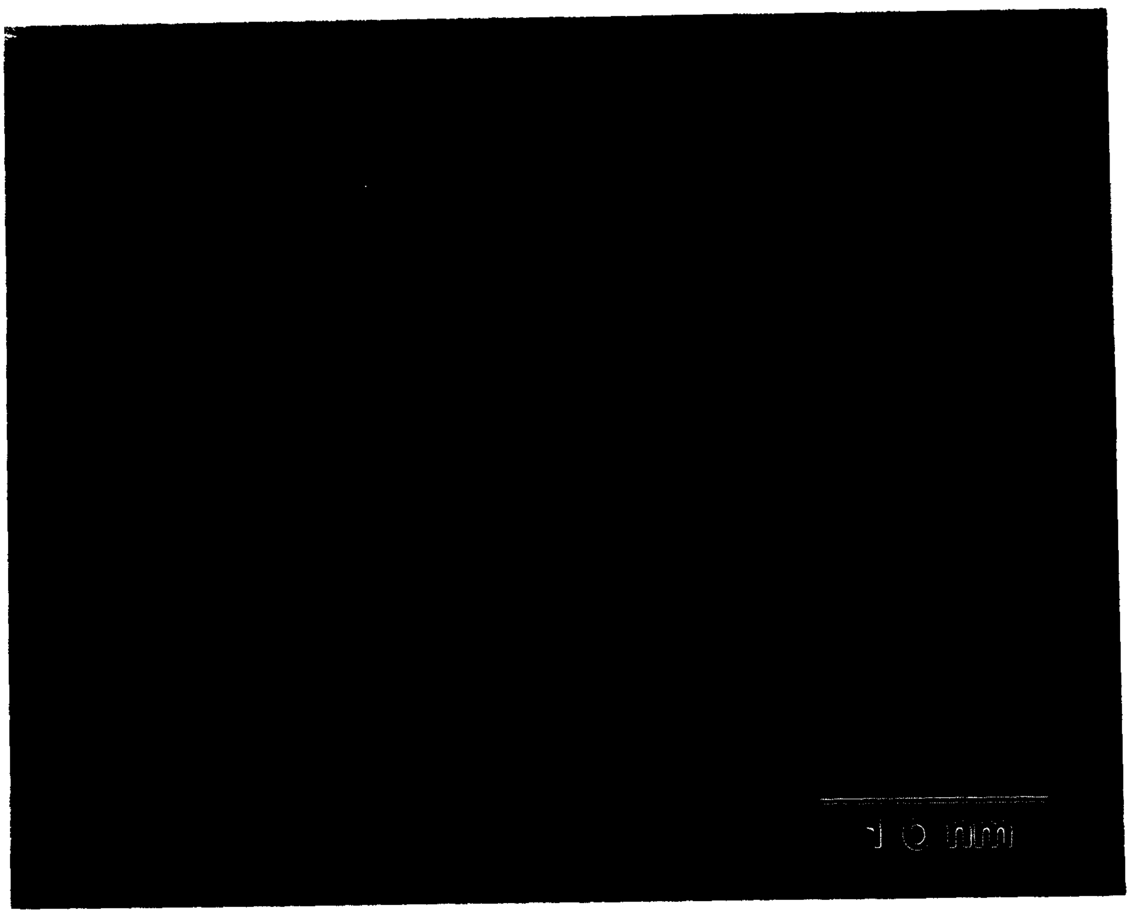
Si_3N_4/SiC nanocomposite is Si_3N_4 matrix composite with dispersion of nano-size particles which are distributed both inside Si_3N_4 grains and at grain boundaries. The nanocomposites show improved mechanical properties compared to monolithic Si_3N_4 ceramics.

It is well known that Si_3N_4 based ceramics contains a residual grain boundary amorphous phase formed by reaction between sintering additives and the surface SiO_2 on Si_3N_4 powder surfaces. Grain boundary phases influence the high temperature strength of Si_3N_4 based ceramics, because the grain boundary phases soften at elevated temperature.

