Fabrication and Characterization of Thermistor from Amorphous Semiconductor Composition Se$_{(90-x)}$Te$_{10}$Cd$_x$

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ABSTRACT

Five semiconductor thermistors are fabricated from five glasses of the system Se$_{(90-x)}$Te$_{10}$Cd$_x$ where X = 0, 3, 6, 9 and 15. These thermistors have been prepared from highly pure Selenium, Tellurium and Cadmium (99.999 % purity) elements by melting the constituents together under vacuum ($10^{-6}$ torr) in precleaned silica tubes at 850°C for about 8 hours and subsequently quenching in liquid nitrogen. The product ingots were confirmed to be amorphous by X-ray diffraction patterns (Co-K$_\alpha$ source), and differential thermal analysis (DTA).

Key Words: Amorphous / semiconductor / thermistor / Selenium / Cadmium.

INTRODUCTION

Chalcogenide glasses have been recognized as promising materials for IR optical elements and transfer of information. The nature of glass structure and the glass-forming tendency of these compounds is one of the most challenging problems of glass science and condensed matter of physics. The doping of chalcogenide glassy semiconductors with metal is an effective step of controlling the electrical and optical properties of glasses in a desired direction. Chalcogenide glasses are known IR–transmitting materials $(1)$ and exhibit wide range of photo – induced effects that enable them to be used as optical recording or imaging media $(2)$. Photo-structural change in the density $(3)$, electronic transport $(4, 5)$ and optical properties $(6, 7)$ are inducing by exposing the sample to near – band gap light. Depending on the experimental conditions, these changes can be reversible or irreversible. Chalcogenide glasses have been produce recently on a commercial scale for infrared optical applications.

The aim of the work is fabricated five semiconductor thermistors from amorphous semiconductor composition Se$_{(90-x)}$Te$_{10}$Cd$_x$ where X = 0, 3, 6, 9 and 15.

EXPERIMENTAL WORK

1-Preparation of Bulk Amorphous Se$_{(90-x)}$Te$_{10}$Cd$_x$

Five compositions of the system SeTeCd were selected, the proposed compositions of the investigated system are Se$_{(90-x)}$Te$_{10}$Cd$_x$, where x = 0, 3, 6, 9, 15. The suffix used for each element denotes its content in the system in atomic percentage. These glasses were prepared from Se, Te and Cd elements with purity 99.999%. These glasses are reactive at high temperature with oxygen. Therefore, synthesis was accomplished in evacuated clean silica tubes. The tubes were washing by distilled water, and then dried in a furnace whose temperature was about 100°C. For each composition, the proper amounts of materials were weighed using an electrical balance type with accuracy ±10$^{-4}$ gm. The weighted materials were introduced in the cleaned silica tubes and then evacuated to about 10$^{-6}$ torr and sealed. The sealed tubes were placed inside the furnace and the temperature of the furnace was...
raised gradually up to 850°C within one hour and kept constant for 8 hours. Moreover, shaking of the constituent materials inside the tube in the furnace was necessary for realizing the homogeneity of the composition. After synthesis, the tubes were quenched in liquid nitrogen. The glassy ingots could obtain by drastic quenching. Then, the material was removed from the tubes and kept in dry atmosphere. The ingot materials were identified as glass due to their bright features. The proper ingots were confirmed to be completely amorphous using X-ray diffraction and differential thermal analysis. Homogeneity of prepared samples was proved by determination of density of different parts.

2- Preparation of Thin Films Samples

Thin films of the selected compositions were prepared by thermal evaporation technique. Edward 306E coating unit was used for thin film deposition. The vacuum system consists mainly of a rotary pump, diffusion pump, penning bridge for measuring vacuum, high A.C. current source and the bell jar. A specially designed silica boat was used for evaporation instead of using metallic boats to obtain highly homogeneous uniform films. The silica boat was used instead of metallic boat used to omit the probability of contamination. The heating of the silica was achieved by spiral tungsten wire. The silica boat had to be cleaned every time before evaporation. This was accomplished by using hydrochloric acid, then washing several times with boiled distilled water and finally it was dried in a furnace, whose temperature was about 100°C.

3- Density Determination

The density of the considered samples was determined using the method of hydrostatic weight using toluene. A single crystal of germanium was used as a reference material for determining the toluene density. The latter has been determined from the formula:

\[ d_{\text{toluene}} = \frac{W_{\text{air}} ' - W_{\text{toluene}} '}{W_{\text{air}}} \times d_{\text{Ge}} \]  

(1)

where, \( W' \) is the weight of single Ge crystal and \( d_{\text{Ge}} \) is the density of Ge.

