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Magnetic Studies on LiZn Ferrite Films

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Abstract. In this paper, we report the study of the magnetic properties of $(\text{Li}_{0.5-x/2} \text{Mn}_{0.1} \text{Zn}_x \text{Fe}_{2.35-x/2} \text{O}_4)$ films with $x=0, 0.16, 0.32, 0.48$. The films were deposited on fused quartz substrates by rf sputtering technique under various deposition conditions. The magnetic properties of the films annealed at 750°C are being reported. The M_s values of the films deposited at a rf power of 240 W in argon atmosphere were found to be smaller than the corresponding bulk values. The M_s value was found to be maximum at $x=0.32$, similar to the bulk. The H_c values of the films are much higher than the bulk values and decrease as a function of x .

1 Introduction

Lithium ferrites are good material for low power microwave devices with low dielectric losses. Substitution of diamagnetic zinc increases the magnetization and make these ferrites useful for latching devices. Recent microwave integrated circuit design demands the use of ferrites in thin film form. In the literature, there are very few reports on lithium ferrite thin films [1,2]. Oliver et al. [2] have deposited $\text{Li}_{0.45} \text{Zn}_{0.1} \text{Mn}_{0.05} \text{Fe}_{2.4} \text{O}_4$ films on MgO single crystal substrates using pulsed laser deposition technique (PLD). We have earlier reported the magnetic properties of $\text{Li}_{0.5-x/2} \text{Mn}_{0.1} \text{Zn}_x \text{Fe}_{2.35-x/2} \text{O}_4$ films with $x=0.32$ [3], deposited on amorphous fused quartz substrates with various deposition conditions by rf sputtering. We have carried out a systematic study of lithium zinc ferrite (LiZn) films for different values of x . In this paper, we report the magnetic properties of these films with $x=0, 0.16, 0.32, 0.48$.

2 Experimental

Lithium zinc ferrite films were deposited in a Leybold Z400 rf sputtering unit. Four polycrystalline LiZn ferrite targets with varying zinc concentration were used for deposition. Before sputtering, the chamber was evacuated to 2×10^{-6} mbar. The films were deposited by varying rf power, O_2/Ar and target-substrate distance. In this paper, we report the films with varying x deposited at a rf power of 240 W. All the films were deposited onto fused quartz substrates in argon atmosphere. The total pressure in the chamber during deposition was 6×10^{-3} mbar. The in-plane M - H loop of the films were measured on a vibrating sample magnetometer at room temperature.

3 Results and discussion

The as-deposited films were x-ray amorphous. Films with spinel structure were obtained after annealing at 750°C for two hours with a lattice constant similar to the bulk.

The saturation magnetization (M_s) values of the films as a function of x is shown in Fig. 1. The bottom plot of Fig. 1 corresponds to the M_s values of the film, whereas the top plot corresponds to the bulk [4] with composition $\text{Li}_{0.5-x/2} \text{Zn}_x \text{Fe}_{2.5-x/2} \text{O}_4$. It is clear that the M_s values in the films are smaller than those expected for the bulk.

The reduction of M_s values in ferrite thin films as compared to bulk has been observed in various types of magnetic thin films[3,5-7]. This could be because of many reasons, some of which are the presence of superparamagnetic particles and/or uncrystallized portions and voids in the films. Oliver et al.[2] have observed around 73-100 % of bulk M_s values in their films deposited on single crystal substrates. Hence, it is likely that amorphous substrates used by us caused a grain structure which was responsible for lowering of M_s . One also notes from Fig. 1 that M_s value reaches a maximum at $x=0.32$ and thereafter decreases with increase in zinc concentration, similar to the phenomenon observed in the bulk[4]. This indicates that the films most likely maintain the composition of the target. This is also supported by the fact that our earlier studies of the energy dispersive analysis of x-ray(EDAX) for $x=0.32$ samples[3] indicated a composition similar to the target.

Fig. 1: M_s values as a function of zinc concentration

Fig. 2: H_c and M_r/M_s values as a function of zinc concentration

The remanence ratio (M_r/M_s) and coercivity (H_c) of the films are shown in Fig. 2. As seen in the figure, the M_r/M_s values decrease as x increases. The H_c values are also found to decrease almost linearly as a function of x . A similar decrease of H_c with x was also observed in case of bulk LiZn ferrites[4]. However, in bulk, the H_c values are much smaller and were 3.75 Oe for $x=0$ and 2 Oe for $x=0.48$. Oliver et al. [2] have also reported a higher value of H_c for their samples. Their observed H_c values varied between 30-55 Oe, depending upon the oxygen partial pressure. It, therefore, appears that larger values of H_c are typical of thin films. The reason for this is not clear but may be related to microstructure or growth mechanism of the films. A study of microstructure on the films are being carried out and will be reported later.

In conclusion, we have deposited ($\text{Li}_{0.5-x/2} \text{Mn}_{0.1} \text{Zn}_x \text{Fe}_{2.35-x/2} \text{O}_4$) films with $x = 0, 0.16, 0.32, 0.48$ using rf sputtering. The M_s values are found to be smaller than the bulk while the H_c values are much larger. The M_s values reach a maximum at $x=0.32$ as seen in bulk.

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