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Dielectric and pyroelectric properties of PCaT/P(VDF–TrFE) 0–3 composite thin films

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Abstract

Powder of calcium modified lead titanate [$(Pb_{0.8}Ca_{0.2})TiO_3$ or PCaT] with particle sizes < 100 nm prepared by a sol–gel process has been embedded in a vinylidene fluoride–trifluoroethylene copolymer [P(VDF–TrFE)] matrix to form 0–3 composites. PCaT/P(VDF–TrFE) films and pyroelectric sensors have been fabricated by spin-coating. The dielectric and pyroelectric properties of the composite film have been investigated. The current and voltage responsivities as well as the voltage noise have been measured, resulting in a specific detectivity $D^* = 1.2 \times 10^7$ cm $Hz^{1/2}/W$. The results show that this kind of composite material has a good potential for pyroelectric sensor applications.

1. Introduction

Pyroelectric ceramics and polymers are used in infrared sensor and integrated thermal imaging device applications [1–5]. 0–3 type ceramic/polymer composites consisting of ceramic powder imbedded in a polymer matrix have also attracted attention since they combine the excellent pyroelectric properties of the ceramic and the flexible mechanical properties of the polymer [6]. The dielectric and pyroelectric properties of different types of composites have been studied theoretically and experimentally [7–9]. These composites usually contain a volume fraction $\geqslant 0.5$ of ceramic particles whose size $\geqslant 2$ μm. They are normally formed by tape-casting or hot-pressing techniques into films with thickness greater than 50 μm. In integrated thermal imaging devices much thinner pyroelectric films are required [10].

Using a sol–gel technique, we have prepared ceramic powder of calcium modified lead titanate [$(Pb_{0.8}Ca_{0.2})TiO_3$ or PCaT] with grain size <100 nm [11], and have used the powder to fabricate films of a few μm thickness [12]. In this paper, we describe the fabrication of composite films of PCaT powder dispersed in vinylidene fluoride–trifluoroethylene copolymer [P(VDF–TrFE)] using the spin-coating technique [4]. The dielectric and pyroelectric properties of the composite films have been determined. The current and voltage responsivities, as well as voltage noise and specific detectivity, of a single-element pyroelectric sensor with PCaT/P(VDF–TrFE) as the sensing material have also been measured.

2. Experimental

P(VDF–TrFE) copolymer with 70 mol% VDF (supplied by Piezotech) was used as the matrix material, and PCaT ceramic powder prepared by a

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