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Structure and temperature profile limits of optic fiber material based tellurium

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Abstract
The X-ray diffraction pattern of the system $Te_{80}S_{20-x}B_x$ where (x=0,2.5,5 and B=In or As) confirm the amorphous nature of the thin film samples. The addition of In or As to $Te_{80}S_{20}$ on the expense of S confirms this result. Also, the non-uniformity of SEM micrographs assures the amorphous nature of these samples. The SEM micrographs of all samples after addition of In or As on the expense of S and even the Er cover layer reveals no change in the amorphous state. The thermal differential analysis (DTA) proves that the glass transition range for $Te_{80}S_{20}$was 15^0C(119-134^0C). This range reduced to be 8^0C as 2.5 at % In added on the expense of S. The replacement of In by As reduced this range to be 2-3^0C depending on the As ratio. The crystallization temperature T_C of $Te_{80}S_{20}$ was 165^0C. This temperature increased to be 277^0C as 2.5 at % In added on the expense of S. The replacement of In by As leads to increase T_c to be in the range 233-250^0C depending on the As content. Generally, the observed shrink of the glass transition range give chance to produce optic fiber cables in the amorphous state, saving costs. The high melting temperature T_m keep the optic fiber cable from distortion under the environmental factors and earth movers. Accordingly, these cables can serve the international net communication well.

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I. Introduction

Chalcogenide have active properties such as nonlinear optical parameters and photo-sensitivity (1). Thin film of chalcogenide materials was used in optical data storage and in high efficiency solar cell (2-4). Chalcogenide fibers have been used for the transmission of light at wavelength even beyond those possible with silica (5). Chalcogenide fibers can be drawn at low temperature even close to the material crystallization temperature(6) with high purity(7). The material purity is important for practical applications of chalcogenide glasses. The impurities even of low level,i.e parts per million,can alter the spectroscopic behavior of chalcogenide glass material. In optic fiber,impurities not only contribute to the optical loss through absorption and scattering, but also,serve as nucleation sites for phase transformation(8-10).Tellurium-rich chalcogenide glasses exhibits the ability to transmit light in the infrared range(8-10).

Glass transition limits, crystallization temperature and melting temperature along with thermal expansion coefficient, thermal diffusivity…etc are thermal properties associated with chalcogenide glasses. The glass transition temperature of chalcogenide is related to the magnitude of cohesive forces with a network. These forces must be overcome to allow atom movements (11).

The aim of this work is to study and illustrate the structure and temperature profile limits of the system $Te_{80}S_{20-x}B_x$where (x=0,2.5,5 and B=In or As) , to be used as optic fiber cables covered with Er cover layer.

II. Experimental technique:-

The chalcogenide samples of the system $Te_{80}S_{20-x}B_x$ where (x=0,2.5,5 and B=In or As) were prepared by melting quenching technique. Elements Te, S, In& As were weighted and mixed well using the ball milling method for each sample alone. The homogeneous mixture was placed in an evacuated (10^{-4} Pa) and capsulated silica tube. The silica tube containing each sample was heated at fixed temperature for fixed time. The sample $Te_{80}S_{20}$ and the samples contain In on the expense of S were melted at 500C for 8hours and quenched in Ice water. The samples containing As on the expense of S were melted at 800C for 8 hours and then quenched in ice water. The thin film samples were prepared from the bulk ingots using laser ablation on glass substrate. This was done using Nd:YAG pulsed laser deposition of wavelength 532nm under $55*10^{-4}$Pa vacuum, laser ablation was used under the same condition to cover each sample by Er layer. The thickness of the obtained thin films was determined using interferometry method. The structure of the obtained thin films was found to be amorphous as detected by X-ray hump and the non-homogenous SEM Images(fig(1,2)&(3,4)).

The thermal profile of each sample was recorded using DTA analyzer ShimadZU DTA50 Japan at 10 degree/min heating rate.

