ABSTRACT

The dielectric constant (K), loss (tanδ) and hence conductivity (σ) of $TbAsO_4$, $SrTiO_3$ and NaCl single crystals under different conditions (viz. γ-ray irradiation, X-ray irradiation, quenching, high electric field (AC or DC) application, laser excitation or a combination of such treatments) have been studied in the frequency region 10^2 to 10^7 Hz and in the temperature range 30°C to 350°C for $TbAsO_4$ and $SrTiO_3$ (while for NaCl, it is 25°C to 425°C). Further the F-band absorption of NaCl crystals X-ray irradiated at room or elevated temperatures (25°C, 40°C and 90°C) has been investigated in the wavelength region 300 to 800 nm when they are later subjected to high electric fields (AC or DC) or laser excitation; the thermoluminescence (TL) of these samples is also investigated in the temperature range 25°C to 400°C. These crystals are found to exhibit interesting changes in their dielectric and optical properties under the mentioned conditions.

The dielectric constant (K) of $TbAsO_4$ at room temperature, decreases with frequency attaining a constant value beyond 10^5 Hz. The dielectric loss (tanδ) shows similar behaviour. The values of K and tanδ of $TbAsO_4$ at 30°C

and 10^6 Hz are 8.3 and 3.4 x 10^{-3} respectively. γ-ray irradiation is found to increase the K and tanδ values at low frequencies only but it has no appreciable effect on these parameters at higher frequencies. K increases with temperature slowly up to about 190°C beyond which the increase is faster and frequency dependent. tanδ also exhibites similar behaviour. The temperature coefficient of dielectric constant (dK/dT) has larger values at 10^2 Hz compared to 10^5 Hz; also (dK/dT) is larger for γ-ray irradiated samples compared to as-cut $TbAsO_4$ at any frequency. The conductivity (σ) versus 1/T plots give activation energy for conduction in the intrinsic region as 0.70 eV; this value is found to decrease to 0.56 eV for γ-ray irradiated $TbAsO_4$.

K and tanδ of $SrTiO_3$ at room temperature, also decrease with frequency attaining a constant value beyond 10^6 Hz and their values at 30°C and 10^6 Hz being 276 and 3.0 x 10^{-3} respectively. Quenching, laser excitation, high electric field treatment (AC or DC), γ-ray irradiation or a combination of such treatments, is found to decrease K and tanδ values at low frequencies but has no appreciable effect on these parameters at higher frequencies. The largest decrease in K and tanδ occur at 10^2 Hz in the

quenched and 60 KV/cm AC field treated $SrTiO_3$ crystals, but X-ray or γ-ray irradiation of these crystals has been found to increase K and $\tan\delta$ values at low frequencies.

Variation of K with temperature at different frequencies shows that K decreases with temperature up to a certain temperature called the inversion temperature T_i where (dK/dT) changes sign and it depends on the frequency and sample conditions. Also dK/dT in the two regions - (i) 30°C to about 200°C and (ii) 200°C to 350°C - has larger values at 10^2 Hz compared to that at 10^5 Hz. The inversion temperature T_i is found to shift to lower temperature with the increase of concentration of defects produced by various treatments. Logσ versus 1/T graphs give the activation energy for conduction in the high temperature region to be 0.8 eV; this value is found to increase for different treatments, being largest (1.15 eV) for the quenched $SrTiO_3$ crystals subjected to 60 KV/cm AC field for 1/2 hr.

Dielectric constant of NaCl at 25°C and 10^6 Hz is 5.9 and is frequency independent, dielectric loss ($\tan\delta$) is about 10^{-4}. Quenching, high electric field application, X-ray irradiation at elevated temperature or laser excitation each independently has no significant effect on K and $\tan\delta$.

However, a combination of these treatments is found to increase the K and tanδ values appreciably at low frequencies only, though the high frequency (10^6 Hz) values remain practically unchanged. Variation of K and tanδ with temperature at different frequencies for these variously treated samples shows that these parameters increase considerably with temperature, exhibit a strong frequency dependence at higher temperature region and dipolar relaxation effects; also it is observed that (dK/dT) at low frequencies and in the high temperature region is much larger in these samples compared to that in as-cleaved crystals; dK/dT has the largest value for quenched NaCl crystals which are laser excited for 30 minutes, X-ray irradiated for $1\frac{1}{2}$ hr at $90^{o}C$ and later again laser excited for 30 minutes. The measurements also indicate that the activation energy for conduction in the intrinsic region (which is 1.1 eV in the temperature region $275^{o}C$ to $400^{o}C$) is considerably decreased when quenched NaCl crystals are subjected to a combination of treatments like laser excitation or electric field application before and after X-ray irradiation at elevated temperatures.

The absorption in the F-band of X-ray irradiated NaCl crystals decreases with increase in irradiation

temperature. The F-band absorption in X-ray irradiated NaCl crystals is found to decrease with time of laser excitation or the electric field applied (AC or DC) in two stages: (i) a moderately fast stage and (ii) comparatively slow one, and this stage is found to be dependent on the temperature at which X-ray irradiation is done.

X-ray irradiated NaCl crystals exhibit thermoluminescence peaks at 122^{o}C and 235^{o}C. When the irradiation is done at elevated temperatures, these peak temperatures are pushed to slightly higher temperatures and also the TL light output in the peaks is reduced. TL measurements on NaCl crystals under different conditions indicate that the TL light output in the peaks is proportional to the F-centre concentration in the crystals under the corresponding conditions.

An attempt has been made to understand the data obtained on these solids in terms of the defect processes taking place in these crystals under the various conditions mentioned.