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Electric and dielectric properties of chalcogenide optic fiber material based tellurium

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Abstract
The Ac conductivity of the system $Te_{80}S_{20-x}As_x$ was very small under the effect of each of frequency and temperature. The exponent factor decrease with temperature and reach zero at high temperature. The zero value of the exponent factor keep the electric conduction at minimum constant value. The dielectric constant and dielectric losses very high at low frequency and their values depends the medium temperature. At high frequency, the dielectric constant and dielectric losses become temperature independent. The addition of As on expense of S decrease the Ac conductivity and increase dielectric properties. The low Ac conductivity and high dielectric properties confirm the use of these material as optic fiber cables.

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I. Introduction: -

The chalcogenide glasses attract lot of attention due to their potential and current uses in various solid state optical and electric device [1]. These glasses have got the important application as core material for optical fibers having short length and flexibility [2]. The structural disorder of its alloys have a high optical transparency in the infra-red (IR) spectral regions up to 10 μm [3]. Besides, it has large refractive index, thermal stability [4]and high degree of covalent bonding.

Recently, these material are subjected to scientific scrutiny due to the strong relation between their electronic properties and disordered structure [5]. The study of the dielectric properties and Ac conductivity are important, not only for the application point of view but also for the fundamental point of view [6,7]. The temperature depends of dielectric properties at different constant frequency is important topics to understand the nature and origin of the losses occurring in these materials. Also , addition of some metallic elements to the chalcogenide glasses causes enriched conductivity [8].

Thus the study of their electrical behavior is extremely important. The dielectric study of chalcogenide glasses has indicated that dielectric dispersion does exist at low frequencies even though these materials are covalently bonded. The origin and nature of dielectric losses in these materials has, therefore, become a matter of curiosity. Generally, the undoped chalcogenide glasses show low electrical conductivity values, which could mean a serious limit to their technological application. Certain additives are used to improve these properties. It was believed earlier that impurities have little effect on the properties of amorphous semiconductors as each impurity atom can satisfy its valence requirement by adjusting its nearest neighbor environment [9].

The aim of this paper is to study, the Ac conductivity of the system $Te_{80}S_{20-x}As_x$ as well as its dielectric properties. This will have carried under the effect of frequency and under the effect of temperature.

II. Experimental: -

The chalcogenide samples of the system $Te_{80}S_{20-x}As_x$ where (x=0, 5) were prepared by melting quenching technique. Elements Se, S, Te, 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 $Te_{80}S_{20}$ was melted at 500C for 8 hours and quenching in ice water. The samples containing As on the expense of S were melted at 800C for 8 hours and then quenching in ice water. The Ac conductivity and dielectric properties of samples were investigated using Broadband dielectric spectroscopy (BDS)technique.

III. Result and discussion

1- Frequency dependence of Ac conductivity: -

Fig[1] shows that the Ac conductivity of the system $Te_{80}S_{20-x}As_x$ where (x=0 , 5) increase with frequency at different isotherms.

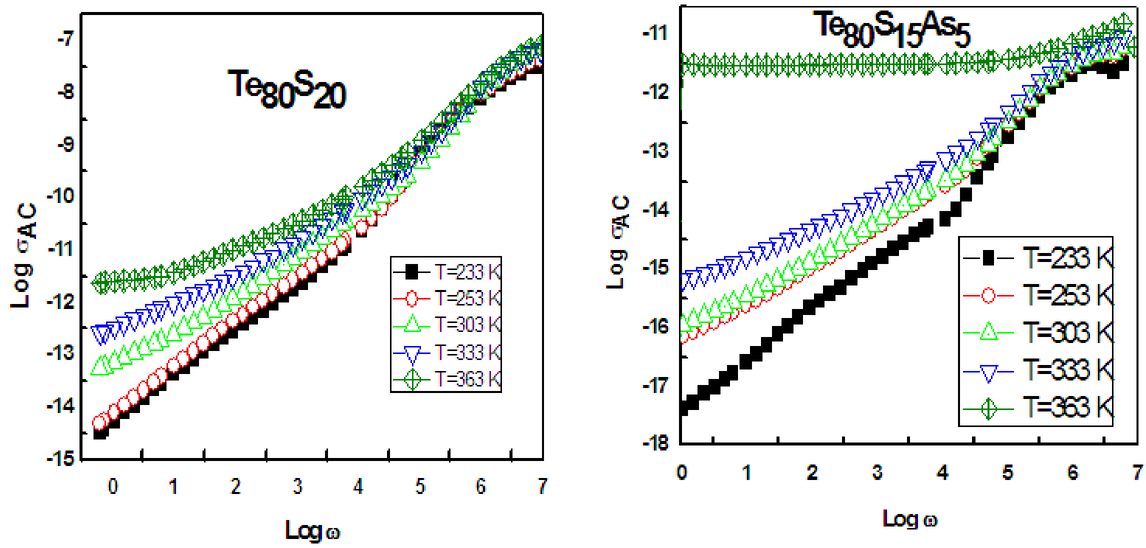

Fig [1] Variation of Log σ_{Ac}' as a function of frequency at constant isotherms for the thin film samples $Te_{80}S_{20}$ and $Te_{80}S_{15}As_5$.

