Deposition and Characterization of Cadmium Ferrite Thin Film by Spray Pyrolysis Technique

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Abstract: In the present work, $CdFe_2O_4$ thin film has been prepared by spray pyrolysis technique at deposition temperature 360 °C. The deposited thin film was annealed at 500°C for 4 h. The prepared thin film was characterized by X-ray diffraction and Raman spectroscopy. X-ray diffraction technique was employed to confirm the formation of single phase nanocrystalline thin film. The crystallite size of the present thin film is of the order of 19 nm confirming the nanocrystalline nature of the film. Raman spectroscopy was used for phase confirmation.

Index Terms - Cadmium ferrite, Spray pyrolysis, XRD, Raman

I. INTRODUCTION

Ferrites are most useful important magnetic materials due to their combined electrical and magnetic properties, which can be modified for desired application [1-2]. The ferrite thin films are used for lot of applications, such as magnetic recording media, sensors, microinductors and microwave devices [3]. The ferrite films are effectively utilized as magnetic core materials with low iron loss in, opto-magnetic devices, vertical recording magnetic material and in surface magnetism study [4]. Transition metal oxide ferrites (MFe_2O_4) are magnetic materials with cubic spinel structure and have been used in various electronic and electrical applications for the last two-three decades [5]. The high permeability in the radio frequency region, make them suitable for use in electronic devices. Nano-cadmium ferrite ($CdFe_2O_4$) is a normal spinel ferrite that can be applied in various fields [6]. The $CdFe_2O_4$ thin film exhibits ferromagnetism, and ∼54% of Fe^{3+} ions occupy the A site in contrast to 0% for the bulk materials with normal spinel structures [7]. The enhanced occupancy of Fe^{3+} ions in $CdFe_2O_4$ is explained by a higher octahedral preferential energy of Cd^{2+}. In this paper, nano-$CdFe_2O_4$ thin film is prepared using the spray pyrolysis that is considered as one of the important methods used in nanoparticles synthesis. This process is chosen because it gives enhanced homogeneity, better control for thickness of thin film, uniformity and degree of agglomeration of the resulting nanocrystals, simple compositional control.

The aim of the present work is to prepare $CdFe_2O_4$ thin film using the spray pyrolysis technique and to characterize by X-ray diffraction and Raman spectroscopy for structural analysis of $CdFe_2O_4$ thin film.

II. EXPERIMENTAL METHOD

The Cadmium ferrite ($CdFe_2O_4$) thin film was deposited on to preheated glass substrate using spray pyrolysis technique. The solutions were prepared by using mixture of $Cd(NO_3)_2.6H_2O$ (Cadmium nitrate hexahydrate) of 0.08 M and $Fe(NO_3)_3.9H_2O$ (ferric nitrate nonahydrate) of 0.08 M and 1:2 volumetric proportion. The $CdFe_2O_4$ thin film was prepared by spraying solution on to preheated glass substrate. The glass substrate was cleaned with an ultrasonification for 30 min in distiled water before film deposition. Then after cleaning glass substrate was mounted on to hot plate surface and set the substrate temperature to 360 °C. The as deposited thin film was annealed at 500 °C for 4 h. The deposited thin film was characterized by X-ray diffraction (XRD) analysis (BRUKERD8 Advance) with Cu-Kα radiation. Raman spectrum was taken by Micro-Raman Spectrometer (STR-500 Japan) at room temperature.

III. RESULTS AND DISCUSSION

The **Fig. 1** shows that X-ray diffraction patterns of $CdFe_2O_4$ thin film deposited on glass substrate temperature at 360 °C. The X-ray diffraction shows that some lower intensity peaks appeared in cobalt ferrite thin film due to the lower peaks as (220), (311), (222), (400), (422), (511) and (440) also the spinel cubic crystal structure of the deposited film. Average crystallite size of nanoparticles was calculated from the Debye-Scherrer's equation.

$$D = (0.90 /\lambda) / (\beta \cos \theta) \quad (1)$$

Where, d is the crystalline size, λ the wavelength of x-ray (1.5406 A). β the full-width at half–maximum and θ is the angle of diffraction. Crystalline size of the present cadmium ferrite thin film was obtained to be 19 nm. The lattice constant, X-ray density and crystallite size are tabulated in table 1.

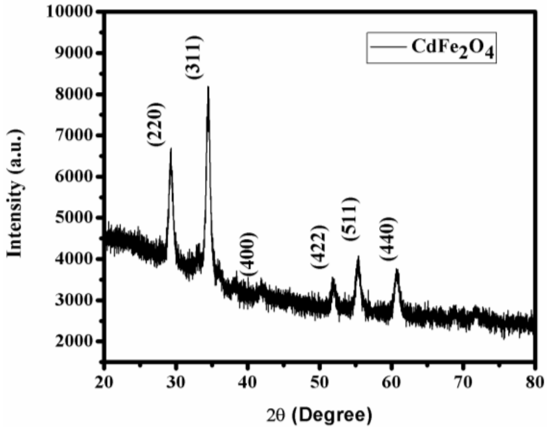

Fig.1 (a) The X-ray diffraction pattern of $CdFe_2O_4$ thin film

Table 1 Lattice constant, X-ray density and crystallite size for $CdFe_2O_4$ thin film.

Lattice constant	X-ray density	Crystallite size	Grain size
8.526	6.175	19	36

There are five first order Raman active modes ($A_{1g} + E_g + 3F_{2g}$) in the normal cubic spinel structure as shown in **Fig. 1(b).** The A_{1g} mode is due to symmetric stretching of oxygen atoms along Fe-O (or M-O) tetrahedral bonds, Eg and $3F_{2g}$ are due to symmetric and asymmetric bending of oxygen with respect to Fe (M), respectively. Raman spectrum of sintered $CdFe_2O_4$ ferrite exhibits a normal spinel structure with symmetric peaks. The Raman peak over the region 660 12 cm^{-1} represents the modes of tetrahedral group and 440.08 cm^{-1}region to the octahedral group of cadmium ferrite thin film In the case of the $CdFe_2O_4$ all five Raman peaks seem asymmetric.

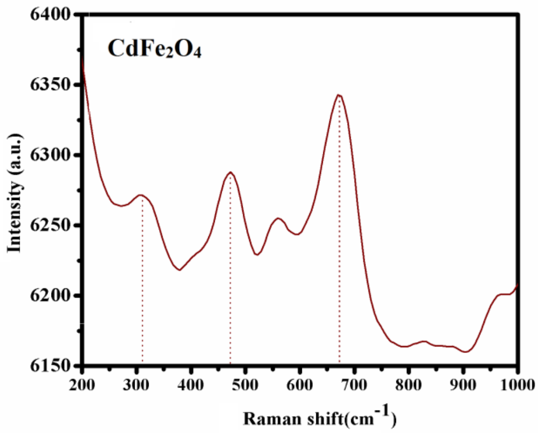

Fig.1 (b) Raman spectra of $CdFe_2O_4$ thin film

IV. CONCLUSION

The cadmium ferrite ($CdFe_2O_4$) thin film was successfully deposited using spray pyrolysis technique. The X-ray diffraction patterns show that, the single phase nature without any secondary phase. The result of Raman modes confirms the five Raman modes confirm to cubic spinel structure.

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