III. Results and discussion:

i. The X-ray diffraction:-

Fig [1] shows the X-ray diffraction pattern of the thin film samples of the system $Te_{80}S_{20-x}B_x$ where(x=0,2.5,5 and B=In or As). These results confirm the amorphous nature of the structure of all samples of this system. This fact was revealed as a single intense hump of symmetric wings around $2\Theta=25^0$ (11,12). The X-ray diffraction pattern of these samples was recorded once again after covering each sample surface by Erbium (Er) cover layer fig [2]. The results confirm the amorphous nature of the formed Er cover layer. The detected intense hump around $2\Theta=25^0$ characterized by wide half width and low relative intensities. This may confirm that, the Er cover layer was formed as nano scale structure(13) .

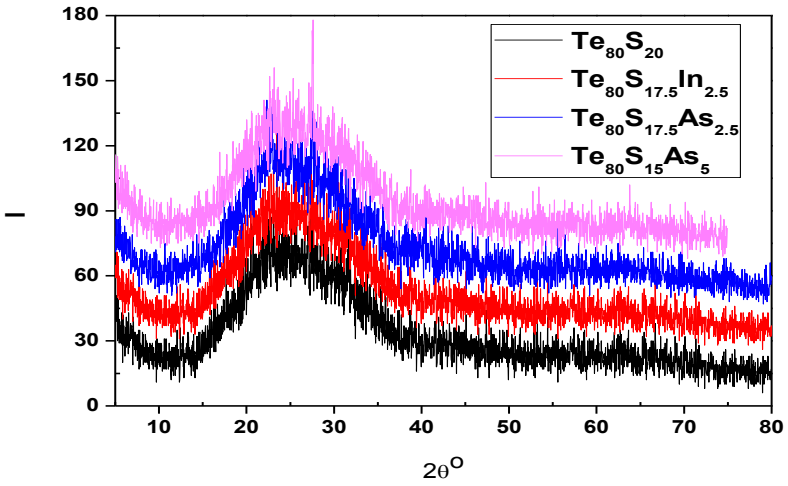

Fig [1] X-ray diffraction patterns of system $Te_{80}S_{20-x}B_x$ where (x=0,2.5,5 and B=In or AS)thin film deposited on a glass substrate.

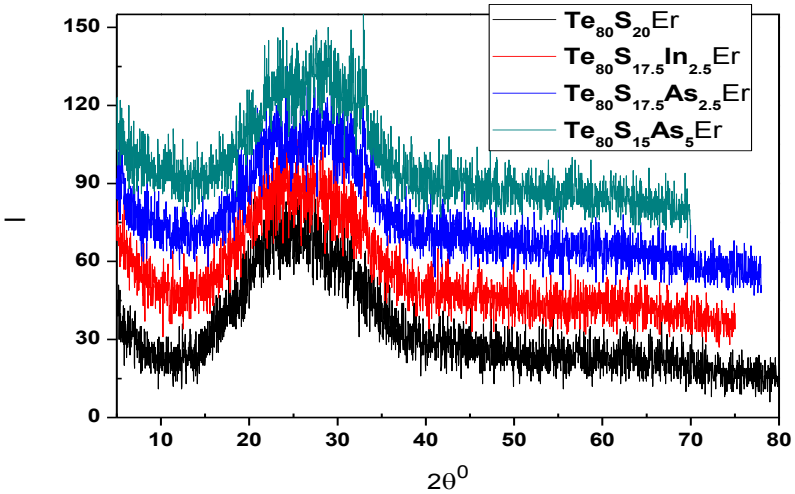

Fig [2] X-ray diffraction patterns of system $Te_{80}S_{20-x}B_x$ where (x=0,2.5,5 and B=In or AS)thin film covered with Er layer.

ii. Scanning electron microscope micrographs (SEM) :-

Fig[3] shows the SEM micrographs of the thin film samples of the system under test. The observed non-homogeneity of SEM micrographs illustrate the amorphous nature of all samples, as was detected by X-ray charts. The addition of 2.5 at % In to the sample $Te_{80}S_{20}$ on the expense of S change the form of non-homogeneity to some extent. This was revealed as the detected structure domains occupy different areas[14]. Replacing In by 2.5 at % As reduce, the difference in the occupied domains area. Increasing As ratio to be 5 at %, reducing the non-homogeneity to a minimum value with clear nano-domains.

