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Structural Properties Magnetic Measurement of Nano Crystalline NiFe2O4 Prepared by Co-Sputtering Techniques

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***Abstract*— Nickel ferrite (NiFe2O4) nanoparticles with an average crystallite size of about 20-25 nm were prepared by dc plasma sputtering system employing closed-field unbalanced magnetron, structural and magnetic properties were investigated by using X-ray diffraction, scanning electron microscopy (SEM) and magnetization measurements. Besides that The study demonstrates that one can tailor the magnetic properties of NiFe2O4 nanoparticles by suitably controlling their size by using different gasses mixture.**

***Index Terms*— Magnetite measurement, Nickel ferrite, Nanostructures..**

I. Introduction

Magnetic semiconductor ferrites were studied extensively due to their wide field of technological applications. Ferrites have a vast range of applications from microwave to radio frequencies, and have a very low conductivity, which is an important requirement for microwave applications [1, 2]. They play a very important role in the electrical, electronic, automobile industries because of their interesting electrical and magnetic properties. These properties of ferrite depend upon chemical composition, methods of preparation, porosity, grain size, cation distribution etc. [3]. Among the ferrites spinel ferrites are commercially important materials because of their excellent combined magnetic and electrical properties [4]. The development of ferrite thin films will provide several advantages for microwave and millimeter wave devices. Spinel structure materials are cubic and have the form AB_2O_4 (A = divalent cations and B = trivalent cations). The cations are distributed at tetrahedral (A) site and octahedral (B) site. The occupancy of cations at (A) and (B) site decides whether the spinel ferrite is normal, inverse or random.

The distribution of cations at (A) and (B) sites largely influences the structural, electrical and magnetic properties of spinel ferrites. NiFe2O4 is a typical soft ferromagnetic material, which crystallizes in a completely inverse spinel structure with all nickel ions located in the octahedral sites and iron ions occupying tetrahedral and octahedral sites [4][5]. The spinel structure contains two cation sites for metal cation occupancy. There are 8 A-sites in which the metal cations are tetrahedral coordinated with oxygen, and 16 B-sites which possess octahedral coordination. When the A-sites are occupied by Me2+ cations and the B-sites are occupied. By Fe3+ cations, the ferrite is called a normal spinel. If the A-sites are completely occupied by Fe3+ cations and the B sites are randomly occupied by Me2+ and Fe3+ cations, the structure is referred to as an inverse spinel[6,7] [8,9].

Nickel ferrite thin films can be prepared by numerous deposition technique viz. ferrite plating [5,10], plasma method[8,11],chemical vapour deposition [9,12], sputtering [10,12],pulsed laser deposition technique [11,12]etc. In this study, highly crystalline Nano sized nickel ferrite thin film was prepared by spray co-sputtering techniques from at low pressures with employment of concentric Ni and Fe targets. The structural characteristics of the prepared nanostructures are studied. Among the several deposition methods of thin film, sputtering deposition involves some advantages over other deposition methods since elements, alloys and compounds can be sputtered and deposited. Sputtering target provides a stable, long-lived vaporization source, so reactive deposition can be easily accomplished using reactive gaseous species that are activated in plasma. Deposition process causes very little heat, and the adhesion of the deposited films on the substrate surface is enhanced because the average arrival energy at the substrate surface is higher for sputtered atoms (about 10 eV) than for evaporated atoms (about 0.25 eV at 3000K)[12]..

II. Experimental Part

In order to study the influence of the preparation method on the structural and magnetic properties of nickel ferrite nanoparticles we have prepared nanoparticles by using the DC plasma sputtering system.

Two discharge electrodes, vacuum pumps and accessories, and cooling and heating facilities. The chamber could be evacuated down to 10-3 mbar by a rotary pump and to 10-5 mbar by a diffusion pump. The base vacuum was determined by the purpose of the discharge process. Argon at maximum pressure of 0.8mbar was used as the discharge gas and its pressure was finely controlled by needle valve. More details on the dc plasma sputtering system can be found in references [13].

