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Behavioural Study Of SmF_3 Thin Films Due To AC And DC Voltages

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ABSTRACT

Samarium fluoride thin films were prepared by vacuum thermal evaporation using tantalum boats. Film thickness was measured by Tolansky's multiple beam interferometric method. The effect of DC voltage on capacitance and loss tangent was studied. The time dependent decay characteristic of the capacitor at a given DC voltage also studied. The effect of AC voltage and temperature (77K to above room – temperature) on capacitance and loss tangent were also studied and the results were discussed.

KEYWORDS

Thin films;
AC voltage;
Loss tangent;
Capacitance.

INTRODUCTION

Thin insulating films are used as surface passivation, insulation between conductors and as a dielectric in capacitors. In all these applications it is mandatory that the insulating film retains its insulating properties with time and stress. Breakdown studies[1], dielectric properties[2] in samarium fluoride thin films have been studied earlier. The present paper describes the effect of AC voltages on capacitance and loss tangent at various temperatures, the effect of DC voltages on capacitance and loss tangent and the time dependent decay characteristics of vacuum evaporated samarium fluoride thin films.

EXPERIMENTAL

High purity samarium fluoride powder (99.999%) supplied by rare earths India Ltd) was thermally evaporated from tantalum boat on to a glass substrate. Thick deposits of Aluminum were used as top and bottom electrodes and the thin film capaci-

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tors were fabricated in MIM form. All the depositions were carried out at room-temperature and at a vacuum of 10^{-5} Torr. Indium was used as a contact material. The width of the Aluminum electrode was about 0.2 cm., so that the film capacitor had an effective area of about 0.04 cm^2. Thickness of the film was measured by multiple beam interferometry technique developed by Tolansky[3]. The capacitance and loss tangent were measured using systronics LCR bridge type 921 with Philips external frequency generator.

RESULTS AND DISCUSSION

The variation of capacitance with AC voltage at different temperatures for a frequency of 5 kHz film having thickness 3635 A^0 was shown in figure1. At liquid Nitrogen temperature, the capacitance was minimum and was independent of AC Voltage (upto 12 volts). The increase in capacitance was gradual at the temperatures of 219K and 243K. Above the room-temperature from 320-400K the increase in capacitance with AC voltage was rapid.

The variation of loss tangent with AC Voltage at different temperatures at a frequency of 5 kHz for SmF_3 film of thickness 3635 A^0 was shown in fig.2. At liquid nitrogen temperature the loss tangent was independent of AC voltage. The plot drawn for the temperature at 187K the increase in loss tangent was not much with ac voltage. For the temperatures 243K, 257K, 282K the tan δ increases considerably with ac voltage. At 377K the tan δ increases considerably with AC voltage. In the presence of AC fields the charge carriers can move apart was found to be the function of the field strength. Hence, as the field strength increases more number of charges can be separated causing an increase in ac voltage. From the fig.1. it was clear that the amount of variation in capacitance with AC voltage was function of temperature. Higher the temperature, the variation in

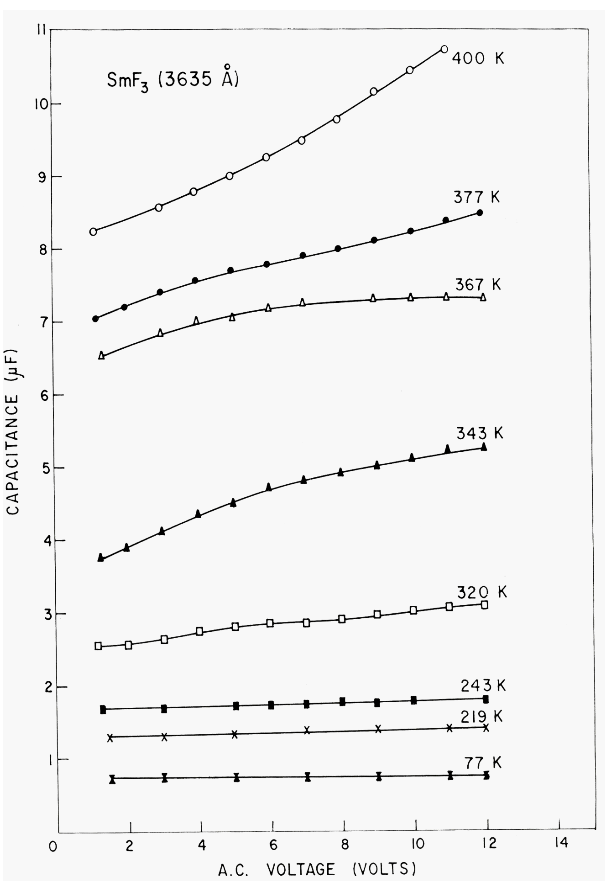

Figure 1: C v/s AC voltage at different T(K)

