Available online at www.sciencedirect.com

ScienceDirect

materialstoday: PROCEEDINGS

Materials Today: Proceedings 3 (2016) 1277 – 1282

International Semiconductor Science and Technology Conference 2015 (ISSTC 2015)

Maghemite produced by Chemical Spray Pyrolysis method on different substrates

Sevda Sarıtaş, Mutlu Kundakçi and Muhammet Yıldırım*

Department of Physics, Science Faculty, Atatürk University, Erzurum and 25250, Turkey

Abstract

Maghemite (Fe_2O_3) was synthesized by chemical spray pyrolysis (CSP) method at same substrate temperatures on glass, MgO and ZnO thin films. In this study, first maghemite thin film was grown on glass substrate and structural analysis of maghemite thin film was made by X-ray diffraction (XRD) and scanning electron microscopy (SEM) techniques. MgO and ZnO thin films were synthesized by CSP on glass and their structural analysis was done. Then Fe_2O_3 thin film's comparative analyzes were performed.

Keywords: Maghemite (Fe_2O_3); MgO; ZnO; Spray Pyrolysis

1. Introduction

Maghemite (γ-Fe_2O_3) is the second most stable polymorph of iron oxide. Maghemite exhibits ferromagnetic ordering with a net magnetic moment (2.5 μ_B per formula unit) and high Néel temperature (~950 K), which together with its chemical stability and low cost led to its wide application as magnetic pigment in electronic recording media since the late 1940's [1]. Maghemite nanoparticles are also widely used in biomedicine, because their magnetism allows manipulation with external fields, while they are biocompatible and potentially non-toxic to humans [2-3]. Another promising application is in the field of spintronics, where it has been suggested that γ-Fe_2O_3 can be used as a magnetic tunneling-barrier for room-temperature spin-filter devices [4-5]. Both maghemite and magnetite exhibit a

* Corresponding author. Tel.:+90-442-231-1111 (ext) (4175); fax: +0-000-000-0000 .
*E-mail address:*myildir@atauni.edu.tr

doi:10.1016/j.matpr.2016.03.071

spinel crystal structure, but while the latter contains both Fe^{2+} and Fe^{3+} cations, in maghemite all the iron cations are in trivalent state, and the charge neutrality of the cell is guaranteed by the presence of cation vacancies. The unit cell of magnetite can be represented as $(Fe^{3+})_8[Fe^{2.5+}]_{16}O_{32}$, where the brackets () and [] designate tetrahedral and octahedral sites, respectively, corresponding to 8a and 16d Wyckoff positions in space group Fd_3 m. The maghemite structure can be obtained by creating 8/3 vacancies out of the 24 Fe sites in the cubic unit cell of magnetite. These vacancies are known to be located in the octahedral sites [7] and therefore the structure of maghemite can be approximated as a cubic unit cell with composition $(Fe^{3+})_8[Fe^{3+}{}_{5/6}\ Fe^{2+}{}_{1/6}]_{16}O_{32}$.

Prior to application in real devices, spintronics should be able to control the growth, magnetic and transport properties of Fe_2O_3 in the form of thin films. Therefore, in this study we investigated that Fe_2O_3 which was synthesized by CSP method at same substrate temperatures on glass, MgO and ZnO thin films. CSP is a technique that has been applied for the preparation of thin and thick films, because it is economical, fast, requires no vacuum, and it is simple to prepare thin films [8]. In addition, it is suitable for industrial scale production. Maghemite thin films grown on different substrates are compared by structural properties and surface morphologies.

2. Experimental details

In order to synthesize the maghemite, first we chemically cleaned the three parts of the glass in piranha solution. Then, Iron tri-chloride ($FeCl_3.6H_2O$), Iron (II) chloride ($FeCl_2.4H_2O$) salts were mixed with the ratio of (1:2). NaOH was dissolved in deionized water and added into mixed solution. Acetone was also added in precursor solution. Fe_2O_3 thin film was grown on glass substrate at 320°C and structural, morphological and elemental properties of the film is examined by XRD, SEM, EDX techniques. As shown in Table 1 MgO and ZnO thin films were grown on glass substrates with determined experimental parameters. Table 1 shows experimental procedure of film growth parameters for different substrates. For all film growth process, distance between the substrate and nozzle is set 30 cm. Obtained MgO and ZnO thin films on glass were used as substrates, for maghemite thin film growth. Then also structural, morphology and elemental properties of the Fe_2O_3 thin films grown on different substrates were examined by XRD, SEM, EDX techniques.

Table 1. Experimental parameters by using CSP method grown on different substrates the Fe_2O_3 thin films

Substrate	Thin films	Salts for precursors solutions (in deionized water)	Molar ratio of precursors solutions	Substrate Temperature (°C)	Carrier gas	Film Growth Process time (min)
Glass	Fe_2O_3	$FeCl_3.6H_2O$+ $FeCl_2.4H_2O$+NaOH	1:2:0.25	320	air	35
	MgO	$Mg(NO_3)_2$.6H2O+NaOH	1:0.25	450	air	20
	ZnO	$Zn(NO3)_2.6H_2O$+ $(CH_2)_6N_4$	1:2	450	air	25
MgO/Glass	Fe_2O_3	$FeCl_3.6H_2O+FeCl_2.4H_2O$+NaOH	1:2:0.25	320	air	35
ZnO/glass	Fe_2O_3	$FeCl_3.6H_2O+FeCl_2.4H_2O$+NaOH	1:2:0.25	320	air	35

3. Results and discussion

Fig. 1 (a) shows the XRD spectra of the Fe_2O_3 thin films deposited on glass by CSP at 320°C substrate temperature. The structural analysis of Fe_2O_3 thin films was examined by XRD with varying diffraction angle 2θ°, by Rigaku 2200D/Max (CuKα (λ=1.5405 Å)).