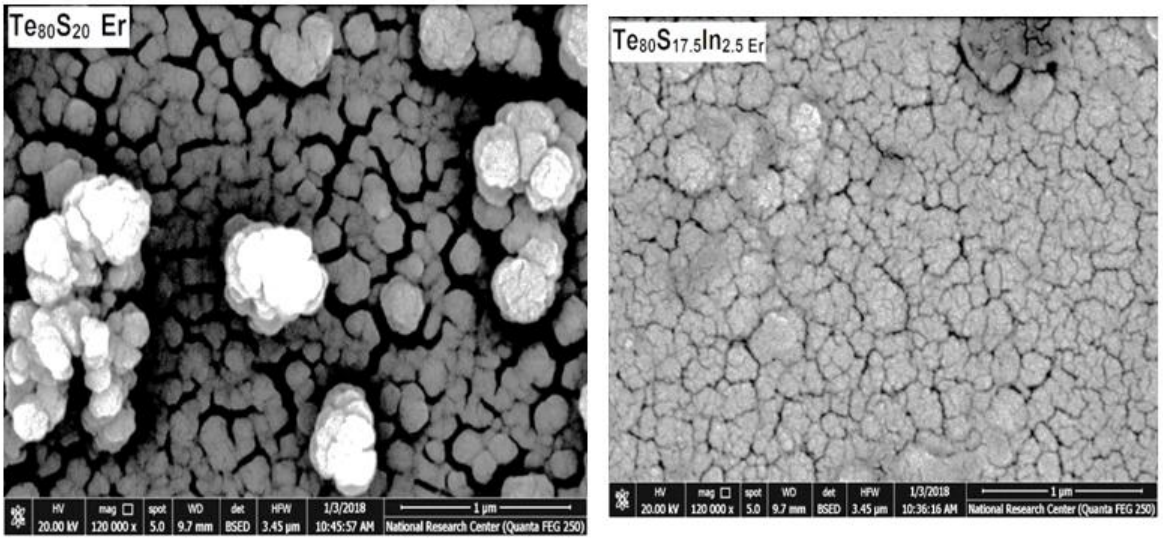

Fig [3] scanning electron micrograph image of chalcogenide system $Te_{80}S_{20-x}B_x$ where (x=0,2.5,5 and B=In or AS) thin films

Fig[4] shows that the effect of addition of Er cover layer to the thin film sample surface of the system $Te_{80}S_{20-x}B_x$ where (x=0,2.5,5 and B=In or As). It is clear that for the sample $Te_{80}S_{20}$, the SEM micrograph is irregular image. This condition was changed as 2.5 at % In replacing S. The Er cover layer repared the sample's surfaces to be homogenous. This homogeneity become better as 2.5 at % As replacing In. The increasing of As content to be 5 at % increase the homogeneity more. This means that, the Er cover layer increases the homogeneity of the samples as it the surface smoothing increases. This will lead to producingsmooth optic fiber material surfaces. This will lead to serve and save the light energy as it launched through it.