The change of Ac conductivity during the frequency range -1 to 8 Hz very small and depends on the sample structure. For the sample $Te_{80}S_{20}$, the change of Ac conductivity was in the range -15 to -7. The addition of 5 at % As on the expense of S, leads to decrease the Ac conductivity to be in the range -18 to -11. This means that, the small Ac conductivity values decreased more by the addition of As on the expense of S.

Fig [2] shows the decrement of the exponent factor (S) with temperature. This may mean that at high temperature the value of S may be tends to zero. Under this conduction the relation

$\sigma = A\omega^S$, will reduced to σ =A . This leads to keep the electric conduction at minimum constant value. This indicate that, the given material is electrically very poor or nearly insulating materials.

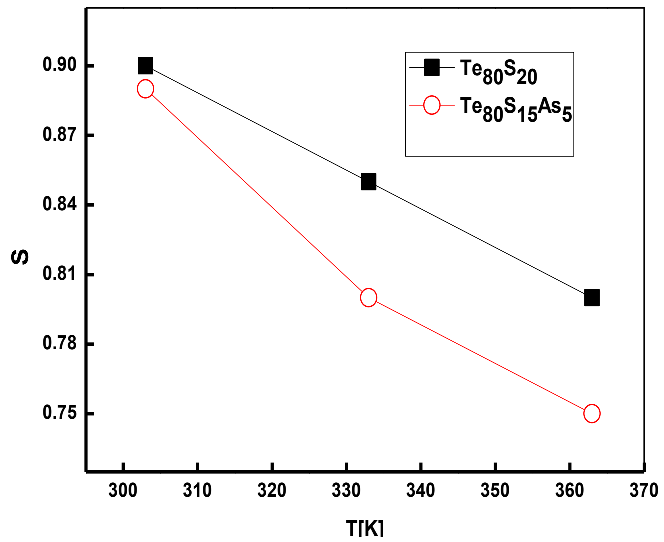

Fig [2] the exponent factor S as function of temperature T for the thin film samples $Te_{80}S_{20}$ and $Te_{80}S_{15}As_5$.

2- Temperature dependence of the Ac conductivity: -

Fig [3] shows the increment of Ln σ_{Ac} with temperature at different constant frequencies for the system $Te_{80}S_{20-x}As_x$ where (x=0, 5).

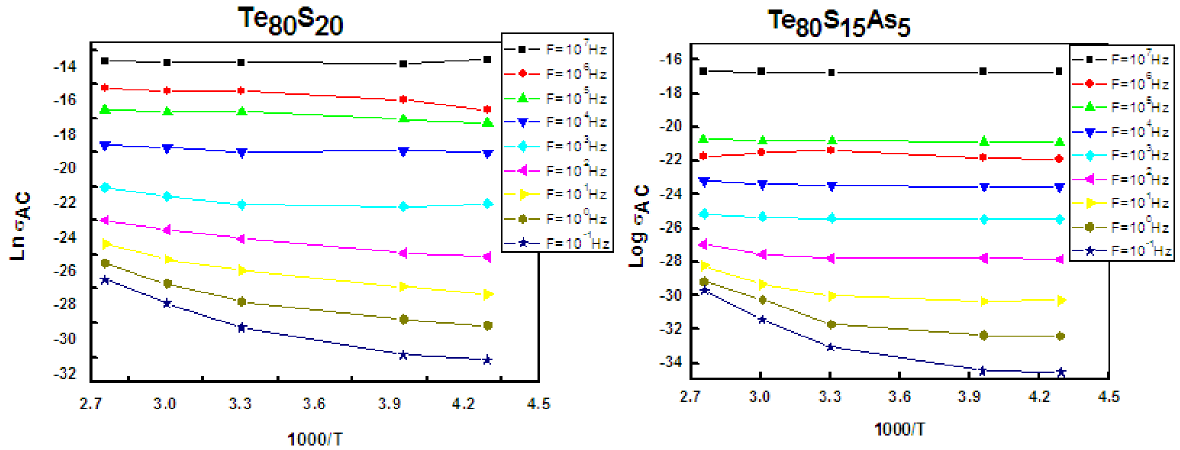

Fig [3] Variation of Ln σ_{Ac} as function of 1000/T at different constant frequencies for the thin film samples $Te_{80}S_{20}$ and $Te_{80}S_{15}As_5$.

