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Tuning Properties of Cesium Nitrate: Poly (vinyl alcohol) Composite Films

Arvind Nautiyal

Department of Physics S.G.R.R. (P.G.) College Dehradun
E-mail: nautyphysics@gmail.com

Abstract—*Cesium nitrate ($CsNO_3$): poly (vinyl alcohol) (PVA) composite films of different composition were prepared by a solvent cast method. The Current density –Voltage (J-V) characteristics were strongly dependent on the weight percentage of $CsNO_3$ and indicate ferroelectric nature of the composite films. The hysteresis loop of 50 wt% composite film gave the remnant polarization $P_r = 2.75\ \mu C/cm^2$ and coercive field $E_c = 1.6$ kV/cm at room temperature. The butterfly features of capacitance-voltage (C-V) and conductance-voltage (G-V) characteristics have been attributed to the polarization switching.*

1. INTRODUCTION

Cesium nitrate $CsNO_3$ has a trigonal symmetry with the space group $P3_1$ or $P3_2$ at room temperature [1]. This crystal undergoes a structural phase transition at 154^0C from trigonal symmetry to cubic symmetry [2]. Y.Takagi, S.Kimura and Y.Takcuchi were first observed directly the spontaneous polarization of $CsNO_3$ single crystal from the P-E loop characteristics at higher temperature [3].

To investigate the ferroelectric properties of $CsNO_3$ at room temperature we have prepared composite films of the $CsNO_3$ and PVA. It has been shown that the mixing of sodium nitrite into the PVA matrix improved the ferroelectric properties of $NaNO_2$ [4]. The ceramic polymer composite films have been attracting the considerable attention because of their outstanding advantages in science and technology. The composite films with ferroelectric properties combine many useful properties such as flexibility and electroactivity of the ceramic to produce large surface area with reasonable mechanical strength.

The composite film of $CsNO_3$: PVA have been prepared by solvent cast method. In order to investigate the ferroelectric properties in composite films the P-E hysteresis loop characteristic has been studied by using modified Sawyer-tower circuit. To confirm the ferroelectric behavior of composite films, various experiment such as current density voltage (J-V), capacitance voltage (C-V), conductance voltage (G-V) and switching current characteristics have been performed.

2. RESULT AND DISCUSSION:

2.1 Ferroelectric measurements:

Figure (1) shows the ferroelectric hysteresis loops of 50 wt.% composition of $CsNO_3$ in the composite film. The loop was obtained at room temperature using a modified Sawyer-Tower circuit along with a storage oscilloscope connected to a computer by applying the sinusoidal wave of frequency 50 Hz. The value of $P_r = 2.75\ \mu C/cm^2$ and coercive field of 1.6 Kv/cm were obtained in 50 wt.% composite film.

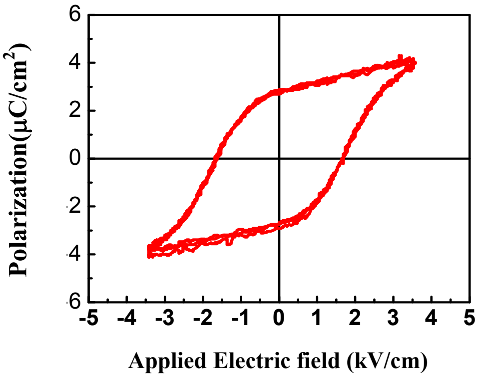

Figure 1: P-E Loop of 50 wt% 0f $CsNO_3$: PVA Composite film

The polarization values were strongly dependent on the weight percentage of $CsNO_3$ fig (2) in different composite films. The value of P_r increases up to 50 wt% of $CsNO_3$ composition of the composite film.

Figure (2) shows the current density voltage characteristics in 50 wt.% composite films. Here the current density peaks were appeared at 8.8V on positive side and 8.2 V on negative side of cycle.

