Poling of Ferroelectric Composites

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Abstract

In 0–3 nanocomposites of lead titanate (PT) in polivinylidenefluoride trifluoroethylene (PVDF-TrFE) it is possible to polarize the inclusions and the matrix separately. The pyroelectric coefficients of both components have the same sign, but the piezoelectric coefficients have the opposite sign. If matrix and inclusions of a composite of PT in PVDF-TrFE are polarized in the same direction, then the pyroelectric response of both components overlays constructively, the piezoelectric response destructively. By poling in opposite directions a material with reduced pyroelectric but increased piezoelectric sensitivity is produced. Under special poling conditions and for a certain ceramic volume fraction the pyroelectric coefficient vanishes completely for the antiparallel poled case but is piezoelectric with a piezoelectric coefficient of 20 pC/N. Such a material with internally compensated pyroelectricity is of high interest for the application in piezoelectric sensors were the cross sensitivity of piezoelectric sensors to temperature changes is often a large obstacle for their practical use.

1. Introduction

Composites of ferroelectric ceramic inclusions embedded in a polymer matrix have a promising potential for applications as they combine the high pyroelectric and piezoelectric coefficients of the ceramic with the good mechanical properties of the polymer. The selection of the components and of the volume ratio allows the fabrication of new materials with custom taylored properties. If not only the inclusions but also the matrix is ferroelectric (e.g. a PVDF matrix [1]) the poling state of the matrix provides an additional degree of freedom. For our investigations we choose P(VDF–TrFE) 56/44 mol–% as a matrix material, as it can easily be depolarized by heating it from the ferroelectric to the paraelectric phase above the transition temperature at 65 °C. This allows to polarize the inclusions alone [2, 3], as well as to investigate their contribution to the combined pyroelectric coefficient after depolarizing the copolymer matrix. Investigations on 2.5 μm thick spin–coated PT / P(VDF–TrFE) composites with 8 vol–% PT [4] had shown that using a special poling procedure matrix and inclusions can be polarized independently from each other. In particular, it is possible to polarize matrix and inclusions in opposite direction. However, due to the low ceramic volume fraction the pyroelectric response from the ceramic particles was small compared to the contribution of the copolymer matrix. In the following, results on 30 μm heat pressed samples with a volume fraction of up to 34 vol–% PT are presented.

2. Experimental

Composites of nanocrystalline lead tianate (PT) ceramic powder [5] embedded in a P(VDF–TrFE) 56/44 mol–% copolymer matrix with ceramic volume fractions of 15, 27 and 34 vol–% have been prepared. The copolymer was dissolved in Methylethylketone and the ceramic powder dispersed in

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