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Internal Friction Studies in $Ni_xZn_{1-x}Fe_2O_4$ Films

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ABSTRACT: Internal friction in polycrystalline($Ni_x Zn_{1-x}$) Fe_2O_4(where x =0.2, 0.6 and 0.8) films has been measured using one crystal composite oscillator method. The internal friction was recorded at three different frequencies i.e, 60, 100 and 160 KHz in the temperature range of 80 to 600 K. The films used are prepared by rf-sputtering method on quartz plate substate. X-ray analysis was carried out on the as prepared and annealed films to check the crystallization. MH curves at room temperature are observed using a VSM up to a magnetic field of 20 kOe. It was found that the results of X-ray diffraction and saturation magnetization are consistent each other. It was also found that the values of initial permeability in the frequency range of 1 MHz- 600 MHz are better than those of bulk materials. In all samples under investigation the internal friction with temperature three peaks at 580 , 510 and 280 K . The observed peaks and other results are compared with magnetic properties and available domain theories.

1. INTRODUCTION

Ni-Zn ferrites are considered as the substances which are suitable for the devices used in the high frequency applications, because of their resistivity is very high. Therefore many studies are undertaken on the bulk materials. However, there is very less information on the thin films of Ni-Zn ferrites,hence we report on the results of the preparation of Ni-Zn ferrite thin films by rf- sputtering. As a part of our programme on investigation of domain wall dynamics in ferrimagnetic oxides, internal friction studies are conducted using the one crystal composite oscillator method in the temperature of 80-600 K.

2. EXPERIMENTAL

The Ni-Zn ferrites films with formula $Ni_x Zn_{1-x} Fe_2 O_4$ (x =0.2, 0.6 and 0.8) about 60 nm to 1.2 μm thick were been prepared by rf-sputtering apparatus. The quartz glass plate of 2.5 mm thick was selected as substrate.The background vacuum was about 10^{-6} Torr before discharge. The flow meters are used to control the flow rate of argon and oxygen gases. The power supply between the target and the substrate amounted to 10 W/cm^2 . X-ray analysis was carried out on the prepared and annealed films to check the crystallization. It was found that the films are of a random polcrystalline Ni-Zn ferrites.The mean grain size and surface roughness have been measured by using an atomic force microscope and it was found that the average thickness for all films is 1 μm, the mean grain size is 540 nm and surface roughness is 80 nm. Many more results about preparation of films are given in our earlier communication [1].

The magnetic properties were measured by using a VSM up to a maximum field of 20 kOe. The initial relative permeability was measured in the frequency range of 1- 600 MHz using a impedance analyzer at room temperature.

A one crystal piezoelectric composite osillator was used to measure the internal friction in the thin films.The major disadvantage of composite oscillator methods [2] was that it is not possible to determine the internal friction on the solids at different frequencies. The present exprimental setup consists of one quartz crystal in the place of two crystals. Hence, the cost of the oscillatory system decreases; errors occuring to bonding are

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lower and the mechanical rigidity is better. A 20 kHz quartz crystal of length (L) with gaps of eltrodes at L/2, L/4,and L/8 yielding frequencies 40.80 and 160 kHz have been used in the present investigation. The accuracy of measurements of internal friction is about +/- 2 % .

3. RESULTS AND DISCUSSION

The Fig. 1 gives typical MH curve obtained for the $Ni_{0.4}Zn_{0.6}Fe_2O_4$ film. It was found that the saturation magnetization values are consistent with the results of X-ray diffraction. It can be seen from Fig. 2 that the real part of permeability is independent of frequency in the range of 1- 600 MHz. The magnitude of the initial permeability for the all the films is in the range of 30 to 60. Thus. the observed frequency characteristics for these films are better than bulk materials. It can be seen from the Fig. 3 that the variation of Q^{-1} versus temperature T, for one of the typical $Ni_{0.4}$ Zn $_{0.6}$ Fe_2 O_4 film at three frequencies i.e.. 40. 80 and 160 kHz. It can be seen from the figure that the thermal variations of internal friction are similar: however. the magnitude are different. It can be seen from the figure that the variation of Q^{-1} versus T shows three peaks at 580, 510, and 280 K. The peak observed at 580 K disappeared when we applied a magnetic field equal to the saturation field of the sample under investigation i.e.. 2000 Oe. It was also found that the peaks observed at 510 and 280 K are found to be independent of the applied magnetic field. Similar results are observed in all other films.

The peak observed at 580 K is found to be near the Curie temperature of the sample i.e.. 585° C and therefore it is due to domain walls. This is because. this peak was absent in the single domain state of the sample and present only in the multidomain state. The occurence of this peak can be theoretically explained by statistical theory of ferromagnetic domain walls given by Landau [3]. According to this theory: the domain wall energy changes periodically with the variation of its position. There exists a barrier which obstructs the motion of the domain walls and which inturn decreases their mobility. As the temperature increases and approches T_c . the domain wall width increases as $1 / (T_c - T)$and results in the exponential decrease of barriers and causes an infinite increase of mobility of domain walls. There may be a greater number of domains which appear abruptly when passing through the Curie point and then these domains slowly coagulate into larger ones. In other words. the density of the domain walls increases when the temperature approaches Curie point.

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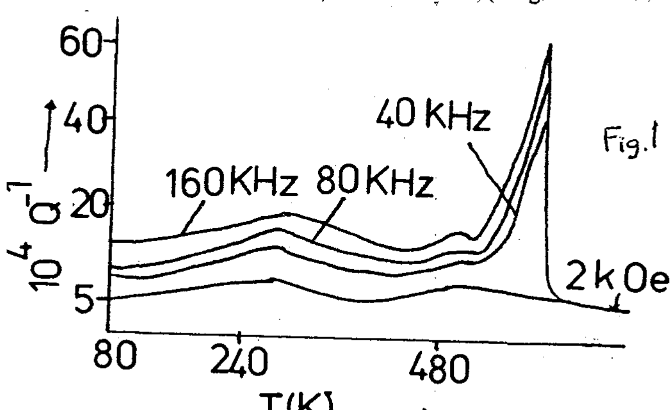

Fig·3

Fig.1

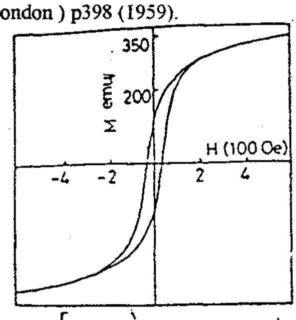

Fig.2