# EFFECT OF GAMMA IRRADIATION ON THE CRYSTAL STRUCTURE OF $Cd_{1-x}Fe_xTe$ THIN FILMS

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In the present investigations effect of $\gamma$-irradiation on crystal structure and surface morphology of $Cd_{1-x}Fe_xTe$ (x = 0.08) thin films were studied. The properties of thin films exposed to $\gamma$- rays of 50, 100 and 150 kGy doses were characterized by XRD, SEM, EDX methods. XRD analysis confirmed the change in orientation of crystal planes after $\gamma$- exposure. It was defined that the peak intensity of (111) plane increased with irradiation dose and crystallite sizes were increased.

**Keywords:** Thin film, semimagnetic semiconductor, SEM, XRD, EDX, $\gamma$-radiation.
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## 1. INTRODUCTION

Obtain of new semiconductor materials, study of their physical properties, purposeful management and identification of applications in the creation of devices is one of the important issues of modern material science.

Thin films of II-VI compounds are attractive candidates for various optoelectronic applications in engineering. Bulk crystals of $Cd_{1-x}Fe_xTe$ semimagnetic semiconductors (SMSC) have been successfully used in modern instrumentation, especially in solar cells, radiation detectors, IR detectors, photodetectors, optical insulators, and etc. However, today it is impossible to imagine modern electronics without thin films. Because the devices are created on the crystals surface and all structural changes are reflected in the parameters of the devices, it is necessary to obtain thin films with a perfect crystal structure and clean smooth surface.

On the other hand, obtain of radiation-resistant and radiation-sensitive materials with stable physical properties is one of the actual problems of modern physics. It should be noted that under certain conditions, materials exposed to the strongest effects of ionizing radiation, change their physical properties due to the formation of radiation defects. Therefore, the study of effect of ionizing radiation on the physical properties of semiconductor materials is relevant.

It should be noted that $Cd_{1-x}Fe_xTe$ thin films are considered to be of special importance for fundamental research and practical application [1-5]. Few works have been devoted to the study of their physical properties. Present work devoted to the investigations of effect of $\gamma$-irradiation on crystal structure and surface morphology of $Cd_{1-x}Fe_xTe$ ($x$=0.08) thin films.

## 2. METODOLOGY

$Cd_{1-x}Fe_xTe$ ($x$=0.08) SMSC thin films of thickness 1.2 μm were deposited on cleaned glass substrates at the rate of $\upsilon$=18-20 Å/s by molecular beam condensation technique in a vacuum of $10^{-4}$ Pa. All technical details of the preparation methodology were given in our earlier works [4].

The films were irradiated with γ- rays obtained from a $^{60}Co$ source of $E$=1.17MeV, $E$=1.33MeV energies.

The structure and phase purity of the as-deposited and irradiated films were checked at room temperature by means of X-ray diffraction (XRD) using a BRUKER XRD D8 ADVANCE.

The studies of surface morphology were performed on the JEOL JSM-7600F Field Emission SEM.

## 3. EXPERIMENTAL AND RESULTS

Since the characteristics of electronic devices are mainly related to the surface morphology of the crystals, the study of external influences (temperature, pressure, illumination, radiation, etc.) on their surface diagnostics is of particular importance. It is known that one of the most convenient methods for the modification of semiconductor materials is radiation technology. Thus, it is possible to control the physical properties of materials by irradiation of material and predict the characteristics of the devices on their base. In this regard, it is of great interest to study the changes in the surface of the $Cd_{1-x}Fe_xTe$ thin films as a result of the effects of γ-radiation. The results of SEM and XRD studies of $Cd_{1-x}Fe_xTe$ ($x$= 0.08) thin films exposed to γ-irradiation ($D_\gamma \leq$200kGy) are presented in this study.

