Journal of ELECTRONIC MATERIALS, Vol. 42, No. 4, 2013
DOI: 10.1007/s11664-012-2390-1

Preparation and Dielectric Characteristics of Semitransparent $CoFe_2O_4$–P(VDF-TrFE) Nanocomposite Films

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Polymer–ceramic nanocomposites play an important role in embedded capacitors. However, polymer–ceramic dielectrics are limited for commercial applications due to their low transmittance, poor adhesion, and poor thermal stress reliability at high filler loadings. Thus, materials design and processing is critical to prepare films with improved dielectric properties and low filler loading. In this work, we use a spin coating-assisted method to fabricate poly(vinylidene fluoride-co-trifluoroethylene) [P(VDF-TrFE)]–$CoFe_2O_4$ (CFO) nanocomposite films. Magnetic CFO nanoparticles in the size range of 10 nm to 40 nm were successfully synthesized using a hydrothermal process. The dispersion of the nanoparticles, the dielectric properties, and the transmittance of the nanocomposite films were studied. The dielectric constant of the nanocomposite films increased by about 45% over the frequency range of 100 Hz to 1 MHz, compared with that of pristine P(VDF-TrFE) film. Optical measurements indicated that the transmittance of the films remains above 60% in the visible range, indicating a relatively low content of CFO in the polymer matrix. Our experimental results suggest that spin coating-assisted dispersion may be a promising route to fabricate dielectric polymer–ceramic nanocomposite films of controllable thickness.

Key words: $CoFe_2O_4$ nanoparticles, polymer–ceramic nanocomposite, spin coating-assisted dispersion, dielectric properties

INTRODUCTION

Dielectric materials are used as insulation materials to store charge and energy in modern electronics and electric power systems. Polymer-based dielectric materials are the material of choice for insulation applications because of their relatively high energy density, high electric breakdown field, low dielectric loss, excellent flexibility, and easy processing.[1–4] Polymer–ceramic composites can combine the advantages of ceramics and polymers to obtain composites with high flexibility, easy processing, relatively high dielectric constant, and high breakdown strength. Recently, significant improvements in dielectric constant have been observed for polymer–ceramic composites. Among the reported works, Ogitani et al.[5] used lead magnesium niobate-lead titanate (PMN-PT) to modify XP-9500 epoxy and obtained an increase of dielectric constant from 43 to 70 with 71 vol.% loading of ceramic measured at 10 kHz. Rao et al.[6,7] increased the dielectric constant of ERL-4221 epoxy by about 50% from 74 to 110 with 70 vol.% loading of ceramic measured at 10 kHz and subsequently obtained a high constant of 153 with 85 vol.% loading using a novel nanostructure polymer–ceramic composite material. However, high filler loadings of ~60 vol.% were required to increase the dielectric constant, which dramatically deteriorated the surface morphology, adhesion strength, thermal stress reliability, and transparency.[8,9] Thus, modification for low loading is crucial to widen the

(Received April 17, 2012; accepted December 13, 2012; published online January 19, 2013)