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Studying Effect of Eu Doping on the Structural Properties and Infrared Spectroscopy of Aluminum Oxide powders by Solid State Reaction Method

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Abstract
Eu doped Aluminum oxide transparent conducting powder were preparedbysolid state reactionmethod. Structural properties of the samples were investigated as a function of various Eu-dopinglevels (x=0.00-0.0012-0.0016-0.002-0.003). The results of x-ray diffraction haveshown that the samples are polycrystalline structure in tetragonal phase with preferential orientationsalong the (400) for all samples The relative intensities, distance between crystalline planes (d),crystallite size (D) and lattice parameters (a), (c) were determined. Infrared Spectroscopyhave been studied by Infrared Spectrometer Device.
Keywords: powder, Eu doped Aluminum Oxide, solid state reaction, Structural properties,Infrared Spectroscopy.
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1. Introduction

Transparent conducting oxides (TCOs) are semiconductors that are produced from a combination of metal andoxygen such as: ZnO, In_2O_3, SnO_2. The studying of TCOs is very important because of their specialproperties that is used in technology applications [1].

Aluminum oxide (Al_2O_3) is considered as one of the most important member of the TCOs for its uniqueelectrical and optical properties because it has low electrical resistivity, high optical transparency in visibleregion, high optical reflectance in infrared region and chemical inertness. So, Al_2O_3 is used in solar cells, sensorgas, display devices and in other important applications [2].

Al_2O_3 is an p-type semiconductor with wide band gap energy (Eg = 3.5-4 eV) [3]. Al_2O_3 has tetragonalstructure belonging to the P42/mnm space group. The lattice parameters are a = b = 2.184 and c = 3.184 A [4].Its unit cell contains two Aluminum and three oxygen atoms as is shown in figure 1. The Aluminum atom is at the center of sixoxygen atoms placed at the corners of a regular octahedron. Every oxygen atom is surrounded by four Aluminum atomsat the corners of an equilateral triangle [5,6].

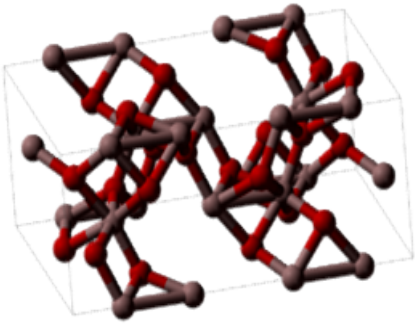


Fig. 1: Unit cell of the crystal structure of . Al_2O_3 Large circles indicate oxygen atoms and the small circlesindicate tin atoms.

2 .Experimental Method

$Al_{1-x}Au_xO_3$ powders (x = 0.00.0.012,0.016, 0.002, 0.003) were prepared bya solid state reaction method. were accurately weighed in required proportions and were mixed andground thoroughly using an Agate mortar and pestle to convert to very fine powders.

The grinding of the mixtures was carried out for 3 hours for all the powder samples.The groundpowder samples werefiring at 700°C for 3 hours.