\( d_{\text{Ge}} = 5.32 \ \text{gm/cm}^3 \)

\( d_{\text{toluene}} = 5.15 \ \text{gm/cm}^3 \)

Then, the sample density was calculated from the formula

\[ d_{\text{sample}} = \frac{W_{\text{air}}}{W_{\text{air}} - W_{\text{toluene}}} \times d_{\text{toluene}} \]  

(2)

where \( W \) is the weight of the sample.

The devices which used in different measurements are as follow:

1- X-ray Philips diffractometer was used to investigate and characterize the structure of the samples.
2- A micro-Data apparatus, Shimadzu DT-30 model was used for the measurements of DTA.
3- Double-Beam Jasco V-530 UV/V is spectrophotometer. It was used for optical measurements.
4- Edward 306E coating unit was used for thin film deposition.
5- Gamma irradiation type J-6500 Canada Ltd was used for radiation.
1- X-Ray Diffraction

The XRD examination indicates the amorphous structure of the prepared Se_{(90-x)}Te_{10}Cd_{x} (with x= 0, 3, 6, 9 and 15) bulk sample as shown in Fig. (1), and the chemical composition of the film was determined by using energy dispersive X-ray analysis where the estimated average precision was about 3 \% in atomic fraction of each element.

![X-ray diffraction (XRD) Spectra of amorphous bulk sample of the system Se_{(90-x)}Te_{10}Cd_{x} (with X= 0, 3, 6, 9 and 15).](image1)

![X-ray diffraction (XRD) Spectra of amorphous thin film sample of the system Se_{(90-x)}Te_{10}Cd_{x} (with X= 0, 3, 6, 9 and 15).](image2)
2- Composition Dependence of Density

The density of the thin film of the system Se\(_{90-x}\)Te\(_{10}\)Cd\(_x\) (with X= 0,3,6, 9 and 15) glasses has been determined by hydrostatic method with an accuracy of ±0.05%. The obtained results are given in Table (1) and Fig.(3) where it is noticed that the density increases by increasing Cd content from 4.81 gm/cm\(^3\) for the composition Se\(_{90}\)Te\(_{10}\)Cd\(_0\) at x=0 up to 5.81 gm/cm\(^3\) for the composition Se\(_{75}\)Te\(_{10}\)Cd\(_{15}\) at x=15.

It is known that the change in the density is related to the change in the atomic weight and the atomic volume of the elements constituting the system. The atomic weight of Se, Te and Cd are 78.96, 127.6 and 112.4, respectively.

Table (1): The composition dependence of density

<table>
<thead>
<tr>
<th>Se(<em>{90-x})Te(</em>{10})Cd(_x)</th>
<th>Density gm/cm(^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>X = 0</td>
<td>4.81</td>
</tr>
<tr>
<td>X = 3</td>
<td>5.22</td>
</tr>
<tr>
<td>X = 6</td>
<td>5.31</td>
</tr>
<tr>
<td>X = 9</td>
<td>5.33</td>
</tr>
<tr>
<td>X = 15</td>
<td>5.81</td>
</tr>
</tbody>
</table>

Fig. (3): Dependence of density on Cd-content in the system Se\(_{90-x}\)Te\(_{10}\)Cd\(_x\) (with X= 0, 3, 6, 9 and 15).

3 - Crystallization Kinetics and Glass Formation of the System Se\(_{90-x}\)Te\(_{10}\)Cd\(_x\) (with X = 0, 3, 6, 9 and 15)

The DTA curve of the investigated compositions at heating rate of 10\(^\circ\)C/min is shown in Fig.(4). An endothermic peak in the DTA curve results from an increase in specific heat at glass transition temperature (T\(_g\)). The absence of any sharp exothermic peak in the DTA curve is a good indicator for the absence of the structural changes.
Table (2) presents the define temperatures for all composition. It is notice that the composition Se$_{90}$Te$_{10}$Cd$_0$ has the highest peak temperature (T$_p$). This means that it can measure the temperature up to 150.93°C. Also the composition Se$_{90}$Te$_{10}$Cd$_0$ has the highest glass transition temperature (T$_g$). For this reason the composition Se$_{90}$Te$_{10}$Cd$_0$ is the best one of the above compositions and it is preferable to use this composition in fabricating the semiconductor thermistor $^{(9)}$.