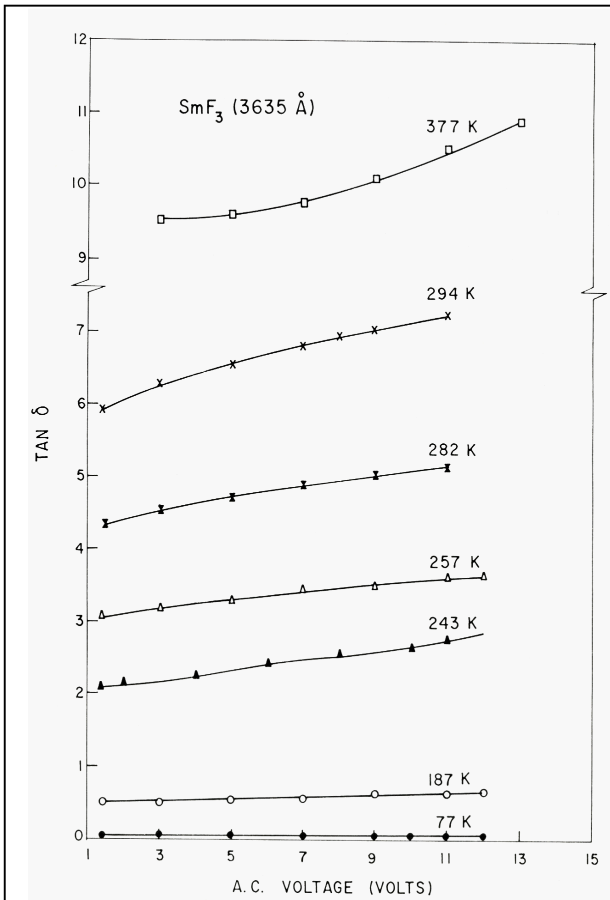

Figure 2: Tan δ v/s AC voltage at different T(K)

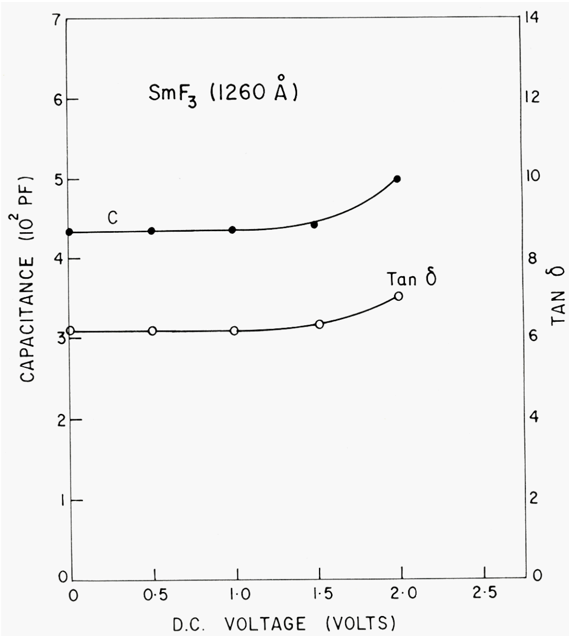

Figure 3: C and tan δ with DC voltage

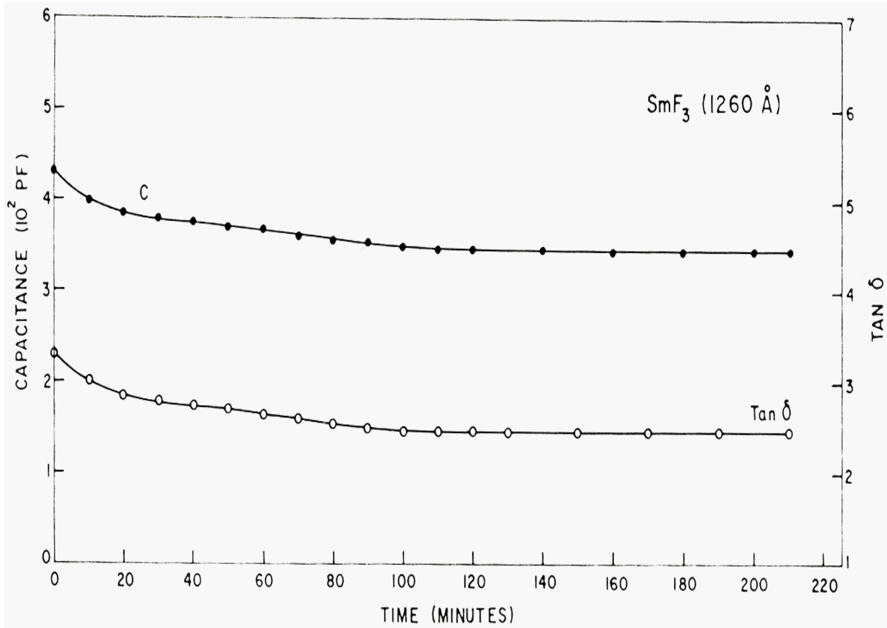

Figure 4: Time dependent decay characteristics of C and Tan δ

capacitance was more with AC voltage. This behaviour can be easily understood, as at higher temperature the contribution to the conductivity from the charge carriers was more. The variation of capacitance and loss tangent with DC voltage for Samarium fluoride thin film of thickness 1260A^0 was shown in figure 3. The capacitance and loss tangent was found to be independent of DC voltage upto 1.5V and above this voltage there was a slight increase in capacitance and loss factor. Similar studies were made on MoO_3 films prepared at high temperatures[4]. It was observed that after this if the DC bias was further increased the capacitor became unstable and their decay characteristics were shown in figure 4. Initially the charges were slowly mobilized so that there was a slight increase in capacitance and once this stage was crossed the charge carriers will take easy paths so that the accumulation of charges at the electrodes gradually falls off resulting in decrease of capacitance. The decay in capacitance may be due to high density of defects in the films, which act like weak paths.

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