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Enhanced Thermal and Electrical Properties of Terbium Manganate-Polyvinyl Alcohol Nanocomposite Film

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Abstract : Polymer nanocomposites are very significant materials both in academia and industry for diverse potential applicability in electronics. Polymer plays the role of matrix element which has low density, flexibility, good mechanical strength and electrical properties. Use of nanosized multiferroic filler in the polymer matrix is suitable to achieve nanocomposites with enhanced magneto-dielectric effect and good mechanical properties both at the same time. Multiferroic terbium manganate ($TbMnO_3$) nanoparticles have been synthesized by sol-gel method using chloride precursors. Terbium manganate-polyvinyl alcohol ($TbMnO_3$-PVA) nanocomposite film has been prepared by solution casting method. Crystallite size of $TbMnO_3$ nanoparticle has been calculated to be ~ 40 nm from XRD analysis. Morphological study of the samples has been done by scanning electron microscopy and a well dispersion of the nanoparticles in the PVA matrix has been found. Thermogravimetric analysis (TGA) exhibits enhancement of thermal stability of the nanocomposite film with the inclusion of $TbMnO_3$ nanofiller in PVA matrix. The electrical transport properties of the nanocomposite film sample have been studied in the frequency range 20Hz - 2MHz at and above room temperature. The frequency dependent variation of ac conductivity follows universal dielectric response (UDR) obeying Jhonscher's sublinear power law. Correlated barrier hopping (CBH) mechanism is the dominant charge transport mechanism with maximum barrier height 19 meV above room temperature. The variation of dielectric constant of the sample with frequency has been studied at different temperatures. Real part of dielectric constant at 1 KHz frequency at room temperature of the sample is found to be ~ 8 which is higher than that of the pure PVA film sample (~ 6). Dielectric constant decreases with the increase in frequency. Relaxation peaks have been observed in the variation of imaginary part of electric modulus with frequency. The relaxation peaks shift towards higher frequency as temperature increases probably due to the existence of interfacial polarization in the sample in presence of applied electric field. The current-voltage (I-V) characteristics of the nanocomposite film have been studied under ±40 V applied at different temperatures. I-V characteristic exhibits temperature dependent rectifying nature indicating the formation of Schottky barrier diode (SBD) with barrier height 23 meV. In conclusion, using multiferroic $TbMnO_3$ nanofiller in PVA matrix, enhanced thermal stability and electrical properties can be achieved.

Keywords : correlated barrier hopping, nanocomposite, schottky diode, $TbMnO_3$, TGA
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