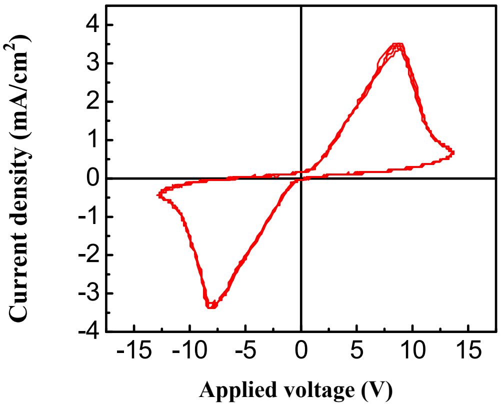

Figure 5: J-V Characteristic of 50 wt% of $CsNO_3$: PVA composite film

This asymmetry of peak voltages is may be due to space charge effect. The current density increases up to peak voltage and then decreases above the peak voltage on both sides. This could be due to the saturation of the polarization beyond the peak voltage and hence the polarization current falls down. Therefore, the polarization current is predominant in the composite films. If there is no ferroelectric city in the composite films the J-V characteristics should be a straight line.

2.2 C-V and G-V Characteristics

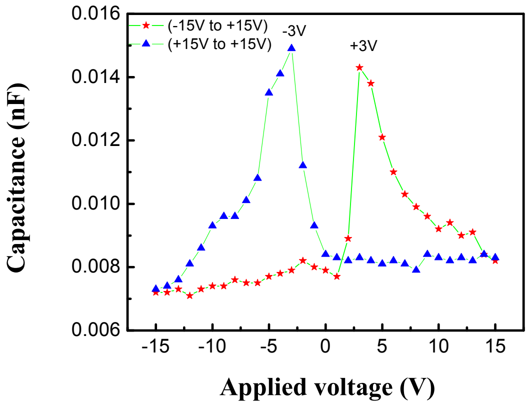

Figure 3: C-V characteristics of $CsNO_3$: PVA composite film

The C-V and G-V characteristics of 50 wt.% composite film are shown in the figure (3) and Fig (4). These measurements were performed at 100 KHz. The voltage was swept from -15V to +15V in forward bias and -15V to +15V in reverse bias with bias step of 1V. The swept time was kept at 23.2 sec in each cycle. The capacitance shows a strong bias dependence and exhibit nonlinear behavior as shown in figure (3). The sharp peaks of these curves attributed to the polarization switching phenomena [6]. The C_{max} occurs at +3V on the other side of zero in positive cycle and -3V in the negative cycle. Similarly the G_{max} occurs at +2V in positive sweep and -2V in negative sweep.

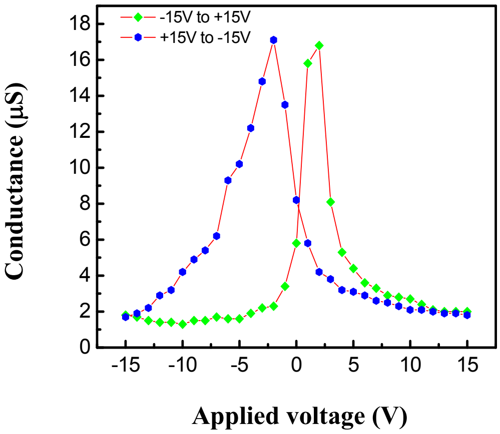

Figure 7: G-V characteristics of $CsNO_3$: PVA composite film

This could be at which the domain walls are more active due to nucleation of new domains or the maximization of the domain wall mobility so that the contribution from the domain wall motion to the dielectric properties is the greatest [7]. The important aspect is that the voltage corresponding to capacitance peaks are in fact the coercive voltages [8]. The average coercive field evaluated from the C-V measurement is about 1kV/cm, which is less then the value determined from the hysteresis loop. This is due to that P-E loop is measured in a fixed frequency while the C-V curve is quasistatic measurement i.e. d.c. bias voltage is swept with few millivolts/second [9]. The symmetric nature of C-V and G-V curve indicates the space charge effect is diminished at higher frequency 100 KHz, where as the observed asymmetric nature in J-V characteristics is due to contribution of space charge effect at lower frequency 50 Hz. The butterfly features of C-V and G-V curve of composite film like other ferroelectric films strongly indicate the presence of ferroelectric nature at room temperature. The nonlinear dependence of dielectric constant on electric field is used in tunable microwave devices [10-13]. The microwave dielectric substrate can be made from the ferroelectric-polymer composite films in which the dielectric permittivity of microwave substrate can be control by an electric field as a result one can control the propagation of microwave signal in the strip line waveguides [14-19].

3. CONCLUSIONS

The tuning properties of $CsNO_3$: PVA composite films have been investigated. The values of P_r = 2.75 µC/cm^2, E_c = 1.6 kV/cm and switched charge 200 nC were obtained. The butterfly features of J-E, C-V and G-V were also support the tuning nature of the composite films.

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