X-ray diffraction pattern of as-prepared $Cd_{1-x}Fe_xTe$ ($x$ = 0.08) thin films is shown in fig. 1,a. The XRD measurement reveals that all the sharp diffraction peaks (111), (220), (311), (400), (331) and (422) confirmed face centered cubic structure of $Cd_{1-x}Fe_xTe$ with crystal lattice parameter of $a$=6,47Å. The crystallite size of $Cd_{1-x}Fe_xTe$ ($x$ = 0.08) thin films may be estimated from the width of the XRD peak using Debye–Scherrer's formula [6] given by

$$D = (0.9\,\lambda)/(\beta \cos\theta)$$

where, $D$ - is crystallite size, $\beta$ - is full width at half maxima (FWHM) of the peak intensity, $\theta$ - is diffraction angle in degrees and $\lambda$ - is the wavelength of X-ray used (1.54060 A˚). The average crystallite size of $Cd_{1-x}Fe_xTe$ thin films was found to be 1.7 nm (table 1).

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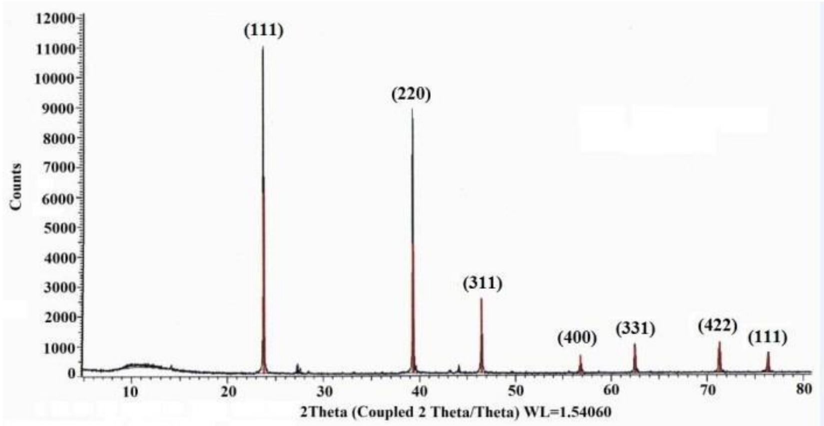
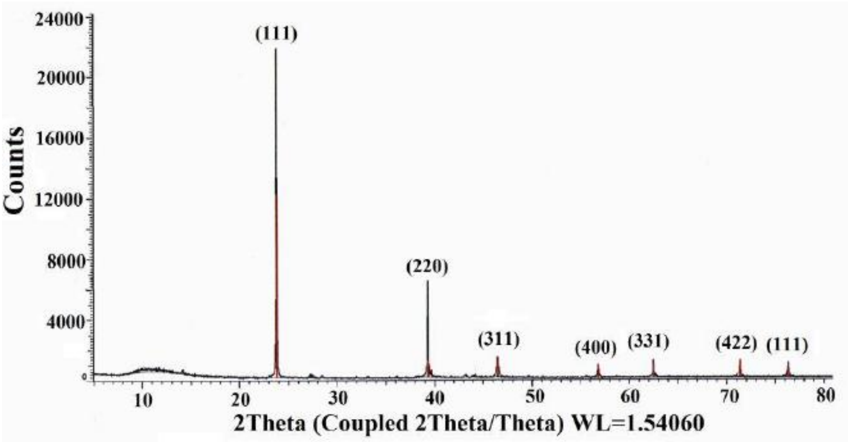
| № | 2θ (deg) | Crystal system (hkl) | FWHM, β (deg) | Crystal size, D (nm) |
|---|---|---|---|---|
| 1 | 24 | 111 | 0.15 | 2.2 |
| 2 | 39.5 | 220 | 0.15 | 4.24 |
| 3 | 46.5 | 311 | 0.15 | 1.15 |
| 4 | 57 | 400 | 0.1 | 1.55 |
| 5 | 62.5 | 331 | 0.25 | 0.6 |
| 6 | 71.5 | 422 | 0.25 | 0.8 |
| 7 | 76.5 | 111 | 0.2 | 1.46 |

