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Doped Polymers as Matrix Materials for Ferroelectric Composites

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The pyroelectric coefficient of 0–3 composites of ferroelectric ceramic particles in a polymer matrix can be increased drastically by introducing a specified dc conductivity as explained by predictions based on the Poon-Shin model. The influence of doping with lithium chlorate on the dielectric permittivity of polyurethane has been studied to identify proper process parameters for the doping of composites. After appropriate doping the pyroelectric coefficient of 0–3 PZT/polyurethane composite is increased by more than a factor of ten at frequencies around 50 Hz.

Keywords Pyroelectric materials; composites; conducting polymers; ceramic particles

Introduction

Composites of ferroelectric ceramic particles in a polymer matrix are promising materials for application in pyroelectric sensors [1, 2]. Compared to ceramic films they have the advantage of higher process compatibility with the fabrication of integrated circuits. While the pyroelectric coefficients of ferroelectric ceramics like lead titanate and polymers like poly(vinylidenefluoride-trifluoroethylene) have the same sign, their piezoelectric coefficients have opposite signs. By an appropriate poling of the matrix and inclusions of a ceramics-polymer composite it can be realized that the piezoelectric activities of the two constituents cancel out while their pyroelectric activities reinforce. This allows the fabrication of composite ferroelectrics which are not piezoelectric [3]. These materials make pyroelectric sensors possible which are not sensitive to vibration. The performance of pyroelectric 0–3 composites is, however, limited by the dielectric mismatch between the high dielectric permittivity of the ferroelectric ceramic particles and the substantially lower dielectric permittivity of the polymer matrix. The recent finding that this mismatch can be reduced substantially when the matrix is partially conducting [4] is the motivation to study the doping of matrix materials for pyroelectric composites.

Theory

A 0–3 composite of pyroelectric ceramic particles dispersed in an unpolar matrix is illustrated in Fig. 1. The ceramic particles are assumed to have the pyroelectric coefficient p_i and the relative dielectric permittivity ε_i while the matrix material has the relative dielectric

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