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Synthesis of Nanocrystalline $CaWO_4$ as Low-Temperature Co-fired Ceramic Material: Processing, Structural and Physical Properties

S. VIDYA,[1] SAM SOLOMON,[2] and J.K. THOMAS[1,3]

1.—Electronic Materials Research Laboratory, Department of Physics, Mar Ivanios College, Thiruvananthapuram 695 015, Kerala, India. 2.—Department of Physics, St. John's College, Anchal, Kollam 691306, Kerala, India. 3.—e-mail: jkthomasemrl@yahoo.com

Nanocrystalline scheelite $CaWO_4$, a promising material for low-temperature co-fired ceramic (LTCC) applications, has been successfully synthesized through a single-step autoignition combustion route. Structural analysis of the sample was performed by powder x-ray diffraction (XRD), Fourier-transform infrared spectroscopy, and Raman spectroscopy. The XRD analysis revealed that the as-prepared sample was single phase with scheelite tetragonal structure. The basic optical properties and optical constants of the $CaWO_4$ nanopowder were studied using ultraviolet (UV)-visible absorption spectroscopy, which showed that the material was a wide-bandgap semiconductor with bandgap of 4.7 eV at room temperature. The sample showed poor transmittance in the ultraviolet region but maximum transmission in the visible/near-infrared regions. The photoluminescence spectra recorded at different temperatures showed intense emission in the green region. The particle size estimated from transmission electron microscopy was 23 nm. The feasibility of $CaWO_4$ for LTCC applications was studied from its sintering behavior. The sample was sintered at a relatively low temperature of 810°C to high density, without using any sintering aid. The surface morphology of the sintered sample was analyzed by scanning electron microscopy. The dielectric constant and loss factor of the sample measured at 5 MHz were found to be 10.50 and 1.56×10^{-3} at room temperature. The temperature coefficient of the dielectric constant was −88.71 ppm/°C. The experimental results obtained in this work demonstrate the potential of nano-$CaWO_4$ as a low-temperature co-fired ceramic as well as an excellent luminescent material.

Key words: $CaWO_4$, LTCC, dielectric, sintering, combustion synthesis

INTRODUCTION

The demands for miniaturization in the field of electronics and communication necessitate the development of novel materials with excellent properties. Low-temperature co-fired ceramic (LTCC) materials play an important role in this area, offering the combined advantages of high-temperature co-fired ceramics and films. LTCC materials are sintered below 950°C, enabling use of low-resistive materials such as silver and gold during the fabrication of multilayer circuits. Usually, glass composite materials or polymer composite materials are used for LTCC applications. They have shortcomings such as high dielectric loss, thermal mismatch, high sintering temperature, etc. A pure ceramic material with good dielectric properties could overcome all these difficulties. Reduction of the sintering temperature without affecting the dielectric properties is a challenging problem in LTCC materials research.

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