

5 - 10 Study on Thermal Conductivity of ZTA-SiC_w Composites

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With the development of the national economy, the contradiction between energy supply and demand has become prominent. Nuclear energy has become a means to solve energy problems because of its clean liness, low-carbon and high energy density. However, the working conditions of nuclear energy systems are harsh, and the requirements for materials are high. The high operating temperature requires materials to have good thermal conductivity. As a potential structural material, the effect of SiC whisker content on the thermal conductivity of ZTA-SiC_w (zirconia toughened alumina-SiC whisker) composite ceramics was studied.

Figure 1 shows thermal diffusivity and thermal conductivity of composites as a function of SiC_w addition and measurement temperature. The thermal diffusivity and thermal conductivity of ZTA matrix at room temperature are 0.053 cm²/s and 16.19 W/mK, respectively. With addition of SiC_w, the thermal diffusivity and thermal conductivity of ZTA-SiC_w composites increase with the increase of whisker content. When the SiC_w content increased to 10.0 vol%, the thermal diffusion coefficient and thermal conductivity of ZTA-SiC_w composites reached the maximum values, which were 0.065 cm²/s and 19.10 W/mK, respectively, and increased by 22.6% and 18.0% compared with the matrix. The addition of whisker improves the thermal conductivity of composites, which is due to the higher thermal conductivity of SiC_w compared to ZTA matrix. The thermal diffusivity and thermal conductivity of all samples decreased with the increase of measurement temperature. When the temperature reaches 1 000 °C, the thermal diffusivity and conductivity of ZTA matrix are 0.012 cm²/s and 6.02 W/mK, respectively. The thermal diffusivity and conductivity of ZTA-SiC_w composite ceramics with 10.0 vol% whisker content are 0.013 cm²/s and 6.06 W/mK, respectively, basically consistent with the matrix. Compared with room temperature, the thermal diffusion coefficient and thermal conductivity of the matrix decrease by 77.4% and 62.8% respectively at 1 000 °C, and the ZTA-SiC_w composite ceramics with 10.0 vol % whisker content decrease by 80.0% and 68.3% respectively. The heat conduction of ceramic composites is mainly through lattice vibrations (phonons), but the pores, defects and reinforcing phases in the material lead to phonon scattering, which affects the thermal properties of the composites. In addition, the vibration of atoms also causes the scattering of phonons. With the increase of test temperature, on the one hand, the vibration of atoms is intensified, which leads to the scattering of phonons. On the other hand, phonons also scatter off each other and get worse as the temperature rises. Therefore, the thermal diffusivity and thermal conductivity of all samples decreased significantly with the increase of test temperature.

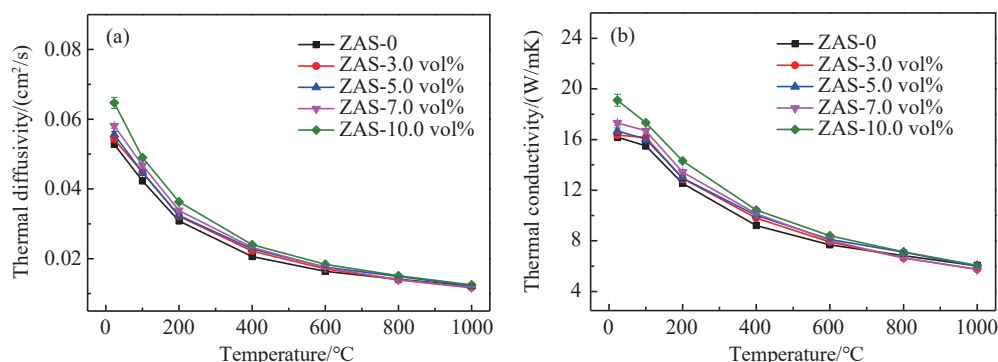


Fig. 1 (color online) Thermal properties of ZTA-SiC_w composites with different SiC whisker components (a) thermal diffusivity, (b) thermal conductivity.

The addition of SiC_w can improve the thermal conductivity of ZTA composite at room temperature, but has little effect on the thermal conductivity at high temperature.