a




b

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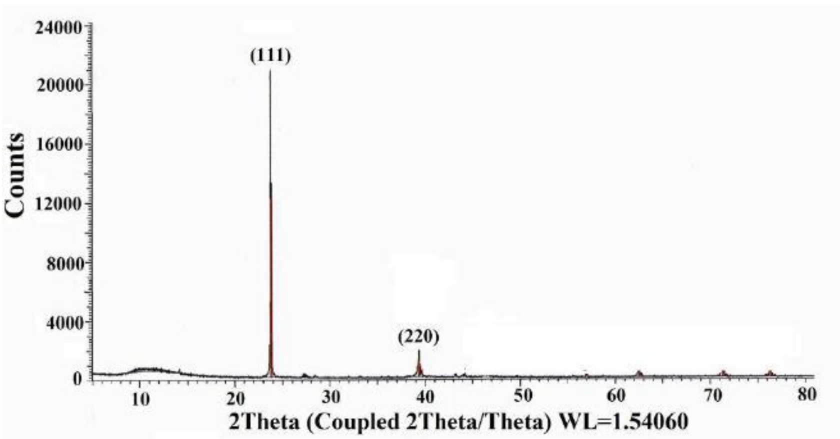
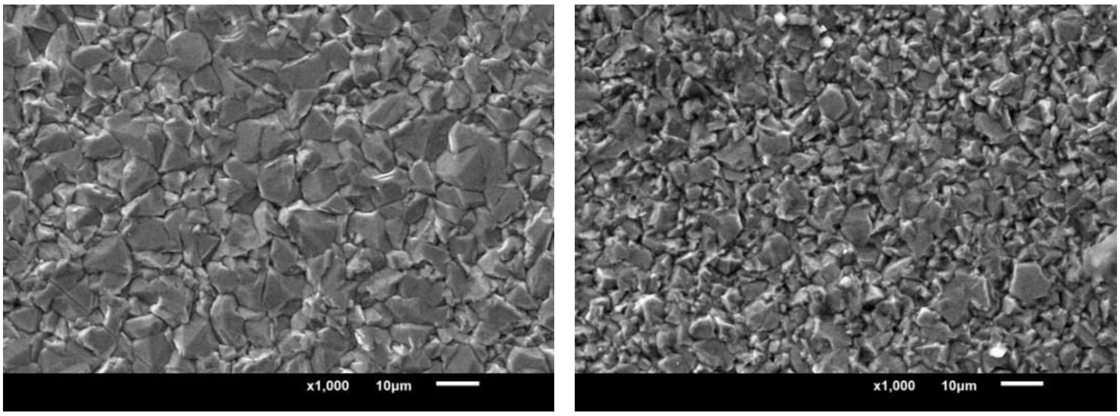



*Fig.1.* X-ray diffraction patterns of $Cd_{1-x}Fe_xTe$ ($x$=0.08) thin films a) $D_\gamma$ =0, b) $D_\gamma$ = 100 kGy, c) $D_\gamma$ = 150 kGy

XRD patterns of pristine $Cd_{1-x}Fe_xTe$ thin film on glass substrate and further irradiated with $\gamma$- radiation ($E$=1.17MeV, $E$=1.33MeV) with different doses ($D_\gamma \leq 200$ kGy) are shown in fig. 1. The diffraction pattern of $\gamma$ -irradiated thin films with different doses 50, 100 and 150 kGy revealed that the peak intensity of (111) plane of $Cd_{1-x}Fe_xTe$ increased with dose. This indicates that the number of planes aligned along the (111) direction increased with γ- irradiation. This is because $^{60}Co$ $\gamma$ -rays are high energy electromagnetic waves. When the radiation dose is large enough (100 kGy and 150 kGy) the surface energy will play an important role in the crystal growth process. In this process, atoms are easy to be attracted by (111) crystal face with high surface energy and condense there, which can result in the preferential growth of (111) plane [7]. Thus, XRD analysis confirmed the change in orientation of planes after gamma exposure.

