

Synthesis and Characterization of Spintronic Material ($\text{Hg}_{0.8}\text{Cd}_{0.2}\text{Te}$) by Solid State Reaction

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Abstract

Poly-crystalline Spintronics material ($\text{Hg}_{0.8}\text{Cd}_{0.2}\text{Te}$) was synthesized through solid state reaction method. The sample with the diameter of $\phi = 5\text{ mm}$ and thickness $T = 1.5\text{ mm}$ was set via uni-axial persistent technique. Sample was melted at 800°C up to 2 h. The sample was characterized through scanning electron microscopy (SEM), Energy dispersive x-rays (EDX), and X-rays diffraction (XRD) studies to confirm the surface morphology and structural analyses. From XRD results it was confirmed that sample structure was cubical. Lattice parameters was determined by XRD 0.65 nm of ($\text{Hg}_{0.8}\text{Cd}_{0.2}\text{Te}$). Using crystallography method the miller indices (hkl) was also studied. The planes were observed (110), (210) and (331). From EDX results Te 42.82%, Cd 19.95%, Al 1.39%, O_2 32.06 % and C 3.79% were found for 2 h heat treatment at 800°C .

Keywords: II–VI Materials; Sintering; Scanning Electron Microscopy; EDX; Grain Size

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INTRODUCTION

Spintronic is a growing know-how that adventures the quantum tendency of the electrons to spin. The spin situation is exposed as an obvious weak magnetic energy state characterized as up and down spin (Sun et al., 2013; Alcock, 1972). Conventional electronic strategies rely on the transport of electrical charge carriers like electrons in a semiconductor. Engineers and physicists are unavoidably confronted the looming presence of quantum mechanics. They are interested to adventure the spin of the electron (Awschalom et al., 2002; Asghar et al., 2011). Instruments that rely on the electron's spin to perform their purposes form the basics of spintronic (Awschalom et al., 2002). Spintronic devices are as order of Pico meter in size, more multipurpose and more vigorous than silicon chips. Its consequences from subtle electron-spin effects in extraordinary thin multilayers of magnetic materials, that cause huge magnetic materials, huge changes in their electrical resistance as magnetic field is applied. This resulted in the first spintronic device in the form of the spin valve. The incorporation of these magical materials allowed the storage capacity from one to 20 gigabits CdTe , HgTe , ZnTe , CdMnHgTe , CdMnTe and CdHgTe are the variety of spintronic materials. These spintronic materials are already studied by our group especially II-VI materials. The spintronics with the compositions like MnTe and MnTe_2 are known, these were prepared by annealing. Stoichiometric quantity of the elements are sealed in vessel with high vacuum (Ladd, 1964) the structure of MnTe has as NiAs (Kunitomi et al., 1963) while pyrite structure of MnTe_2 have been found and are composed of Mn^{+2} and Te_2^{-2} Ions (Asghar et al., 2011).

MnSe and MnTe (Tasiopoulos et al., 1999) $\text{Li}_x\text{Mn}_{1-x}\text{Te}$ and $\text{Na}_x\text{Mn}_{1-x}\text{Te}$ have also been examined (Tasiopoulos et al., 1999; Alcock, 1972) CdTe takes Zinc Blende Lattice Parameter (a_0) at 300 K 0.65 nm . The possessions of Thin Gap cadmium based chemical compositions have been studied (Capper, 1994). II-VI materials particularly spintronic materials $\text{Cd}_x\text{Mn}_{1-x}\text{Te}$ has been studied with $x = 0.1 - 0.5$ (Reddy et al., 2005). The same technique has also been reported by some other researchers (Nakamura et al., 1991).

MATERIALS AND METHODS

Cadmium and Tellurium (Cd, and Te) were in fine granular powder form of up to 99.95% purity level. The Calculation were made for chemical arrangements conferring to the below formula

$\text{Hg}_{0.8}\text{Cd}_{0.2}\text{Te}$.

$$\text{Hg}_{0.8} = 200.59 \times 0.8 = 160.472\text{g}$$

$$\text{Cd}_{0.2} = 112.411 \times 0.2 = 22.482\text{g}$$

$$\text{Te} = 127.66\text{g}$$

For 60 hours, all the compositions were ground in to the grinder through mortar and pestle made by ceramics materials with polished smoothly walls. Hydraulic press was used for preparation samples. 1600 Pa (pressure) was applied. The pallets were of 5 mm dia and 1.5 mm thickness. The ready pallets were plane and compressed well. Pallets color was glassy gray and too shiny. Samples were subjected for heat treatment heated in the furnace at 800°C for 2 h. it was noted that the prepared sample on 800°C had yellow color and the sample was stuck debauched with crucible.