Table (2): Data of T$_g$, T$_p$ and T$_m$ of the system Se$_{(90-x)}$Te$_{10}$Cd$_x$ (with x = 0, 3, 6, 9 and 15)

<table>
<thead>
<tr>
<th>Composition</th>
<th>T$_g$ (°C)</th>
<th>T$_c$ (°C)</th>
<th>T$_p$ (°C)</th>
<th>T$_m$ (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Se$<em>{90}$Te$</em>{10}$Cd$_0$</td>
<td>68.36</td>
<td>80</td>
<td>150.93</td>
<td>232.85</td>
</tr>
<tr>
<td>Se$<em>{87}$Te$</em>{10}$Cd$_3$</td>
<td>61.88</td>
<td>95</td>
<td>129.77</td>
<td>235.15</td>
</tr>
<tr>
<td>Se$<em>{84}$Te$</em>{10}$Cd$_6$</td>
<td>52.73</td>
<td>110</td>
<td>130.00</td>
<td>235.55</td>
</tr>
<tr>
<td>Se$<em>{81}$Te$</em>{10}$Cd$_9$</td>
<td>47.37</td>
<td>115</td>
<td>133.98</td>
<td>235.16</td>
</tr>
<tr>
<td>Se$<em>{75}$Te$</em>{10}$Cd$_{15}$</td>
<td>45.00</td>
<td>120</td>
<td>138.45</td>
<td>235.16</td>
</tr>
</tbody>
</table>

Where:  T$_g$ is the glass transition temperature.
T$_c$ is the crystallization temperature.
T$_p$ is the peak temperature.
T$_m$ is the melting temperature.

Fig.(4): DTA measurements for Se$_{(90-x)}$Te$_{10}$Cd$_x$ (with x = 0, 3, 6, 9 and 15) glasses heating rate: 10°C\minute.
4 - The Resistance Versus Temperature Dependence Measurements

![Diagram of sheet resistance](image)

Fig. (5): Dimensions of sheet resistance

The D.C. conductivity has been measured for thin film samples. Sheet resistance (\(R_s\)) has been measured for these films. As shown in Fig (5) the sheet resistance value is given by the equation

\[
R = \frac{\rho}{db}
\]

(3)

Where \(\rho\) is the resistivity, \(d\) is the thickness, \(b\) is the length of electrode and \(L\) is the distance between electrodes. If \((L = b)\) then equation becomes

\[
R = \frac{\rho}{d} = R_s
\]

(4)

The conductivity equals \(\sigma = \frac{1}{\rho}\)

\[
\sigma = \frac{1}{\rho} = \frac{1}{(R_s d)}
\]

(5)

(6)

<table>
<thead>
<tr>
<th>Composition</th>
<th>(R(K\Omega)) at 20°C</th>
<th>(R(K\Omega)) at 35°C</th>
<th>(\sigma (\Omega^{-1} \text{cm}^{-1})) at 20°C</th>
<th>(\sigma (\Omega^{-1} \text{cm}^{-1})) at 35°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\text{Se}<em>{90}\text{Te}</em>{10}\text{Cd}_0)</td>
<td>53.4</td>
<td>8.72</td>
<td>1.9</td>
<td>11.5</td>
</tr>
<tr>
<td>(\text{Se}<em>{97}\text{Te}</em>{10}\text{Cd}_3)</td>
<td>54.0</td>
<td>22.0</td>
<td>1.9</td>
<td>4.5</td>
</tr>
<tr>
<td>(\text{Se}<em>{94}\text{Te}</em>{10}\text{Cd}_6)</td>
<td>57.8</td>
<td>25.5</td>
<td>1.7</td>
<td>3.9</td>
</tr>
<tr>
<td>(\text{Se}<em>{87}\text{Te}</em>{10}\text{Cd}_9)</td>
<td>59.0</td>
<td>28.5</td>
<td>1.7</td>
<td>3.5</td>
</tr>
<tr>
<td>(\text{Se}<em>{75}\text{Te}</em>{10}\text{Cd}_{15})</td>
<td>65.0</td>
<td>35.0</td>
<td>1.5</td>
<td>2.9</td>
</tr>
</tbody>
</table>

5 - The Sensitivity of the Amorphous Semiconductor Thermistors

From Fig.(6) the value of the sensitivity \((dT/dR)\) for the amorphous semiconductor thermistors is presented in table (4). Table (4) shows that the values of the sensitivity are increased with increasing Cd content. The composition \(\text{Se}_{75}\text{Te}_{10}\text{Cd}_{15}\) has the high sensitivity value. It is the best one of them. The increase in the sensitivity with the increase in Cd content reflects the increase for the density of defect states in the system \(\text{Se}_{(90-x)}\text{Te}_{10}\text{Cd}_x\) thin films. The sensitivity depends upon the lifetime of excess carriers which in turns depends upon the density of localized states in a particular material.
Fig. (6): The resistance versus temperature dependence of the composition Se$_{(90-x)}$Te$_{10}$Cd$_x$ (with $x = 0, 3, 6, 9$ and 15).

