ROOM TEMPERATURE CONDUCTION CHARACTERISTICS OF CALIX [4] ACID/AMINE ALTERNATE LAYER LANGMUIR-BLODGETT FILMS

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Abstract: Multilayered Langmuir-Blodgett (LB) films were prepared by transferring alternately six layers of calix [4] acid and five calix [4] amine molecules from the subphase of Millipore water ($18\mathrm{M}\Omega\,\mathrm{cm}^{-1}$) on aluminised glass substrates. Electrical measurements were made obtained at room temperature on LB films in a sandwich structure with a $50\,\mathrm{nm}$ thick thermally evaporated aluminium films. The low voltage value of conductivity is found to be $13.4\times10^{-12}\,\mathrm{Sm}^{-1}$. The electrode–limited Schottky effect is responsible for conduction mechanism at a relatively high field due to dc bias and the barrier potential height is determined to be $1.65\,\mathrm{eV}$ for metal/ LB film/metal system. The ac conductance shows typical power law dependence with a value of ≈ 0.9 for the exponent.

INDEX TERMS:: Electrical characterisation, LB films, calixarene, dielectricity.

I. Introduction

Organic thin films find many applications in optoelectronic devices [1-2] and sensor industry for example; a gas sensor [3-4], a heat sensor [5-6]. In recent years, calix[n]arene derivatives are extensively studied for their possible application as sensors because these materials are highly selective molecular receptors for various metal ions and organic compounds for separation and analyses applications [7]. Theis article reports the results of DC measurements on calix [4] acid/amine LB film device between two aluminium electrodes.

II. Experimental details

The chemical structure of the materials used in this work is shown in Fig. 1. Chloroform was used as a solvent for both materials. The concentrations of solutions were approximately 0.5 mg ml^{-1}.

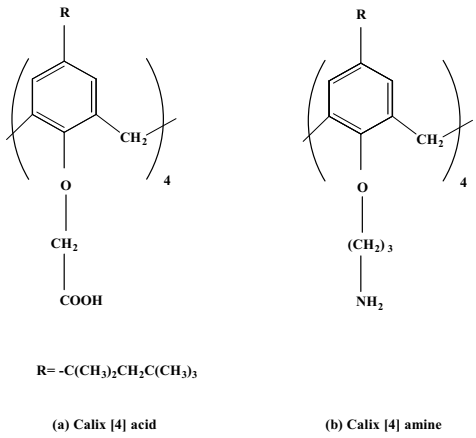

Figure 1: Chemical structure of the materials

Alternate layer LB films were prepared using a NIMA 622 type alternate layer LB trough. Solutions were spread

onto the water surface using a microlitre syringe and approximately 15 minutes were allowed for the chloroform to evaporate. Monolayers at the water surface were sequentially transferred onto an aluminised glass substrate by the alternate layer LB deposition procedure. The deposition pressure for both materials was 22.5 mN m^{-1}. The deposition speed of calix [4] acid for the first three monolayers was 2 mm min^{-1}, and for subsequent layers it was 10 mm min^{-1}. Calix [4] amine were deposited on the withdrawal of the substrate at a speed of 10 mm/min. The substrates used for this LB multilayer assemblies were aluminised glass microscope slides prepared using an Edwards E306A evaporation system. The thickness of bottom and top electrodes were 50 nm. 6 monolayers of calix [4] acid and 5 monolayers of calix [4] amine using LB film deposition process were deposited between two electrodes. DC measurements were performed in the range of ± 4 V..

III. Results and discussions

I-V graph is shown in Fig.2. The experimental results show that the I-V characteristics are symmetrical and highly non-linear. The ohmic or linear part of the I-V curve in the range of 0-1V yields a conductivity of 1.34×10^{-13} S m^{-1}, which is a characteristic of insulator. As shown in Figure 3, the I-V curve obeyed the $\ln J \propto V^{1/2}$ dependence in the range of 1-4 V.

The slope of this graph can be used to determine the experimental β value [8].

$$m = \frac{\beta}{kTd^{1/2}} \qquad (1)$$

where k is the Boltzmann's constant, T is the absolute temperature and d is the film thickness. The molecular thickness of calix [8] arene acid and amine is calculated 1.5 nm using Corey-Pauling-Koltun (CPK) models [14]. In this work bilayer thickness of calix [4] acid/amine alternate layer LB film is assumed to be approximately 3 nm. The field –lowering factor β was estimated to $1.07\,x10^{-5}\,eV\,m^{1/2}\,V^{-1/2}$.

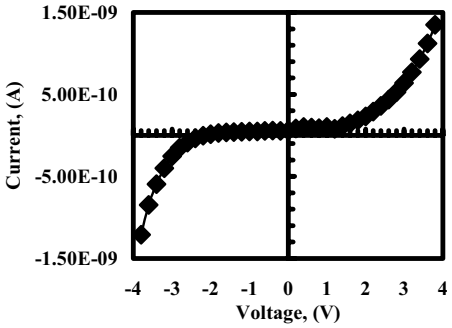

Figure 2: A typical set of I-V characterstic for Al/LB films/Al structure

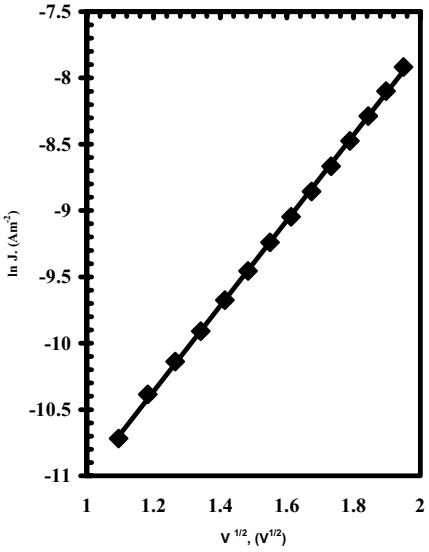

Figure 4: A plot of ln J as a function of $V^{1/2}$.

IV. Conclusions

Calix [4] acid/amine alternate layer LB film is produced using a standard LB film deposition technique and DC electrical properties of this LB film is analysed at room temperature. It is found that two transition mechanisms play in the conduction mechanism that depends on the applied voltage. A linear or ohmic regime in the low voltage value with a

conductivity of $1.34x10^{-13}$ S m^{-1}. I-V results showed that the Schottky effect occurs in the high voltage. The carrier effective mass and the high of potential barrier has been evaluated from I-V measurements. They are found to be 0.46 m_o and 1.65 eV.

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