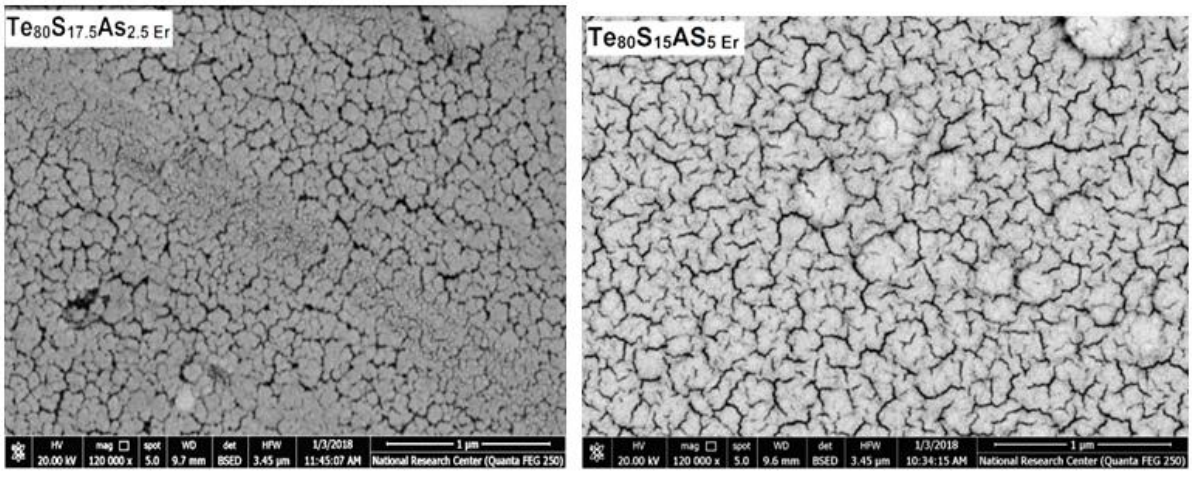

Fig [4] scanning electron micrograph image of chalcogenidesystem$Te_{80}S_{20-x}B_x$ where (x=0,2.5,5 and B=In or AS) thin film cover with Er layer.

iii. Temperature profiles limits:-

Fig[5] shows the DTA thermograms of the samples of the system $Te_{80}S_{20-x}B_x$ where (x=0,2.5,5 and B=In or As) recorded at 10 degree/min heating rate. The detected temperature limits were gathered together in the table[1].

Table[1]

Samples	**Onset $T_g c^o$ offset**	**$T_C C^O$**	**Onset $T_m c^o$ offset**
$Te_{80}S_{20}$	119 134	165	445 467
$Te_{80}S_{17.5}In_{2.5}$	46 54	277	475 700
$Te_{80}S_{17.5}As_{2.5}$	25 27	233	455 725
$Te_{80}S_{15}As_5$	30 33	250	460 755