It is clear that, at low frequency values 10^{-1} to 10^{1} Hz, the Ac conductivity due to more than one conduction mechanism. As the applied frequency exceed the value 10^{2} Hz all the obtained curves becomes parallel. This means that, the exponent factor S become constant. This may be due to high consumed thermal energy of high generated temperature.

This means that the S factor is minimum or zero. This leads to keep the Ac conductivity at minimum constant value (σ =A) and the material under test mostly insulating material.

3- Frequency dependence of the dielectric constant and dielectric losses:

Fig [4,5] shows that the dielectric and dielectric losses are high at low frequency 0.1-1 Hz, and decreases as the frequency increases for all samples of the system $Te_{80}S_{20-x}As_x$.

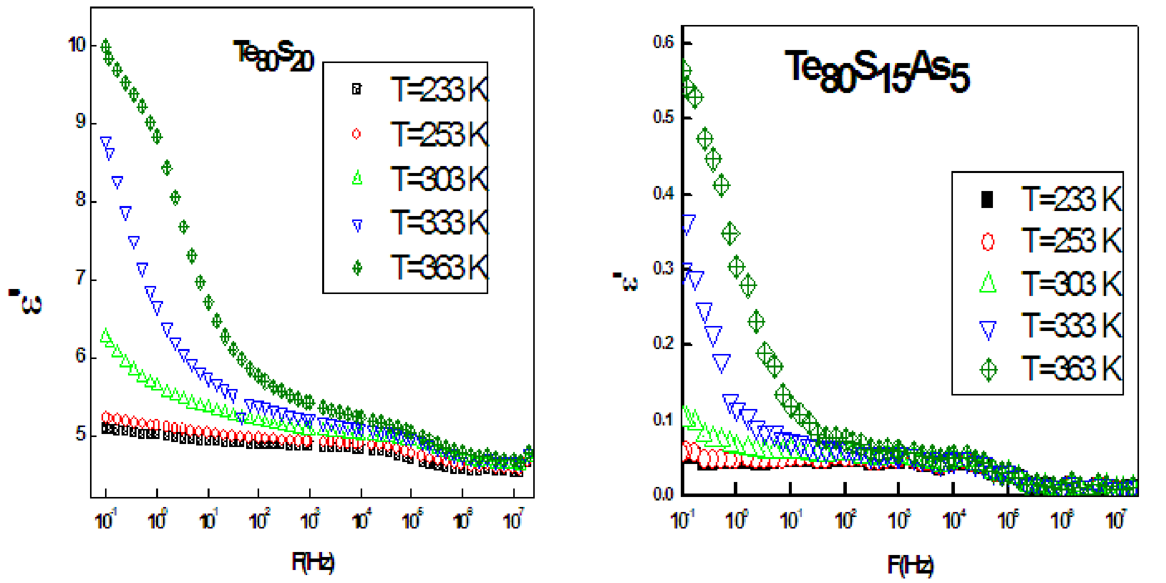

Fig [4] variation of the dielectric constant ε' as function of frequency at different isotherms for the thin film samples $Te_{80}S_{20}$ and $Te_{80}S_{15}As_5$.

