Fabrication of carbon nanotubes reinforced zinc silicate ceramic composites for enhanced optical and thermal properties

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Zinc silicate, also known as willemite (Zn_2SiO_4), is a widely applied glass-ceramics materials in optical applications such as in light emitting diode (LED), due to their excellent optical properties and quantum efficiency. However, for further progress of more practical applications, the drawback of these ceramics are poor thermal properties which will hindered the energy efficiency for high performance application devices. Carbon nanostructures (CNS) such as carbon nanotubes (CNTs), carbon nanofibers (CNFs) and graphene attracts much attention owing to their outstanding mechanical, optical and thermal properties, and widely utilized as filler to reinforced the host materials properties. In this work, we will demonstrate the synthesis of carbon nanotubes reinforced Zn_2SiO_4 ceramic composites (CNTs-Zn_2SiO_4) by powder processing and argon sintering techniques and investigate the structural, optical, mechanical and thermal properties of the composites by X-ray Diffraction (XRD), photoluminescence, UV-vis, FESEM and laser flash apparatus (LFA) characterization.

Sample were synthesized by melt quenching the soda lime silica glass and ZnO powder at 1400 °C for 2 h. The formed zinc silicate glass fritz were then grinded into powder, and mix with CNTs powder. The sample will go through densification and sintering process. The crystallite size of thermal treated sample had improved with lattice strain reduced as increasing the CNT weigh percentage (wt%). On the other hands, the band gap energy (E_g) of CNT/Zn_2SiO_4 composite narrowed down as CNT increased as shown in Fig. 1[1)]. Tauc equation calculated E_{opt} based on the photon absorbance in respected to the EM wavelength of composite, CNT/Zn_2SiO_4 composite with 3 wt% CNT reached 0.100 eV E_g compared to CNT-free composite with 3.214 eV. The thermal conductivity results shown an increment with the conductivity increased from 0.115 (without CNTs) to 0.393 W/mK (3.0 wt% CNTs addition).

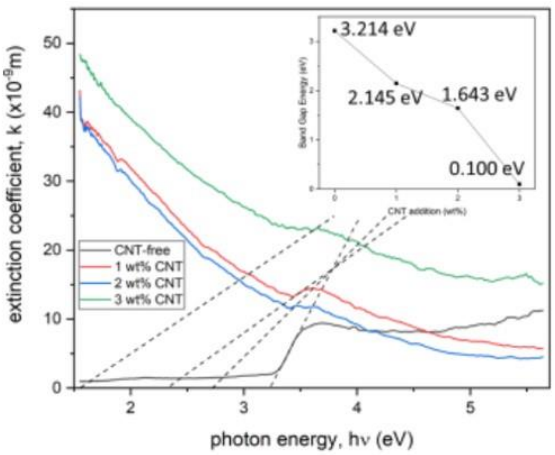

Fig. 1 Extinction coefficient (k) of the ZS/CNT composite with the indicated onset photon energy. Inset is plotted from Tauc equation.

References:

1) K.F. Chan et al, Ceramics International, 47, 14 (2021) 20108-20116.

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