Piezoelectric Propertie of PZT/Polymer Composites

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Abstract

PZT/epoxy composites having 0.4 and 0.6 volume fraction of PZT with 1-3 connectivity were prepared using the dice-and-fill technique. The composites of the PZT powders dispersed in a P(VDF-TrFE) matrix with 0.3 volume fraction of PZT were fabricated by compression molding. Scanning electron microscope (SEM) was used to check the separation of the PZT rods in the 1-3 composites PZT/epoxy and to check the disperser of the PZT clusters in the copolymer matrix of the 0-3 composites PZT/P(VDF-TrFE). Heat capacity of the composites were investigated by using Differential Scanning Calorimeter. It was found that the value of the heat capacity of the 1-3 composites PZT/epoxy having 0, 0.4 and 0.6 volume fraction of PZT and 0-3 composites were 2777, 214, 283 and 2753 $J/kg\ ^{o}C$, respectively. The 1-3 composites PZT/epoxy were poled with an electric field of 10 MV/m for 15 minutes at room temperature. The mechanical strain induced by the external electric field of the composites were obtained using the laser interferometry technique. A ratio between the displacement and driving voltage is a piezoelectric coefficient. It was found that the piezoelectric d_{33} coefficients of the 1-3 composites having 0.4, 0.6 and 1 volume fraction of PZT were 190 ± 10, 188 ± 10 and 360 ± 10 pm/V, respectively. This value agreed closely with the theoretical predictions.

The pyroelectric p coefficients of the composites were investigated using the direct method. In this method the sample is heated and cooled under controlling rate rate and the resulting charge changing is measured. The pyroelectric coefficient is determined by the charge changing at the electrodes due to changing of the sample temperature. It was found that the composite pyroelectric coefficients increase by the volume fraction of PZT increasing. The value of the pyroelectric coefficients having

0.4, 0.6 and 1 volume fraction of PZT composite were found to be 44, 54 and 74 $\mu C/m^2\ {}^{\circ}C$, respectively.

The thermal diffusivity of the composites was determined using technique based on the phase retardation measurement of a thermal wave passing through the material. The composite was attached by means of a high thermal conductivity cement to a $LiTaO_3$ pyroelectric detector. The top surface of the composites was blacken to enhance heat absorption. A sinusoidally-modulated laser beam was projected on the top of the composites and heating results in the propagation of the thermal waves into the composites. The temperature wave diffuses through the composite to the $LiTaO_3$ detector, generating a pyroelectric current. The phase retardation between the pyroelectric current and laser beam intensity is a unique function of the composite thickness and its thermal diffusivity. By the computer package, *Mathematica*, the value of the thermal diffusivity were found to be 2.24×10^{-7} and 1.43×10^{-7} m^2/s for the 1-3 composite PZT/epoxy having 0.4 and 0.6 volume fraction of PZT, respectively, 2.5×10^{-8} m^2/s for the epoxy and 2.04×10^{-8} m^2/s for 0-3 composite PZT/P(VDF-TrFE) having 0.3 volume fraction of PZT. The poled 1-3composite PZT/epoxy having 0.4 volume fraction of PZT is used as the pyroelectric detector for determining the thermal diffusivity of the $LiTaO_3$. The thermal diffusivity of the $LiTaO_3$ was found to be 4.39×10^{-7} m^2/s which was 38% different from the reported value in the literature.

From the investigation, 1-3 composite PZT/epoxy is promising for applications as pyroelectric detector and transducer. For 0-3 composite PZT/P(VDF-TrFE) the poling process was incompleted because of the damages of the sample during the process.