The special point was no use of any kind substrate and lid was used for crucible for possible evaporation. Progressively, the sample ability to stick to the crucible was found grew weak. After 48 h, the crucible was stroke slowly as a result the sample was detached. The sample was subjected for the characterizations of XRD, SEM and EDX.

RESULTS AND DISCUSSION

Structural, morphological and chemical compositions were studied by XRD, SEM and EDS. d-values, lattice constant and planes (hkl) were calculated from XRD data (Hanson et al., 2007; Kunitomi et al., 1963). Particle size was also calculated using Debye Sharer's formula (Kunitomi et al., 1963; Ladd et al., 1964).

$$P = k\lambda / \beta \cos\theta \quad (1)$$

Average crystalline size is obtained 52.49 nm to 31.64 nm as shown in the table. 3. X-Ray diffraction is used to study the crystal structure of $\text{Hg}_{0.8}\text{Cd}_{0.2}\text{Te}$ which is prepared at 800°C for 2 hours.

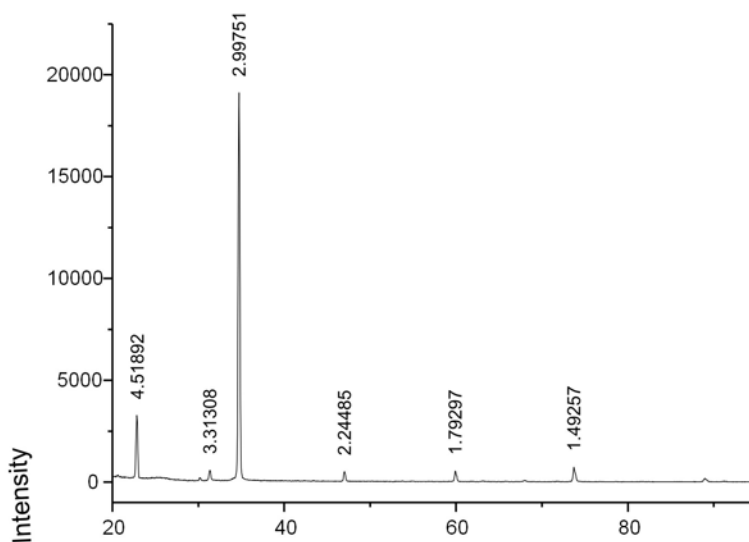


Figure 1: XRD of HgCdTe prepared at 800°C for 3 hours

Plan calculations indexing from XRD data

Indices

$$a = \text{lattice constant} = 6.5 \text{ \AA}$$

$$\lambda = \text{Co } (K\alpha) = 1.79 \text{ \AA}$$

Formula for the calculations of miller indices

$$h^2 + k^2 + l^2 = \sin^2 \theta \left(\frac{4a^2}{\lambda^2} \right)$$

Table 1: Calculation of miller indices for HgCdTe for using 2θ values

S. No.	2θ (Degree)	d-values	Miller indices hkl
1	22.85	4.52	110
2	31.35	3.31	200
3	34.75	2.99	210
4	47	2.25	220
5	59.9	1.79	320
6	73.7	1.49	331