Table (4): The value of the sensitivity ($\Delta T/\Delta R$) for the amorphous semiconductor thermistors.

<table>
<thead>
<tr>
<th>The name of the thermistor</th>
<th>The value of the sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Se$<em>{90}$Te$</em>{10}$Cd$_0$</td>
<td>0.828</td>
</tr>
<tr>
<td>Se$<em>{87}$Te$</em>{10}$Cd$_3$</td>
<td>0.913</td>
</tr>
<tr>
<td>Se$<em>{84}$Te$</em>{10}$Cd$_6$</td>
<td>0.933</td>
</tr>
<tr>
<td>Se$<em>{81}$Te$</em>{10}$Cd$_9$</td>
<td>1.050</td>
</tr>
<tr>
<td>Se$<em>{75}$Te$</em>{10}$Cd$_{15}$</td>
<td>1.100</td>
</tr>
</tbody>
</table>

6 - Optical Measurements

Films of thickness 100 nm were deposited by thermal evaporation technique with an evaporation rate $10$A$^2$sec$^{-1}$ in vacuum of $10^{-5}$ torr onto clean glass substrates. Optical transmittance, reflectance and absorption for the thin film have been measured using 2101 UV-VIS double beam spectrophotometer attached with PC data acquisition system.

7 - Optical Absorption

The absorption coefficient was computed from the experimentally measured values of absorption according to the following expression \(^{(10)}\).

$$\alpha = (2.303 \times A) / d$$ \hspace{1cm} (7)
Where: \( A \) = absorption value. 
\( d \) = thickness of the thin film.

Upon \( \gamma \) – irradiation within doses up to 15 Mega rad, it seems that the \( \gamma \) – irradiation, produces some changes on the thin film. From Fig.(7) and Fig.(8). The values of the width of localized states \( E_o (\text{eV}) \) before radiation and after radiation were obtained. The values are determined by the slope for the curve of each composition as in Table (5). From Fig.(9) and Fig.(10) The values of the optical band gap energy \( E_{\text{opt}} \) were obtained as the intercept of \((ah\gamma)^{1/2}\) versus \((h\gamma)\) at \((ah\gamma)^{1/2} =0\).

To determine the energy gap of all compositions the following relation \(^{11}\) is used:

\[
\ln \sigma_o - \ln \sigma_1 = \frac{E_g}{2 \times 8.616 \times 10^{-5} \times 10^3} \left[ \frac{1000}{T_1} - \frac{1000}{T_o} \right]
\]  

(8)

Where \( \sigma_o \) is the electrical conductivity at \( T_o \) and \( \sigma_1 \) is the electrical conductivity at \( T_1 \). The values of the energy gap \( (E_g) \) of all compositions are as in the table (6).

![Fig. (7): The Optical absorption coefficient for the thin film before radiation](image1)

The thickness of the all samples = 1000 \( \text{\AA} = 1000 \times 10^{-8} \text{ cm} = 10^{-5} \text{ cm} = 100 \text{ nm} \)  

(9)

![Fig. (8): The Optical absorption coefficient for the thin film after radiation](image2)
Table (5): The values of the width of localized states $E_o$ (eV) before radiation and after radiation

<table>
<thead>
<tr>
<th>Composition</th>
<th>Thickness (nm)</th>
<th>$E_o$ (eV) Before Radiation</th>
<th>$E_o$ (eV) After Radiation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Se$<em>{90}$Te$</em>{10}$Cd$_0$</td>
<td>100</td>
<td>0.136</td>
<td>0.171</td>
</tr>
<tr>
<td>Se$<em>{87}$Te$</em>{10}$Cd$_3$</td>
<td>100</td>
<td>0.145</td>
<td>0.171</td>
</tr>
<tr>
<td>Se$<em>{84}$Te$</em>{10}$Cd$_6$</td>
<td>100</td>
<td>0.200</td>
<td>0.214</td>
</tr>
<tr>
<td>Se$<em>{81}$Te$</em>{10}$Cd$_9$</td>
<td>100</td>
<td>0.218</td>
<td>0.200</td>
</tr>
<tr>
<td>Se$<em>{75}$Te$</em>{10}$Cd$_{15}$</td>
<td>100</td>
<td>0.227</td>
<td>0.200</td>
</tr>
</tbody>
</table>

Table (6): The electrical characteristic quantities for the thin film of the system Se$_{(90-x)}$Te$_{10}$Cd$_x$ (with $x = 0, 3, 6, 9$ and 15) at rate 10°C/min.

