Effects of polyvinylpyrrolidone on structural and optical properties of willemite semiconductor nanoparticles by polymer thermal treatment method

ABSTRACT

Willemite is an inorganic semiconductor material used for optoelectronic applications. The present study purposes a new polymer thermal treatment method involving calcination temperature to fabricate the willemite nanoparticles. The effects of polyvinylpyrrolidone (PVP) on the structural and optical properties of the material were thoroughly investigated. Thermogravimetric and its derivative confirmed the decomposition behavior of PVP. The minimum calcination temperature to decompose PVP was appraised at 740 °C. The FTIR and the Raman analyses confirmed the presence of organic source before the calcination process and the formation of the crystalline structure of the willemite nanoparticles after the heat treatment. The optimum PVP concentration in this study based on the FTIR results was found to be 40 g L−1. This is the minimum concentration at which the willemite nanoparticles remained pure with homogenous distribution. X-ray diffraction analysis of the PVP samples before calcination was confirmed to be amorphous, and upon calcination between 800 and 1000 °C, an α-willemite phase was obtained. The morphology and the average particle size were determined with FESEM and HR-TEM analysis. The average particle size is between 23.8 and 36.7 nm. The optical energy band was found to be increasing from 5.24 to 5.32 eV with the corresponding increase in PVP concentration from 20 to 50 g L−1. The findings in this study provides a new pathway to understand the effects of PVP concentrations on the structural and optical properties of willemite semiconductor nanoparticles as it may have key potential applications for future optoelectronic devices.

Keyword: Polyvinylpyrrolidone; Band gap; Semiconductors; Willemite; Nanoparticles; Calcination