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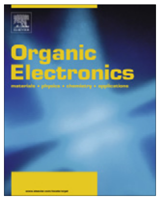

Electrical performance of polymer ferroelectric capacitors fabricated on plastic substrate using transparent electrodes

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A B S T R A C T

Polymer-based flexible ferroelectric capacitors have been fabricated using a transparent conducting oxide (ITO) and a transparent conducting polymer (PEDOT:PSS). It is found that the polarization fatigue performance with transparent oxide electrodes exhibits a significant improvement over the polymer electrodes (20% vs 70% drop in polarization after 10^6 cycles). This result can be explained based on a charge injection model that is controlled by interfacial band-offsets, and subsequent pinning of ferroelectric domain walls by the injected carriers. Furthermore, the coercive field (E_c) of devices with our polymer electrodes is nearly 40% lower than reported values with similar polymer electrodes. Surprisingly, this difference was found to be related to the dry etching process used to define the top electrodes, which is reported for the first time by this group. The temperature dependence of relative permittivity of both devices shows a typical first order ferroelectric-to-paraelectric phase transition, but with a reduced Curie temperature compared to reference devices fabricated on Pt.

1. Introduction

The flexible electronics industry is experiencing significant growth especially in the use of organic electronic materials including small molecules and polymers. One of the potential applications of such multifunctional polymers is ferroelectric non-volatile random access memories using the copolymer polyvinylidene fluoride–trifluoroethylene or P(VDF-TrFE) [1]. Several properties of P(VDF-TrFE) make it nearly an ideal polymer non-volatile memory compared to other types of reported organic ferroelectric materials [2–5]. These include ease of device fabrication using solution processing, non-volatility, sufficiently large remanent polarization, fast switching speeds, and thermal stability. Several reports on high performance, spin-cast films of P(VDF-TrFE) have been demonstrated [1,6,7], but very few reports have been published using transparent electrodes.

In this paper, we report the fabrication of polymer ferroelectric capacitors using P(VDF-TrFE) and two types of transparent electrodes on flexible, optically transparent polyethylene napthalate (PEN) substrates. Specifically, we compare the performance and reliability of these ferroelectric capacitors with a transparent conducting oxide and a transparent conducting polymer (Indium-Tin Oxide (ITO) and poly(3,4-ethylenedioxythiophene):polystyrenesulfonate, PEDOT:PSS)) and offer an explanation for the observed results.

2. Experimental

The devices with transparent polymer electrodes were fabricated by first spinning PEDOT:PSS (Sigma–Aldrich, conductivity ca. 1 S/cm) on a cleaned PEN substrate at 3000 rpm for 30 s and drying on a hotplate in air at 110 °C for 30 min, resulting in a ~100 nm thick film. For comparison, a thin film of transparent conducting oxide (ITO, $R_s \sim 50\ \Omega$/sq.) as the bottom electrode was sputtered on PEN. The P(VDF-TrFE) (70–30 mol%) obtained from

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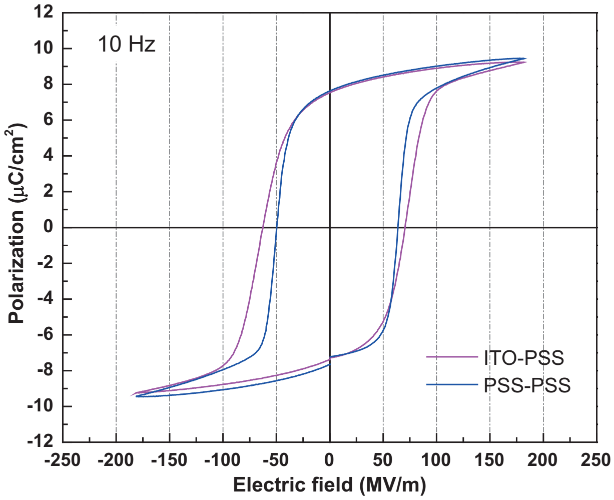

Fig. 1. Polarization–Electric field (P–E) hysteresis curves measured at ±15 V and 10 Hz. The device structures are PEN/ITO/P(VDF-TrFE)/PEDOT:PSS and PEN/PEDOT:PSS/P(VDF-TrFE)/PEDOT:PSS.

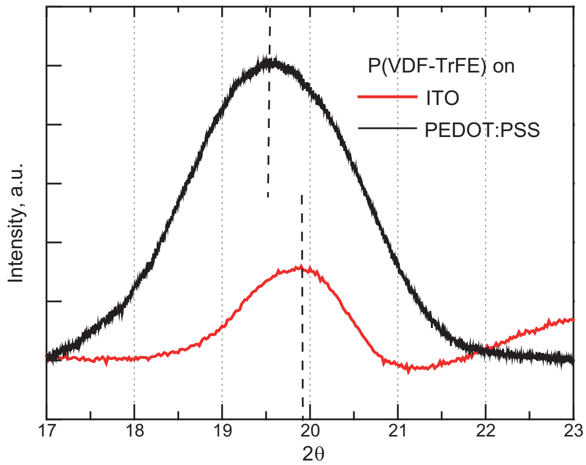

Fig. 2. Grazing Incidence X-ray diffraction spectra for 100 nm P(VDF-TrFE) films grown on ITO and PEDOT:PSS. The incidence angle was set at 0.5°.

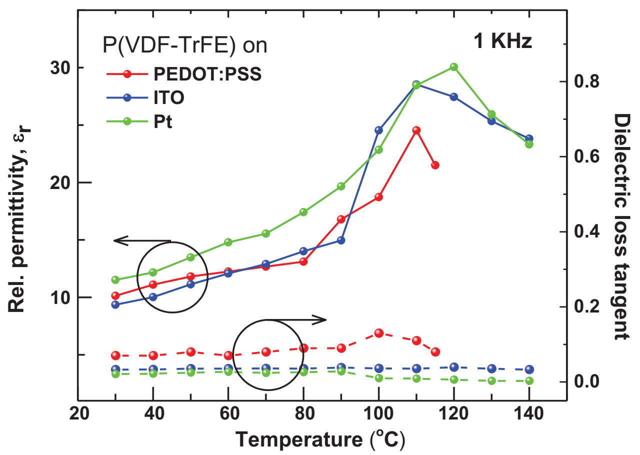

Fig. 3. Temperature characteristics of dielectric constant of P(VDF-TrFE) films on PEDOT:PSS, ITO, and Pt substrates measured at 1 kHz. The corresponding dielectric loss tangent values are plotted on the right *Y* axis.