The two targets of highly pure nickel (Ni, 0.9999) and iron (Fe, 0.999) were mounted on the cathode.

Highly-pure oxygen gas was flowing to the chamber throughout needle valve to represent the reactive gas required to form the compound of nickel ferrite. The mixture of argon and oxygen gases could be controlled by a gas mixing unit before entering the chamber.in this work the ratio of argon to oxygen is (30:70) the gas mixture could be easily varied as the system was operated to controlling their nanoparticles size by using different gasses mixture.

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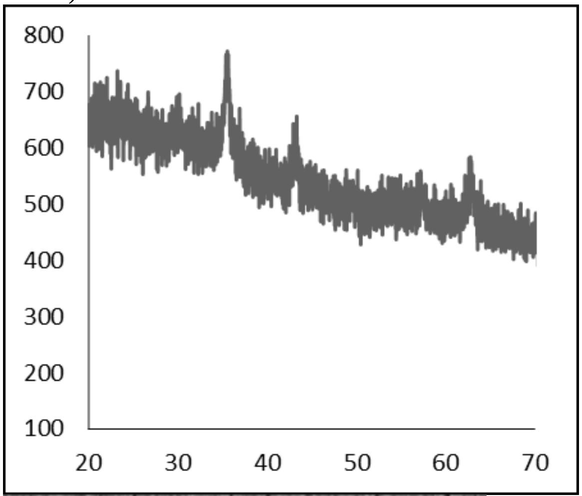
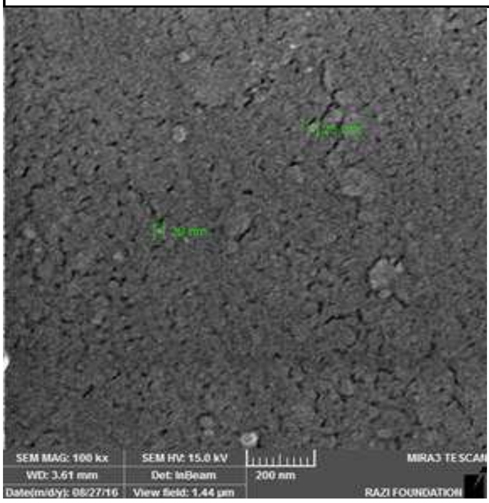
III. CHARACTERIZATION

The obtained samples were characterized by powder X-ray diffraction (XDR) and scanning electron microscopy (SEM). Fig (1) shows the XRD patterns of the prepared sample at gas mixture (30:70) (Ar: O_2). All the diffraction peaks in Fig.2 confirmed the formation of the polycrystalline as more than one peak can be apparently observed on these patterns., scanning electron microscopy (SEM), The experimental measurements to detect the magnetic field near the fabricated sensor were carried out by using an experimental setup prepared in our lab as shown in the figure below Their magnetic measurement were investigated by using The standard probe of the Gauss meter (Alpha Lab GM-2).





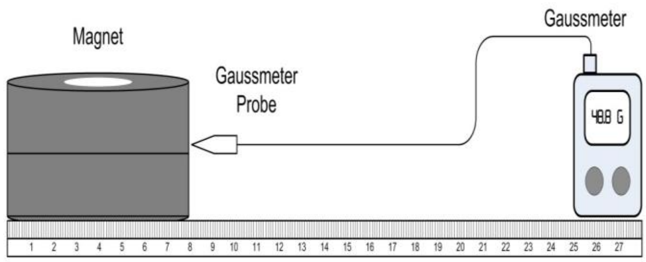


Figure (3) Setup for the density calibration of dc magnetic flux source (magnet) as a function of distance from the surface of the source

respectively. These planes are characteristic for NiFe2O4 structure and since no other peaks are observed, this may highlight that the prepared sample is highly pure. The XRD pattern confirms the formation of spinel cubic structure of NiFe2O4.