<table>
<thead>
<tr>
<th>Composition</th>
<th>$E_{g_{opt}}$ (eV) Before Radiation</th>
<th>$E_{g_{opt}}$ (eV) After Radiation</th>
<th>$E_g$ (eV)</th>
<th>Electric Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>X = 0</td>
<td>1.68</td>
<td>1.635</td>
<td>1.447X10$^2$</td>
<td></td>
</tr>
<tr>
<td>X = 3</td>
<td>1.67</td>
<td>1.656</td>
<td>0.693X10$^2$</td>
<td></td>
</tr>
<tr>
<td>X = 6</td>
<td>1.66</td>
<td>1.635</td>
<td>0.667X10$^2$</td>
<td></td>
</tr>
<tr>
<td>X = 9</td>
<td>1.65</td>
<td>1.694</td>
<td>0.580X10$^2$</td>
<td></td>
</tr>
<tr>
<td>X = 15</td>
<td>1.64</td>
<td>1.668</td>
<td>0.530X10$^2$</td>
<td></td>
</tr>
</tbody>
</table>

Fig. (9): Optical absorption of the composition Se$_{(90-x)}$Te$_{10}$Cd$_x$ (with $x = 0, 3, 6, 9$ and 15) for thin film before radiation.
Fig. (10): Optical absorption of the composition $\text{Se}_{(90-x)}\text{Te}_{10}\text{Cd}_x$ (with $x = 0, 3, 6, 9$ and $15$) for thin film after radiation.

8- Heating Measurements

Amorphous $\text{Se}_{(90-x)}\text{Te}_{10}\text{Cd}_x$ (with $x = 0, 3, 6, 9$ and $15$) thin films were prepared on glass substrates. The effect of heating (in vacuum) at 40°C and 60°C on the resistance for both 30 minutes and 45 minutes was investigated$^{12,13}$ as shown in Fig.(11) to Fig.(14).

Fig.(11): The resistance versus temperature dependence of the composition $\text{Se}_{(90-x)}\text{Te}_{10}\text{Cd}_x$ (with $x = 0, 3, 6, 9$ and $15$) after heating at 40°C for 30 minutes
Fig. (12): The resistance versus temperature dependence of the composition Se$_{(90-x)}$Te$_{10}$Cd$_x$ (with X = 0, 3, 6, 9 and 15) after heating at 40°C for 45 minutes.

Fig. (13): The resistance versus temperature dependence of the composition Se$_{(90-x)}$Te$_{10}$Cd$_x$ (with X = 0, 3, 6, 9 and 15) after heating at 60°C for 30 minutes.
Fig. (14): The resistance versus temperature dependence of the composition Se$_{90-x}$Te$_{10}$Cd$_x$ (with X = 0, 3, 6, 9 and 15) after heating at 60°C for 45 minutes.

Both Fig.(15) and Fig.(16) show two x-ray diffraction patterns for the composition Se$_{90}$Te$_{10}$Cd$_0$ and the composition Se$_{75}$Te$_{10}$Cd$_{15}$ before and after heating at 60°C for 45 minutes. The two patterns for each composition are identical and show no characteristic diffraction peaks, which reflect a short range ordering characterizing the amorphous phase.

Fig. (15): X-ray diffraction (XRD) spectra of amorphous thin film sample of the composition Se$_{90}$Te$_{10}$Cd$_0$:
(a) Before heating
(b) After heating at 60°C for 45 minutes
Fig. (16): X-ray diffraction (XRD) spectra of amorphous thin film sample of the composition Se$_{75}$Te$_{10}$Cd$_{15}$:
(a) Before heating.
(b) After heating at 60°C for 45 minutes

As shown in Fig. (17), it is observed that with increasing the heating temperature to the glass transition temperature ($T_g$) the composition Se$_{90}$Te$_{10}$Cd$_{0}$. It transforms from amorphous structure to crystalline structure.

