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High Permittivity of CaCu3Ti4O12/polymer Nano-Composites for High Energy Storage Application

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Extended Abstract

Ceramic-polymer composites with high permittivity constant have attracted considerable attention recently due to their good fabrication process, low cost and potential applications ranging from embedded capacitors and high electric energy-storage devices. (Das et al., 1996; Kuo et al., 2001). Requirements for real applications of embedded capacitors include high dielectric constant, low dielectric loss, low leakage current, high breakdown voltage and sufficient stability. To meet the stringent requirements for the composites, considerable attention has been devoted to the development of the candidate materials with high dielectric constant. Recently, some perovskite type materials, non-ferroelectric, such as $CaCu_3Ti_4O_{12}$ (CCTO) with giant dielectric constant up to 10^5 at room temperature has been extensively investigated (Subramanian et al., 2000; Amaral et al., 2008). The unusually high dielectric constant of CCTO as suggested is attributed to an internal barrier layer capacitor (IBLC) model, which consists of semiconducting grains and insulating grain boundaries. CCTO doesn't present any ferroelectric phase transition as $BaTiO_3$ and it shows a high dielectric constant almost constant between 100 K and room temperature. The unique dielectric behaviour of CCTO gives an interesting on making up of CCTO ceramic-polymer flexible particulate composites for high density energy storage and capacitor applications.

In this study, nanoparticles of $CaCu_3Ti_4O_{12}$ (CCTO) were obtained by diffusion barrier solid state reaction with a large amount of polyvinyl butyral (PVB). The average particle size of CCTO is about 500nm and the crystalline grain size is about 30nm. CCTO-polymer nanocomposites for CCTO grains concentrations up to 50% by volume were fabricated by incorporating the CCTO nanoparticles in a low-density polyethylene (LDPE) polymer matrix by melt blending and hot pressing into sheets at 150ºC. The dielectric properties of the composite CCTO-LDPE were studied in the frequency range from 100 Hz to 1 kHz. As a result, the effective dielectric constant (ε_{eff}) and dielectric loss of composites increased with the increase of the CCTO content. The dielectric constant is about 350 at 1kHz for the composite with 50Vol % of CCTO. It is found that the dielectric loss of the nanocomposites is dominated by the polymer which has a relaxation process. The nanostructure and the electrical properties of CCTO ceramics are strongly dependent on processing conditions. The Maxwell-Wagner model was employed to discuss and rationalize the dielectric behaviour of the composite.

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