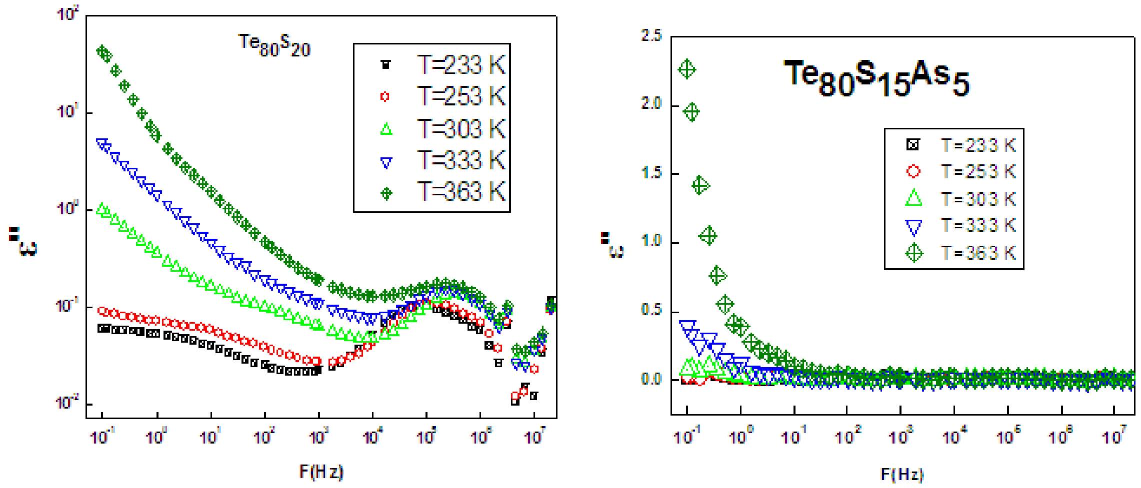

Fig [5] variation of the dielectric losses ε'' as function of frequency at different isotherms for the thin film samples $Te_{80}S_{20}$ and $Te_{80}S_{15}As_5$.

The high values of the dielectric constant and the high values of dielectric losses during the low frequency range depends on the sample isotherms. The values of the dielectric constant and dielectric losses for the sample $Te_{80}S_{20}$ were in range 5-10 and 10^{-2} to 10^{2} respectively at low frequency range 0.1-1 Hz. These values were decreased to be around the value two for the dielectric constant and to be 10^{-1} for the dielectric losses at high frequency range > 10^{2} Hz.

At the most during the high frequency range the dielectric constant and dielectric losses become temperature independent. The addition of As on expense of S, keep this behavior the same, keeping in mind that, the values of the dielectric constant and dielectric losses decreased all over the given frequency range.

4- Temperature dependence of the dielectric constant: -

Fig [6] shows that, the dielectric constant increases with temperature at constant low frequency .

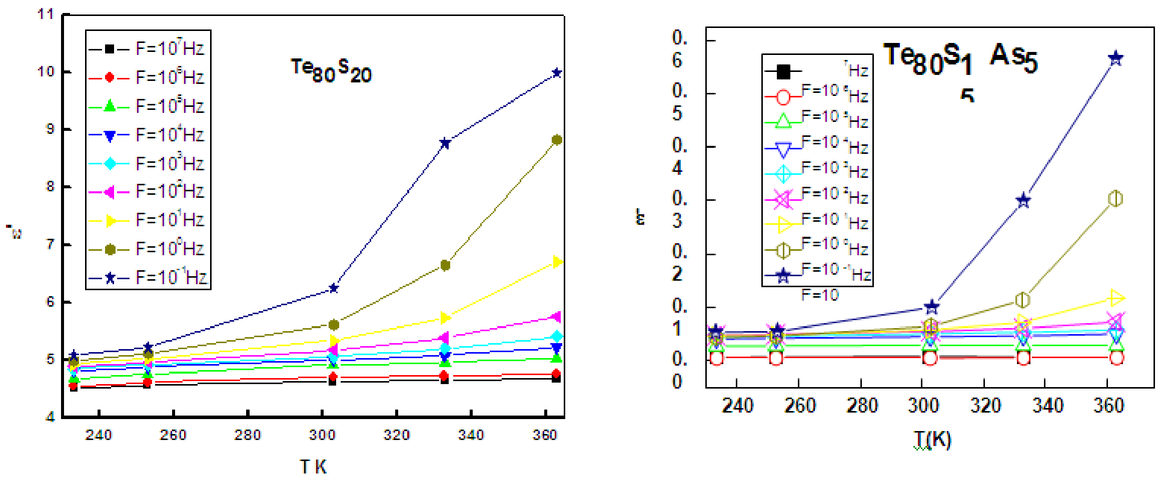

Fig [6] variation of dielectric constant ε' as a function of temperature at different frequency for the thin film samples $Te_{80}S_{20}$ and $Te_{80}S_{15}As_5$

As the frequency exceeds the value 10^{2} Hz, the change of the dielectric constant becomes very small. At frequency greater than 10^{6} Hz, the dielectric constant becomes temperature independent. The addition 5 at % As on expense of S, decrease the dielectric constant and keep this behavior as it is.

IV. Conclusion: -

From the previous study one can conclude that:

1- The Ac conductivity of the system $Te_{80}S_{20-x}As_x$ where x= 0, 5 is very small under the effect of frequency or the under the effect of temperature.

2- The exponent factor S of the relation $\sigma = A\omega^S$ decreased with increasing temperature and reach to zero value at very high temperature.
3- The zero value of the exponent factor (S) keep the electric conduction constant and minimum.
4- The dielectric constant and dielectric losses very high at low frequency range and their values depending on the medium temperature.
5- At high frequency, the Ac conductivity and dielectric properties becomes temperature independent.
6- The addition of As on the expense of S, decrease the Ac conductivity and increase the dielectric properties.
7- The low Ac conductivity and, the high dielectric constant and high dielectric losses confirm the use of these materials as optic fiber cables.

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