Fig. (17): X-ray diffraction (XRD) Spectra of amorphous thin film sample of the composition Se$_{90}$Te$_{10}$Cd$_{0}$:
(a) Before heating
(b) After heating at 80°C for 60 minutes
In Fig.(18) and Fig.(19), the compositions Se$_{87}$Te$_{10}$Cd$_3$ and Se$_{75}$Te$_{10}$Cd$_{15}$ proved of amorphous structure. They do not transform to crystalline structure after heating to 80°C for 60 minutes. It can be concluded that after heating the composition at 80°C for 60 minutes with increasing the cadmium content in the composition the structure of the composition does not transform to crystalline structure.

Fig. (18): X-ray diffraction (XRD) Spectra of amorphous thin film sample of the composition Se$_w$Te$_{10}$Cd$_3$:
(a) Before heating
(b) After heating at 80°C for 60 minutes

Fig. (19): X-ray diffraction (XRD) spectra of amorphous thin film sample of the composition Se$_{75}$Te$_{10}$Cd$_{15}$:
(a) Before heating
(b) After heating at 80°C for 60 minutes

Fig.(20, 21 and 22) show the effect of heating (in vacuum) at 80°C for 60 minutes for the composition Se$_{(90-x)}$Te$_{10}$Cd$_x$ (with $X = 0, 3$ and 15 ). It can be seen that, the resistance decreases significantly with increasing the temperature upon to 40°C, the resistance become independent of temperature (i.e. remain constant).
Fig. (20): The resistance versus temperature dependence for the thermistor \( \text{Se}_{90}\text{Te}_{10}\text{Cd}_0 \) after heating at 80°C for 60 minutes.

Fig. (21): The resistance versus temperature dependence for the thermistor \( \text{Se}_{87}\text{Te}_{13}\text{Cd}_3 \) after heating at 80°C for 60 minutes.
CONCLUSIONS

Five compositions of the system Se_{90-x}Te_{10}Cd_{x} with x = 0, 3, 6, 9 and 15 have been prepared from extremely pure elements Se, Te and Cd. These compositions were confirmed to be amorphous and homogeneous by using different techniques, such as the X-ray diffraction pattern and the differential thermal analysis (DTA). Five semiconductor thermistors are fabricated from these five compositions. The main obtained results can be summarized as follows:

1. The thin film samples proved to have an amorphous structure.
2. The X-ray diffraction technique proved the investigated compositions to be pure amorphous since it showed no regular crystalline structure.
3. The density increases by increasing Cadmium content from 4.81 gm/cm$^3$ for the composition Se_{90}Te_{10}Cd_{0} up to 5.81 gm/cm$^3$ for the composition Se_{75}Te_{10}Cd_{15}.
4. It was found that the electrical conductivity decreases by increasing Cd content in the composition.
5. The electrical activation energy was found to decrease linearly from 1.68 eV to 1.64 eV by increasing the Cd content from x = 0 to x = 15 in the composition Se_{90-x}Te_{10}Cd_{x}.
6. The values of the optical energy gap $E_{opt}$ were found to decrease with increasing Cd content which would be due to the fact that Cd has a metallic behavior.
7. The differential thermal analysis (DTA) measurements showed that the glass transition temperature $T_g$ decreased with increasing Cd content. The absence of any sharp exothermic peak proved the absence of structural changes.
8. The sensitivity is increased with increasing Cd content. The composition Se_{75}Te_{10}Cd_{15} has the high sensitivity value. It is the best one of them. The investigated system proved to be advantageous in application to infrared imaging objectives.
9. It was found that the effect of heating (in vacuum) for the different samples of the composition Se_{90-x}Te_{10}Cd_{x} (with x = 0, 3, 6, 9 and 15) at (40°C and 60°C) for 30 minutes and 45 minutes. The
resistance increases with increasing the Cadmium content in the composition and decreases with increasing the temperature.

10. It was found that the effect of heating (in vacuum) for the different samples of the composition Se_{90-x}Te_{10}Cd_{x} (with x = 0, 3, 6, 9 and 15) at 80°C for 60 minutes that the resistance decreases with increasing the temperature and the compositions investigated keep the amorphous structure except the composition Se_{90}Te_{10}Cd_{0} which transformed from amorphous structure to crystalline structure. Also it was found that with increasing the Cadmium content in the composition kept the structure of the composition at amorphous structure.

REFERENCES