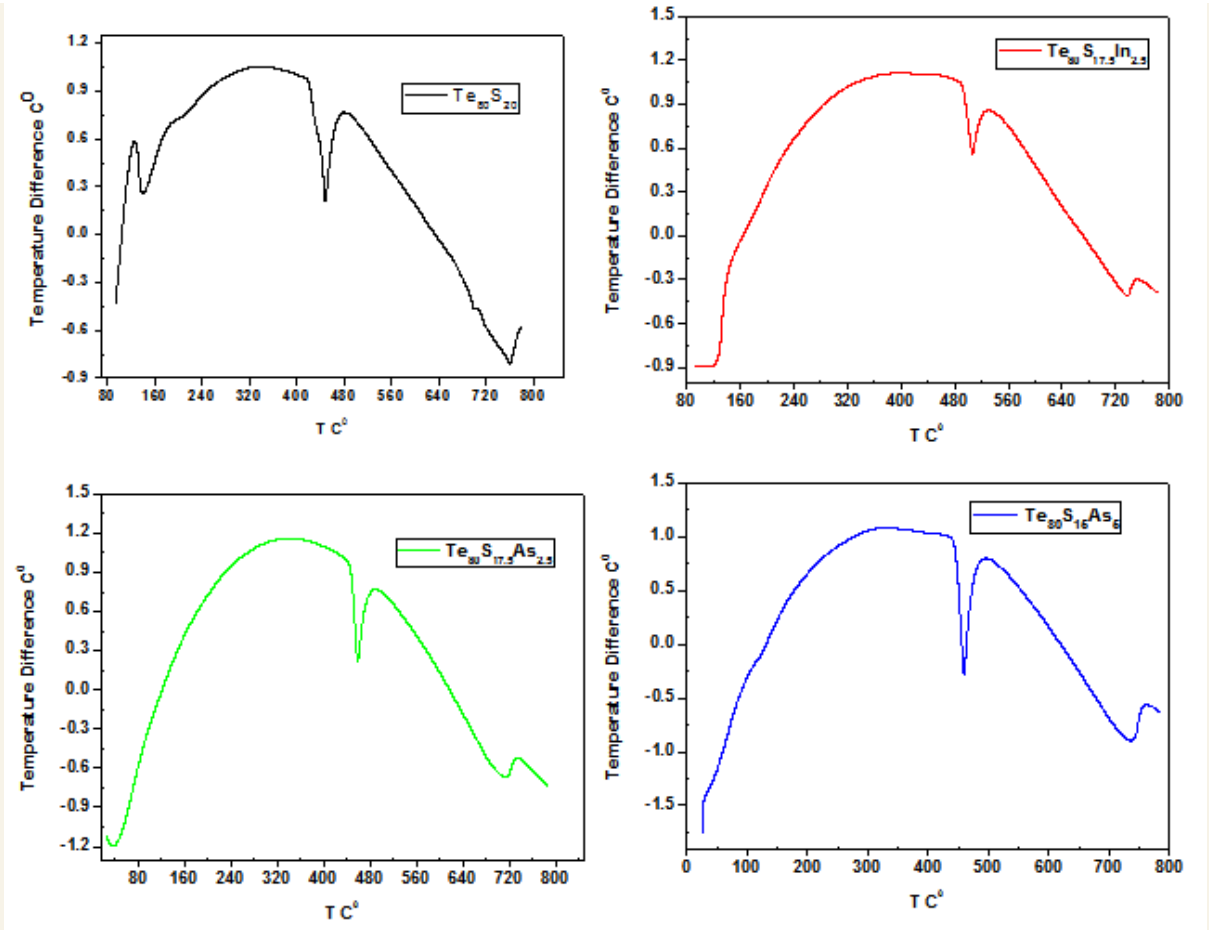

Fig [5] DTA thermograms of chalcogenide system Te80S20-xBx where (x=0,2.5,5 and B=In or As).

From table[1], the glass transition range for $Te_{80}S_{20}$ was 15^0(114-134^0C). This range was reduced to 8^0C(46-54^0C) as In added on the expense of S. This range was reduced to be 2-3^0C as As replacing In with the ratio 2.5 at % or 5 at %.

The detected crystallization temperature(T_c) for $Te_{80}S_{20}$ was 165^0C. This temperature was increased as In added on the expense of S to be 277^0C. The crystallization temperature (T_c) has been increased to be in the range 233-250^0C depending on the ratio of As, but still below its value of In addition. Generally the shrinking of the glass transition range gives chance to produce optic fiber cables in the amorphous state saving costs. Also, the high melting point (T_m) keeps the optic fiber cables from distortion under environmental factor, and earth movers. Accordingly, these cables can serve and save the international net well.

IV. Conclusion

The X-ray diffraction pattern confirms the amorphous nature of all samples under test before and after Er cover layer. The SEM micrographs confirm this fact. The Er cover layer increases the smoothing of the surfaces of the sample under test and increase its reflectivity to restore the losses of light within the optic fiber cables. The temperature profile limits illustrate that, the addition of In&As to $Te_{80}S_{20}$ on the expense of S reduce the glass transition rang to be in the range 2-8^0C depending on the type and ratio of additive. The addition of In or As to $Te_{80}S_{20}$ on the expense of S increase both crystallization temperatures and melting temperatures. Finally, the amorphous nature of the optic fiber cables together with the excellent temperature profile of the chalcogenide tellurium based material must be a good candidate to serve and save the international net of communication all over the earth's crust.

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