RADIATION AND IMPURITY INDUCED THERMALLY ACTIVATED CHARGE TRANSPORT IN CALCIUM FLUORIDE

Ervin B. Podgoršak

Under the Supervision of Professor P. R. Moran

The ionic space charge electret state, the dipolar electret state and the ionic conductivity are the impurity induced thermally activated processes that were studied in CaF_2 . The space charge electret state is strongly correlated with the bulk ionic conductivity. Its thermogram is a narrow symmetric peak with a characteristic depolarization temperature which varies around 370°K depending logarithmically on the impurity doping concentration. The electret state polarization-depolarization dynamics shows dominant bilinear behavior with a simple thermally activated rate function with a single activation energy of 1.30 ± 0.02 eV . The equilibrium electret polarization is first directly proportional to the polarizing voltage and then for voltages

greater than about 250 Volts follows a $V^{1/2}$ dependence. A typical charge release for a polarizing voltage of 10^3 Volts is 0.05×10^{-6} Coulombs cm^{-2}, independent of both the sample thickness and impurity concentration.

The dipolar electret state is strongly dependent on impurity concentration. Its equilibrium polarization is at least three orders of magnitude lower than that of the space charge electret state. Its thermogram is a narrow asymmetric peak with a characteristic depolarization temperature of $\sim150^\circ K$. Its polarization-depolarization dynamics show linear behavior with a simple thermally activated rate function, with an activation energy of 0.42 ± 0.02 eV and a frequency factor of $3\times10^{13 \pm 0.5}$ sec^{-1}.

Thermoluminescence (TL), thermally activated current (TAC) and local RITAD effect are the radiation induced thermally activated processes that were investigated. TL thermograms exhibit eight resolved peaks in the temperature range from LNT to $\sim450^\circ K$. The TAC and local RITAD thermograms exhibit only three peaks in the same temperature range but each is well correlated with a particular TL peak. The $146^\circ K/164^\circ K$ peak structure is associated with the V_k-center diffusion and the $296^\circ K$ peak with electron storage traps. All peaks are described by linear dynamics. The activation energy for the V_k-center diffusion is 0.33 ± 0.01 eV, the frequency factor $10^{9 \pm 0.5}$ sec^{-1}. The $296^\circ K$ peak activation energy is 0.77 ± 0.02 eV, its frequency factor is $6\times10^{12 \pm 0.5}$ sec^{-1}.

All three TAC thermogram peak exhibit linear low exposure dependence, and high exposure saturation effects (at a few 10 R). The 146°K/164°K V_k-center TL peaks show supralinear exposure response, which is shown to be due to the optical recombination process. At temperatures below ∿350°K the polarization component (displacement current) accounts for at least 99% of the total TAC current; no thermally stimulated conductance is observable experimentally.

The strong local RITAD effect is shown to be depolarization signal corresponding to the TAC polarization peaks. That is, the local RITAD signal is a TAC depolarization driven by the internal fields of the pre-polarized ionic space charge electret state. Ease of measurement, very high radiation sensitivity, and simple sample fabrication requirements give the RITAP/RITAD phenomena a great potential for use as a new solid state dosimetry technique. A simple descriptive theory allows analysis of the experiments showing that the sample polarization has a very simple, but strong, spatial distribution.

P. R. Moran

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