The SEM method was used to study the effect of $\gamma$-irradiation on the surface morphology of $Cd_{1-x}Fe_xTe$ ($x$=0.08) thin films (fig.2). The morphology of $Cd_{1-x}Fe_xTe$ thin film was analyzed by SEM before and after $\gamma$- irradiation (Fig. 2). $Cd_{1-x}Fe_xTe$ ($x$=0.08) thin films irradiated by $\gamma$-quanta at a dose of $D_\gamma$=100 kGy, which is due to the interaction of $\gamma$-quanta with atoms in their path during irradiation.

After gamma irradiation, $Cd_{1-x}Fe_xTe$ crystallite size was increased (Fig. 2b) which is a good agreement with XRD results. Compositional analysis of pristine $Cd_{1-x}Fe_xTe$ thin film was done using Energy Dispersive X-Ray Analysis (EDX) shown in fig. 3.




a) b)

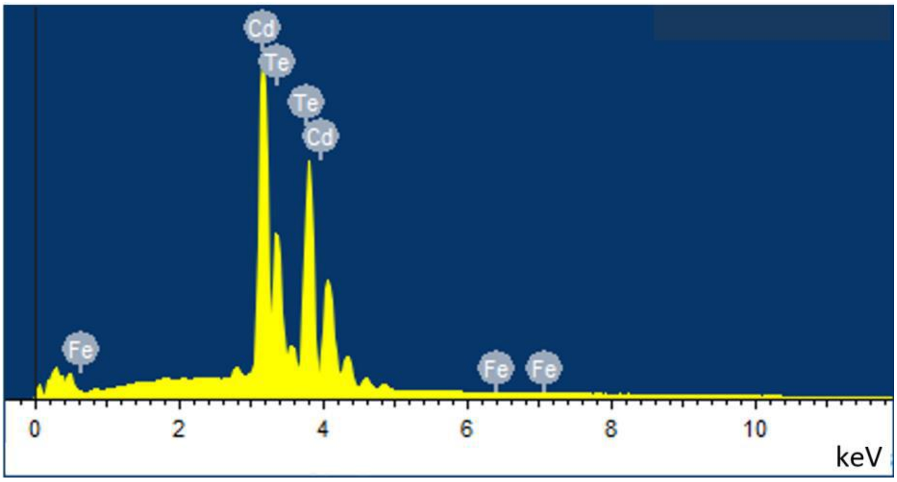



*Fig.2.* SEM imaging of the surface morphology of $Cd_{1-x}Fe_xTe$ ($x$=0.08) thin films: a) $D_\gamma$=0, b) $D_\gamma$ = 100kGy.

| Element | Weight % | Atom% |
|---|---|---|
| Fe K | 0.08 | 0.16 |
| Cd L | 47.33 | 50.45 |
| Te L | 52.60 | 49.39 |
| Total | 100.00 | 100.00 |

*Fig. 3.* EDX analysis of pristine $Cd_{1-x}Fe_xTe$ ($x$ = 0.08) thin film.

## 4. CONCLUSION

In the present investigations, $Cd_{1-x}Fe_xTe$ (x = 0.08) solid solutions were synthesized and thin films were obtained on their base by molecular beam condensation technique. We studied effect of *γ*-irradiation on crystal structure and surface morphology of obtained thin films. The properties of $Cd_{1-x}Fe_xTe$ ($x$ = 0.08) thin films exposed to 50, 100 and 150 kGy doses of *γ*- rays from $^{60}Co$ source were characterized by XRD, SEM, EDX methods. XRD analysis revealed that the peak intensity of (111) plane of $Cd_{1-x}Fe_xTe$ increased with dose. After *γ*- irradiation, crystallite size was increased. Thus, it is possible to manage some crystal properties by γ-irradiation.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