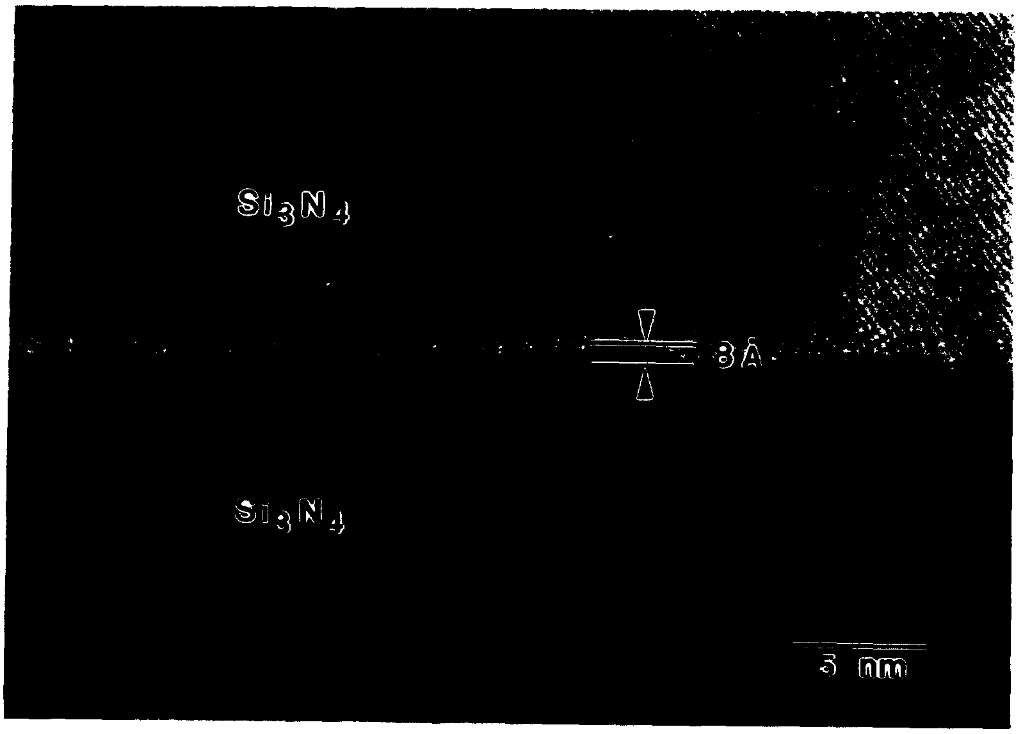
In this study, Si_3N_4/20 vol% SiC nanocomposites were fabricated by hot pressing. In addition to grain boundary phase, the change of microstructure by addition of SiC particles, such as grain morphology, distribution of SiC particles and Si_3N_4/SiC interfaces should influence on high temperature strength of Si_3N_4/SiC nanocomposites. Microstructural analysis was conducted by XRD, SEM, TEM and HREM to investigate the relationship between mechanical properties and microstructure of the nanocomposites.

Si_3N_4/SiC nanocomposites with 4 wt% Y_2O_3 as sintering additive showed fracture strength of 1050 MPa at room temperature, and strength was retended up to 1400℃ with slight strength degradation. Retention of strength at high temperature can be attributed to grain boundary phase and interfacial structure. XRD result showed that grain boundary phase was crystallized during cooling from hot pressing temperature, and then strength degradation of the nanocomposite was occurred higher temperatures compared to Si_3N_4 monolith. HREM analysis of the nanocomposite with 4 wt% Y_2O_3 revealed that intergranular SiC particles were directly bonded to matrix grains without amorphous layer, even though thin amorphous layer was remained at some grain boundaries. Therefore, significant improvement of strength at high temperature can be attributed to the suppression of grain boundary sliding by the directly bonded SiC particles with matrix grains and crystallization of grain boundary phases..

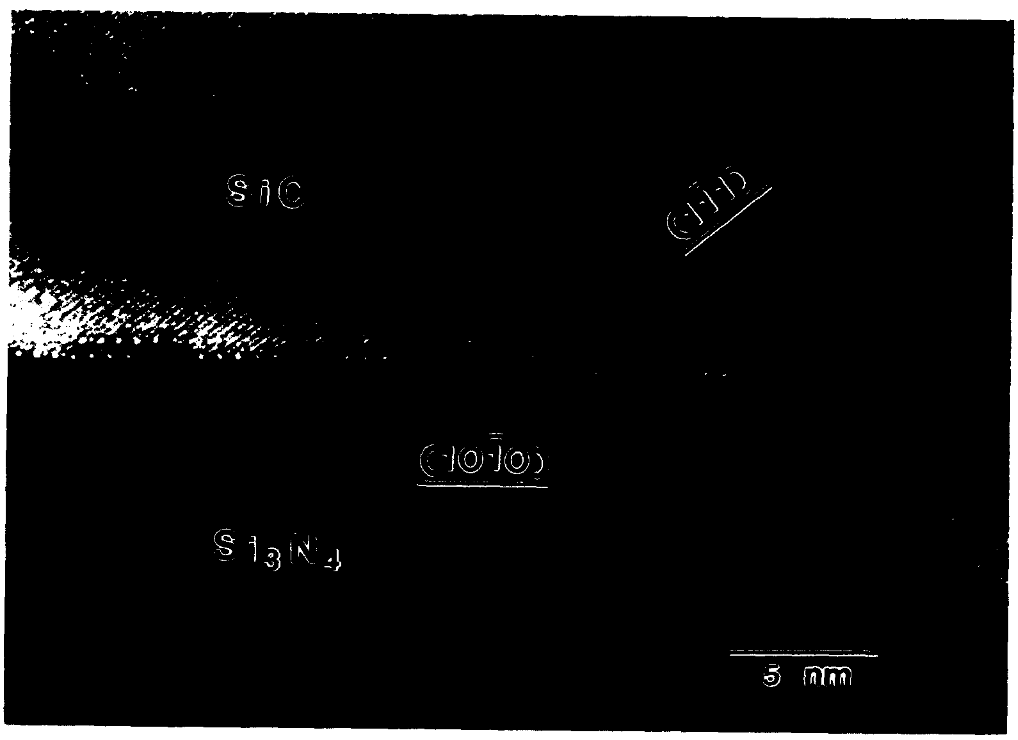
TEM micrograph showing that SiC particles are distributed both inside Si_3N_4 grains and at grain boundaries.



HREM image of triple junction show crystallization of grain boundary phase, crystalline phase is α-$Y_2Si_2O_7$.



HREM image of matrix grain boundary with thin layer of amorphous phase which have negative effect on fracture strength at elevated temperature.



Directly bonding interface between Si_3N_4 and intergranular SiC without amorphous layer.