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CARBON NANOTUBE ASSISTED ULTA-THIN POLY(VINYLIDENE FLUORIDE FILMS FOR DEVELOPING FERROELECTRIC BASED MEMORY DEVICE: A SCANNING PROBE MICROSCOPY STUDY

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ABSTRACT

In this work, the Carbon nanotube (CNT) nucleated fully electroactive β- phase ultra-thin films of poly(vinylidene fluoride) were prepared by homemade heat control spin coating (HCSC) techniques. It seems that HCSC is an effective technique by which one can develop a smooth surface as revealed from the RMS roughness value from Atomic Force Microscope (AFM) images. The effect of CNTs on the crystal modifications and lamellae orientation in PVDF films is investigated using Fourier transform infrared-grazing incidence reflection absorption spectroscopy. The electroactive β- phase and edge-on crystalline lamellae are found to be formed preferentially in CNT filled PVDF films. As a result, CNT filled PVDF ultrathin films gave a very good discernible contrast between the written and erased data bits, which suggests that they can be used as a scanning-probe-microscopy-based ferroelectric memory device or a ferroelectric gate field-effect transistor memory device in the future.

KEYWORDS: CNT nucleated electroactive β- phase, PVDF ultra-thin film, Edge-on crystalline lamellae, Ferroelectric memory.

INTRODUCTION

Low cost and large-area micro-electronic device fabrications such as for rollable displays, electronic paper, smart labels, contactless identification transponders, etc. is becoming a key factor in recent technological development in plastic-based electronics [1, 2]. Notably, most of these applications need memory operations, preferably a non-volatile memory that retains its data when the power is turned off, and that furthermore can be programmed, erased, and readout electrically. In this aspect, organic ferroelectric such as Polyvinylidene (PVDF) and its copolymer namely Poly(vinylidene fluoride-tryfluoroethylene) (P(VDF-TrFE)) are the suitable candidates as they exhibits bistable remanent polarization states. However, due to cost factor and fatal weakness due to far below Curie transition temperature than melting temperature, P(VDF-TrFE) thin film still industrially not viable even though it has permanent ferroelectric β-phase. In contrast, PVDF is a low cost, highly thermally and chemically stable polymer, however the absence of the β-phase and higher boiling point selective solvents limits its applicability. Due to the higher boiling point solvent, the surface morphology of the PVDF films become non-homogeneous and also it prefers a face-on crystalline lamellar type orientation (when main backbone of the PVDF chain standing up on the substrates) which is not suitable for non-volatile memory applications [3]. In this work, we have adopted a modified spin coating (MSC) technique where external temperature can be monitored. In addition, multi-walled Carbon nanotubes (CNTs) are utilized as an effective nucleating agent to β-phase nucleation and stabilization of edge-on crystalline lamellar type orientation. The results indicating that CNTs filled PVDF ultra-thin film (t< 70 nm) can be realized and furthermore excellent ferroelectric written and erased data bits is observed from scanning probe microscopic based technique.