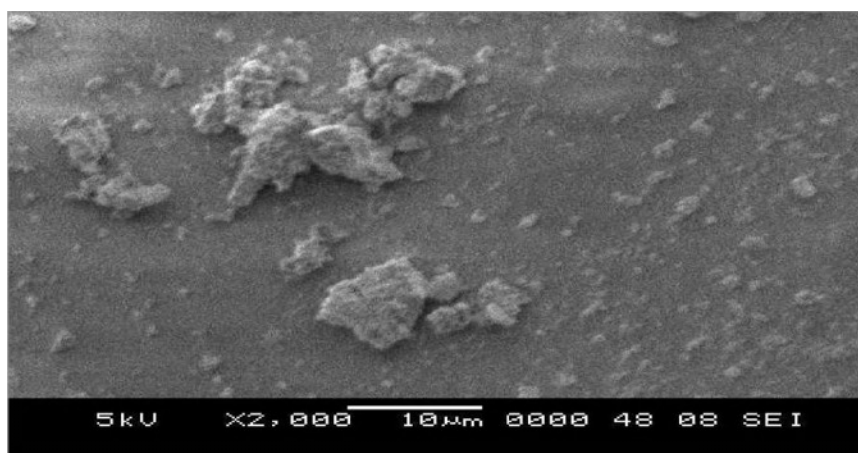


Figure 2: Surface morphology of the HgCdTe samples SEM micrograph

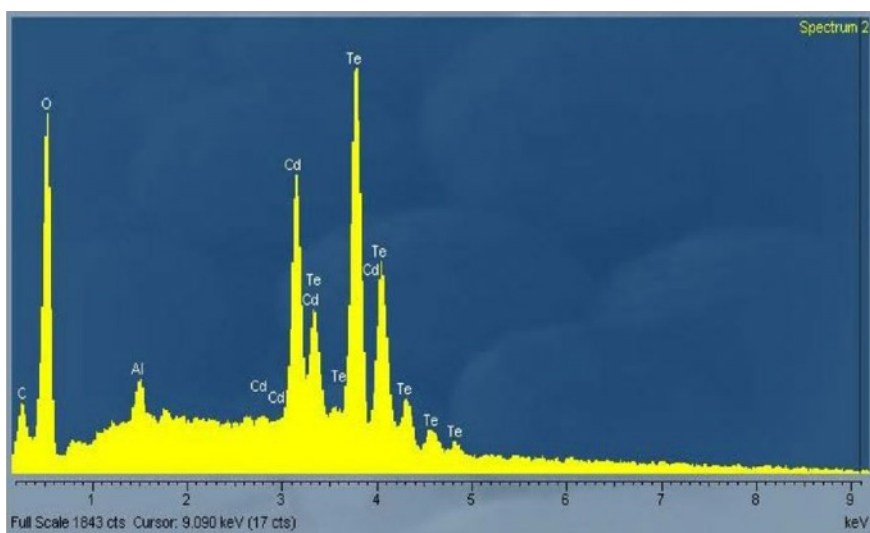


Figure 3: EDX-spectrum of the various elements in the sample

Table 2: Elemental analyses details, all results are considered as in weight percent

Spectrum Label	C	O	Al	Cd	Te	Total
Spectrum 1	4.66	33.52	1.42	19.47	40.94	100.00
Spectrum 2	2.92	30.59	1.36	20.42	44.70	100.00
Max.	4.66	33.52	1.42	20.42	44.70	
Min.	2.92	30.59	1.36	19.47	40.94	

Debye Shererr Formula (using XRD of 2 h. anealed matrial)

$$P = k \lambda / \beta \cos\theta$$

Where

P =

Paricle

Size

$$k = 1 \text{ rad}$$

$$\lambda = 1.790 \text{ \AA}$$

Table 3: Calculation of FWHM and particle size

2 θ Degree	θ (In Radian) in 10^{-1}	Width (FWHM) β (θ°) (Difference)	β Radian in 10^{-3}	$P = k \lambda / \beta \cos\theta$ nm
22.846	1.994	0.23648	4.127	43.37
31.343	2.735	0.23113	4.034	44.37
34.737	3.031	0.19536	3.410	52.49
47.023	4.104	0.22921	4.000	44.75
59.940	5.231	0.25755	4.495	39.82
73.758	6.437	0.32416	5.658	31.64

CONCLUSION

Structural properties of Spintronic material were studied of ($\text{Hg}_{0.8}\text{Cd}_{0.2}\text{Te}$) 99.95. Poly-crystalline Spintronics material ($\text{Hg}_{0.8}\text{Cd}_{0.2}\text{Te}$) was synthesized through solid state reaction method. The sample with the diameter of $\phi = 5$ mm and thickness $T = 1.5$ mm was set via uni-axial persistent technique. Sample was melted at 800°C up to 2 h. The sample was characterized through scanning electron microscopy (SEM), Energy dispersive x-rays (EDX), and X-rays diffraction (XRD) studies to confirm the surface morphology and structural analyses. From XRD results it was confirmed that sample structure was cubical. Lattice parameters was determined by XRD 0.65 nm of ($\text{Hg}_{0.8}\text{Cd}_{0.2}\text{Te}$). Using crystallography method the miller indices (hkl) was also studied. The planes were observed (110), (210) and (331). From EDX results Te 42.82%, Cd 19.95%, Al 1.39%, O_2 32.06 % and C 3.79% were found for 2 h heat treatment at 800°C . The calculated the average crystallite or particle size is 52.49 nm to 31.64 nm

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