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Effect of (Cd:Zn)S Particle Concentration and Photoexcitation on the Electrical and Ferroelectric Properties of (Cd:Zn)S/P(VDF-TrFE) Composite Films

Sebastian Engel [1], David Smykalla [2], Bernd Ploss [2], Stephan Gräf [1] and Frank A. Müller [1,3,4,*]

1 Otto Schott Institute of Materials Research (OSIM), Friedrich Schiller University Jena, Löbdergraben 32, 07743 Jena, Germany; sebastian.engel@uni-jena.de (S.E.); stephan.graef@uni-jena.de (S.G.)
2 Department of SciTec, University of Applied Sciences Jena, Carl-Zeiss-Promenade 2, 07745 Jena, Germany; david.smykalla@eah-jena.de (D.S.); bernd.ploss@eah-jena.de (B.P.)
3 Jena Center for Soft Matter (JCSM), Friedrich Schiller University Jena, Philosophenweg 7, 07743 Jena, Germany
4 Center for Energy and Environmental Chemistry (CEEC), Friedrich Schiller University Jena, Philosophenweg 7a, 07743 Jena, Germany
* Correspondence: frank.mueller@uni-jena.de; Tel.: +49-3641-947-750

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Abstract: The influence of semiconductor particle concentration and photoexcitation on the electrical and ferroelectric properties of ferroelectric-semiconductor-composites was investigated. For this purpose, 32 µm thin films of poly(vinylidene fluoride-*co*-trifluoroethylene) with (Cd:Zn)S particle concentrations of between 0 and 20 vol % were fabricated and characterized by scanning electron microscopy, Fourier transformed infrared spectroscopy, X-ray diffraction, and optical spectroscopy. It was shown that the particle concentration has only a negligible influence on the molecular structure of the polymer but strongly determines the optical properties of the composite. For (Cd:Zn)S particle concentrations below 20 vol %, the I-V characteristics of the composites is only marginally affected by the particle concentration and the optical excitation of the composite material. On the contrary, a strong influence of both parameters on the ferro- and pyroelectric properties of the composite films was observed. For particle fractions that exhibit ferroelectric hysteresis, an increased remanent polarization and pyroelectric coefficient due to optical excitation was obtained. A theoretical approach that is based on a "three phase model" of the internal structure was developed to explain the observed results.

Keywords: composite; ferroelectric polymer; semiconductor; photoexcitation

1. Introduction

Due to their low processing temperatures, large electrical resistivity, and high flexibility polymer based ferroelectric materials are of particular interest to engineer flexible electronic devices, such as energy harvesting systems, memory devices, and sensors [1–9]. In this context, poly(vinylidene fluoride) (PVDF) is a promising candidate due to its extraordinary ferroelectric properties and the feasibility of thin film processing. PVDF is a semi-crystalline polymer that exhibits at least four polymorphs (α-, β-, γ-, δ-) [10]. Under normal conditions, it crystalizes from melt to the non-polar α-phase [10]. The polar and ferroelectric β-phase can be fabricated by mechanical stretching of the α-phase [11]. An alternative material is given by the copolymer poly(vinylidene fluoride-*co*-trifluoroethylene) (P(VDF-TrFE)), which exhibits a structure that is well ordered, polar, and analogous to that of the β-phase of PVDF [12,13]. In line with literature, this ferroelectric phase of P(VDF-TrFE) is also referred to as β-phase in this study. P(VDF-TrFE) can directly crystallizes