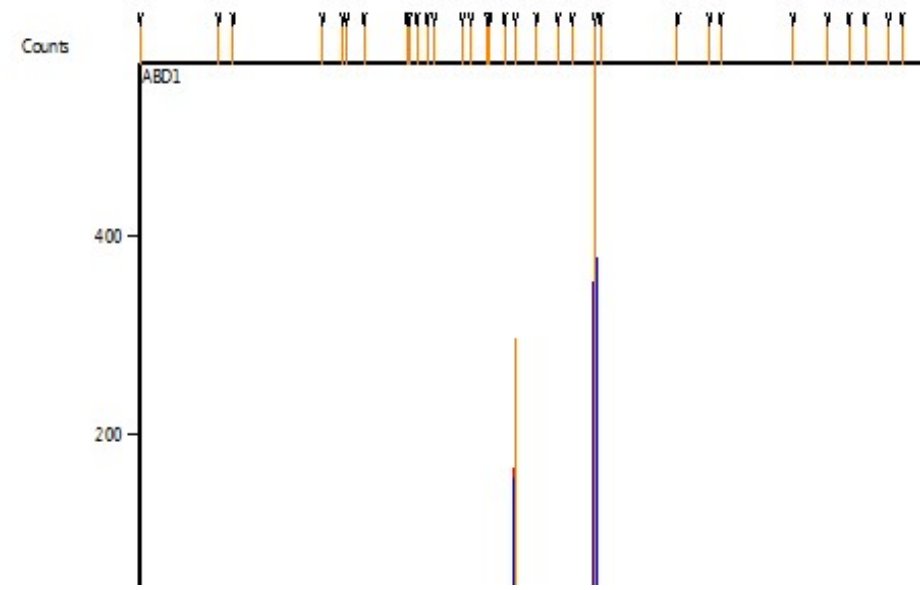
3 .Results and discussions

3.1Structural properties

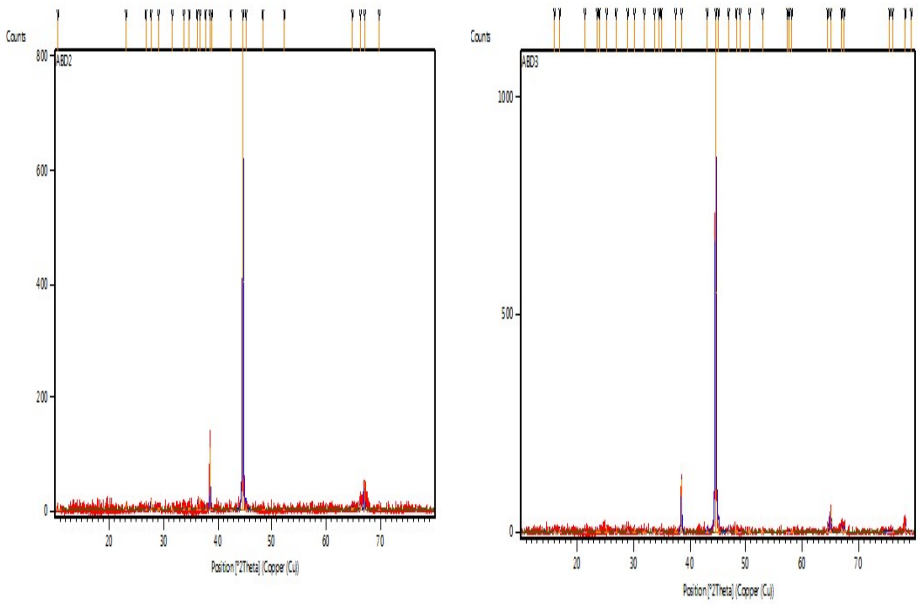
The X-ray diffraction patterns of undoped and Au doped Al_2O_3 powders preparedwith various Au concentration 0 wt%, 0.12 wt%, 0.16 wt%, 0.2wt%and 0.3wt% are shown in Fig. 2.

The XRD reveals that all samples are having polycrystalline nature with tetragonal structureand peaks correspond to (105), (305) , (400), (440) , (4.0.12) , (113) , (314) , (116) , planes. The preferred orientation is (400) forall samples.We noticed disappearance of these orientations (501) ,(518) in all doped samples.

pure



Eu 0.16% **Eu 0. 2%**



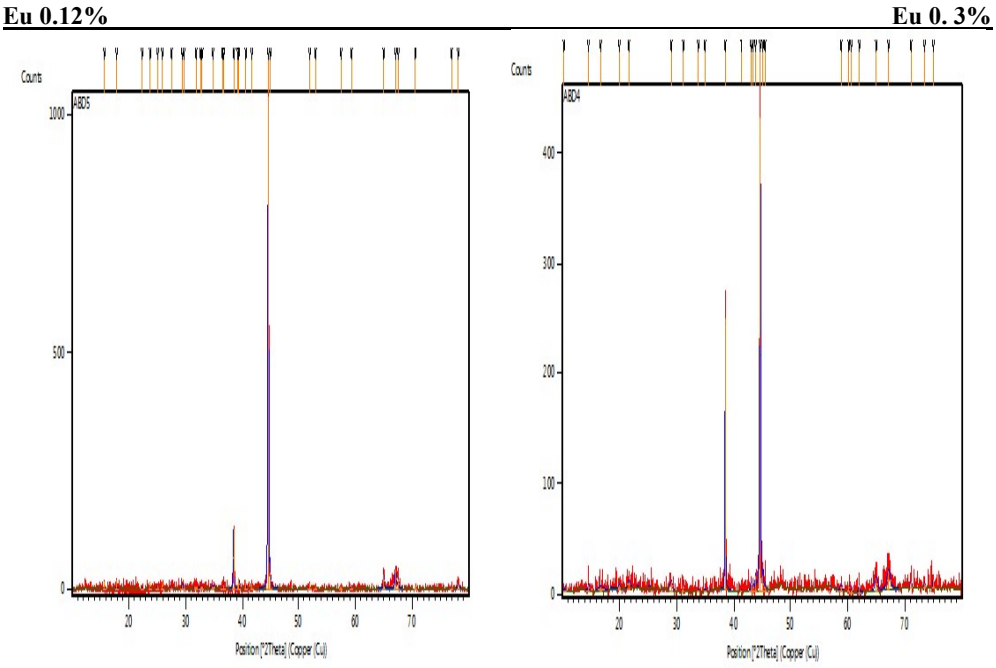


Fig. 2: XRD results of pure. Al_2O_3 , 0.12 wt% Eu doped Al_2O_3 , 0.16 wt% Eu doped. Al_2O_3 , 0.2wt% Eu doped . Al_2O_3, 0.3 wt% Eu doped . Al_2O_3.

Table (1) shows results of structural values of undoped. Al_2O_3 sample.

Table (1)

العينات	2θ	(hkl)	d	الشدات النسبية	β	D	متوسط D(nm)	ثوابت الشبكة	
المدروسة	(deg)		(Å)	Rel. int. [%]	(deg)	(nm)		a(Å)	c(Å)
(نقي)	23.93	(114)	3.717	8	1.12	7.577	1.184	2.184	3.184
	38.52	(305)	2.336	72	1.17	7.516			
	44.71	(400)	2.026	100	1.25	7.180			
	73.12	(501)	1.294	9	1.25	8.266			
	76.63	(518)	1.243	10	1.50	7.052			

Table (2) shows results of structural values of Au doped Al_2O_3samples (x=0.012).