Figure (2) shows the SEM image of the prepared sample and the minimum particle size is 20-25nm and the homogeneity over the tested area is reasonably accepted

Their magnetic measurement were investigated by using The standard probe of the Gauss meter (Alpha Lab GM-2) was replaced by the fabricated sensors to test their response to the magnetic flux in their surroundings, as shown in fig (3), In order to introduce the role of the prepared sample ($NiFe_2O_4$ thin film, which is ferromagnetic material) to support or depress the flux of the magnetic flux source, this sample was placed between the source and the Gauss meter probe. The obtained results were compared with the first condition as shown in the fig. (4), A reduction of about 7% was observed due to the existence of the prepared sample at distances below 6cm while both values were approximately equal at longer distances, fig(5).

The $NiFe_2O_4$ thin film magnetic sensor fabricated in this work can be good attempt to produce reliable device for different applications of magnetics and magnetic field detectors, The readout of the Gauss meter using the standard probe was recorded at different distances from the magnetic field source to be 54.5G at a point P1 in the figure. At the same point, the readout of the Gauss meter using the fabricated sensor was also recorded to be 38.2G.

Nano powder sensor exhibits higher values of detected magnetic field than the thin film sensor. However, the fluctuations in readouts from the Nano powder sensor forced us to use and enhance the thin film sensor design.

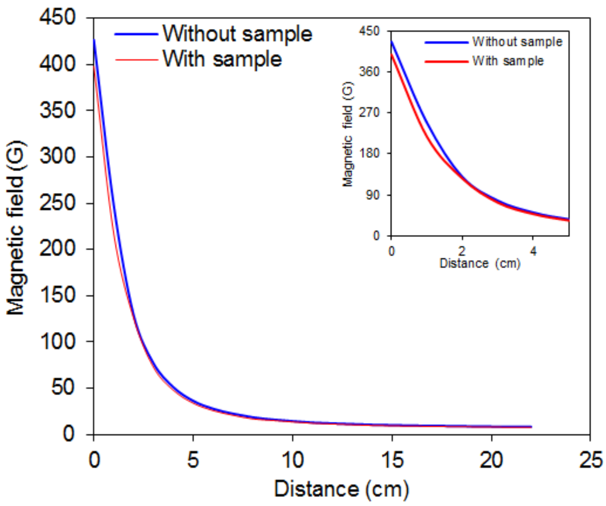


Fig (4) Comparison of the measured density of the magnetic flux source with and without using $NiFe_2O_4$ thin film sample between the source and the standard probe of the Gauss meter

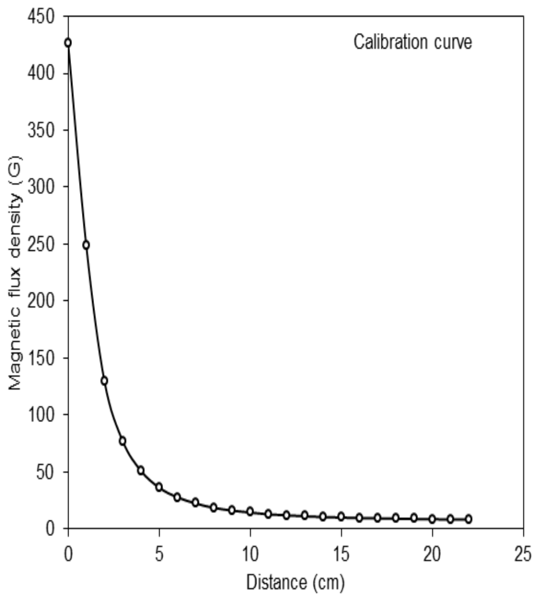


Fig (5) the calibration of flux density of the magnetic flux source (magnet) with the distance from its surface

IV. CONCLUSION

Summarizing the above experimental results we can conclude nickel ferrite (NiFe2O4) nanostructures can be prepared by a low-pressure dc magnetron sputtering technique using a special arrangement of concentric targets to be sputtered and can used the prepared nanostructures showed that they have high structural purity, with particle size (20-25)nm , However the NiFe2O4, nanoparticles prepared by co-sputtering method a fairly high magnetic measurement with different distance from it surface.

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