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Thickness Analysis of Lanthanum Doped $Bi_{3.25}La_{0.75}Ti_3O_{12}$ Thin Films

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Abstract - FRAM is a superior memory that has fast speed of reading and writing the data. Also, it consumes less power. In the proposed work, Sol gel method is used to prepare Lanthanum doped Bismuth Titanate (BLT) thin films. Three samples with different thickness have been prepared. Leakage current, remanent polarization and fatigue behavior of these samples have been studied to find the optimal thickness.

Keywords- FRAM, Sol Gel, Thin film, film thickness, fatigue, BLT

I. INTRODUCTION

Ferroelectric random access memory (FRAM) has features consistent with a RAM technology, but it is non-volatile like ROM technology [1]. FRAM is a RAM-based device that uses the ferroelectric effect for the storage mechanism [2]. BLT with 75% doping of La ($Bi_{3.25}La_{0.75}Ti_3O_{12}$) is used to prepare thin films [3]. BLT thin films have several advantages such as extremely low coercive field, low processing temperature, high remnant polarization, better mechanical strength and minimum field induced polarization switching fatigue [4]. Sol gel is the most suitable method to prepare thin films [5]. However, leakage current, remanent polarization and fatigue behavior are affected by the film thickness. Hence, the analysis of $Bi_{3.25}La_{0.75}Ti_3O_{12}$ is required to find the optimal thickness for making thin films.

II. EXPERIMENTAL PROCEEDURE

A. Sol Preparation

25 ml of $Bi_{3.25}La_{0.75}Ti_3O_{12}$ precursor solution of 0.1 M molarity was prepared. To prepare sol 4.7294gm of Bi $(NO_3)_3.5H_2O$ was dissolved in 25 ml of acetic acid at 140^0C and the net volume was reduced to 12.5 ml. 0.8119gm of La $(NO_3)_3.6H_2O$ was dissolved in 25 ml of 2-Methoxy ethanol at 160^0C .Volume was reduced to 12.5 ml. Both the solutions were mixed at room temperature and 2.2324ml of Ti - (isopropoxide) was added. Sol was stabilized with 2 ml of acetyl acetone. 10% wt of Bi $(NO_3)_3.5H_2O$ and 10%wt of Ti- (isopropoxide) was added to compensate for possible Bi loss during high temperature process.

B. Film Deposition

BLT films were prepared on cleaned Pt (111)/TiO_2/SiO_2/Si (100) substrate. The precursor solution was spin coated on substrate at rotational speed of 5000 rpm for 45 sec. The baked films were spin coated several times to yield the thicknesses of 250 nm, 350 nm & 450 nm. For each coating, films were dried at 110^0C for 5 min and after each two coating films were fired at 400^0C for 20 min. All coated BLT films were annealed at about 600^0C in air 2hours. 6 layers for 250 nm, 8 layers for 350 nm and 10 layers for 450 nm thick films were deposited on platinum-coated silicon substrates.

III. RESULT ANALYSIS

A. Leakage current density

On varying the thickness of the films, the current density has changed and is shown in table I. It has been seen that current density obtained for thin film is higher than thicker films.

Table I
Current Density of BLT Samples

Film Thickness	Current density at 1 volt (A/cm^2)
250 nm	Greater than 10^{-6}
350 nm	Less than 10^{-6}
450 nm	Less than 10^{-6}

B. Hysteresis Analysis

P–E hysteresis analysis for the three samples is done. As per the requirement of the applications of the thin film, high remanent polarization is desirable. Table II shows the measured remanent polarization Pr for the three BLT samples. 350 nm thick film shows highest Pr.

Table II
Remanent Polarization of BLT Samples

Film Thickness	Pr ($\mu C/cm^2$)
250 nm	15
350 nm	22.5
450 nm	20.5

C. Fatigue Behavior

It is desirable that the thin films for memory application must be fatigue free. 250 nm and 450 nm thin film show that polarization is decaying with the switching cycles that result in fatigue. However, 350 nm thick film shows minimum polarization fatigue. Table III shows fatigue characteristics of three samples.

Table III
Fatigue Behavior of BLT Samples

Samples Size	Polarization Fatigue
250 nm	More
350 nm	Negligible
450 nm	More

IV. CONCLUSION

From the above analysis, it is seen that the properties of films change with the thickness. It has been observed that thinnest sample has more leakage current and low remanent polarization while the thicker sample has more polarization fatigue. Therefore, it can be concluded that 350 nm is the optimal thickness that can be used for making thin films.

V. REFERENCES

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