Table (2)

العينات	2θ	(hkl)	d	الشدات النسبية	β	D	متوسط D(nm)	ثوابت الشبكة	
المدروسة	(deg)		(Å)	Rel. int. [%]	(deg)	(nm)		a(Å)	c(Å)
(0.12wt%)	22.36	(113)	3.975	6	0.34	24.888	18.65	4.748	3.184
	38.47	(314)	2.339	18	0.23	38.226			
	44.60	(400)	2.031	100	0.20	44.860			
	65.09	(440)	1.433	8	0.28	35.165			
	67.52	(4.0.12)	1.387	10	0.23	43.406			

Table (3) shows results of structural values of Au doped Al_2O_3samples (x=0.016).

Table (3)

العينات	2θ	(hkl)	d	الشدات النسبية	β	D	متوسط D(nm)	ثوابت الشبكة	
المدروسة	(deg)		(Å)	Rel. int. [%]	(deg)	(nm)		a(Å)	c(Å)
(0.16wt%)	23.14	(105)	3.843	6	1.12	7.566	3.68	4.748	3.184
	38.87	(305)	2.316	28	1.17	7.524			
	44.73	(400)	2.025	100	1.25	7.181			
	66.31	(440)	1.409	7	1.25	7.931			
	67.07	(4.0.12)	1.395	10	1.50	6.638			

Table (4) shows results of structural values of Au doped Al_2O_3samples (x=0.002).

Table (4)

العينات	2θ	(hkl)	d	الشدات النسبية	β	D	متوسط D(nm)	ثوابت الشبكة	
المدروسة	(deg)		(Å)	Rel. int. [%]	(deg)	(nm)		a(Å)	c(Å)
(0.2wt%)	25.27	(105)	3.523	4	1.12	7.596	3.68	4.748	3.184
	38.52	(305)	2.336	16	1.17	7.516			
	44.72	(400)	2.026	100	1.25	7.181			
	65.07	(440)	1.433	8	1.25	7.876			
	67.45	(4.0.12)	1.388	6	1.50	6.653			

Table (5) shows results of structural values of Au doped Al_2O_3samples (x=0.003).

Table (5)

العينات	2θ	(hkl)	d	الشدات النسبية	β	D	متوسط D(nm)	ثوابت الشبكة	
المدروسة	(deg)		(Å)	Rel. int. [%]	(deg)	(nm)		a(Å)	c(Å)
(0.3wt%)	28.05	(116)	3.180	8	1.12	7.640	3.68	4.748	3.184
	38.51	(314)	2.337	84	1.17	7.515			
	44.74	(400)	2.025	100	1.25	7.181			
	64.99	(440)	1.434	10	1.25	7.873			
	67.13	(4012)	1.394	14	1.50	6.641			

The relative intensities of undoped and Au doped Al_2O_3 powders are calculated. Thedistance betweencrystalline planes values (d) are calculated by using following relation:

$$2d.\sin\theta = n\lambda \qquad (1)$$

Where d is distance between crystalline planes (A), θ is the Braggangle, λis the wavelength of X-rays (λ=1.54056 A).

The crystallite size is calculated from Scherrer's equation [7]:

$$D = \frac{0.94\lambda}{\beta\cos\theta} \qquad (2)$$

Where, D is the crystallite size, λ is the wavelength of X-ray, ß is full width at half maximum (FWHM) intensityin radians and θ is Braggs's angle.

The lattice constants a and c for tetragonal phase structure are determined by the relation [8]:

$$\frac{1}{d^2} = \frac{h^2+k^2}{a^2} + \frac{l^2}{c^2} \qquad (3)$$

Where d and (hkl) are distance between crystalline planes and Miller indices, respectively.

The calculated lattice constants a, c values are given in table 1,2,3. It was seen that a, c and c/a match well withJCPDS data(a=b= 2.184 A and c= 3.184 A).

The change in peak intensities is basically due to the replacement of AL^{3+}ions with Au^{2+}ions in the lattice of the Al_2O_3 . This process leads to the movement of AL^{3+}ions in interstitial sites.

5. Conclusion

This paper presents a study of structural properties of Au doped Al_2O_3 powdersprepared by solid state reaction method. X-ray diffraction patterns confirm that the samples have polycrystallinenature with tetragonal structure and show presence (105), (305) , (400), (440) , (4.0.12) , (113) , (314) , (116) planes in pure tin oxide sample. The allsamples have preferred orientation along (400) plane. The average of crystallite size iswithin the range [11.877-7.004 nm] for all samples. It was defined that the lattice constants a, c for all the samples, werealmost

identical with JCPDS values, and the ratio c/a remained constant with increasing Fe dopantconcentration.FTIR analysis revealedthat the Fe doping manifests itself by a shift in Al_2O_3 absorption peaks positions.

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