ELECTRON SPIN RESONANCE STUDY OF TRANSPORT DYNAMICS OF THE SELF-TRAPPED HOLE IN CALCIUM FLUORIDE

BY

GENE EDWIN FULLER

ABSTRACT

Electron spin resonance (ESR) is used to study the formation, annealing,and spin-lattice relaxation of self-trapped holes in calcium fluoride single crystals. First, the production of self-trapped holes in CaF_2 subjected to 120 kVp x-rays is discussed. A simple saturating exponential x-ray exposure dependence is observed with an initial production rate of approximately one self-trapped hole produced per 40 eV of absorbed photon energy and a saturated concentration of about 2.5×10^{16} holes per cubic centimeter. The production behavior observed by ESR is compared to the results of previous studies of self-trapped holes using thermoluminescent (TL) and thermally activated current (TAC) techniques, showing that the production supralinearity observed in the TL studies is due to the recombination mechanism rather than the production mechanism.

A series of isothermal annealing studies of the self-trapped hole were performed in the temperature range of $110^{o}K$ to $140^{o}K$. A two component decay was found with each component obeying linear kinetics, in partial contrast to

previously reported observations. A two-step coupled decay model for the two component behavior is discussed, and correlations between the ESR isothermal annealing results and the previously reported TL and TAC studies are described. An analysis of the temperature dependence of the isothermal annealing rate shows that the self-trapped hole annealing behavior is well described by the theory of small polarons. At temperatures near 140^{o}K the decay rates behave approximately as simple thermally activated functions with activation energies of .325 eV for the slower decay component and .30 eV for the faster decay component.

Finally, a preliminary study of the spin-lattice relaxation rate of the self-trapped holes as a function of temperature in the range from 78^{o}K to 140^{o}K has been performed. A well behaved temperature dependence was observed showing no correlation with the annealing kinetics. The spin-lattice relaxation rate can be fitted either to a simple thermal activation function or to a power law function of the temperature.