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STUDIES OF V_k CENTERS IN CsI BY OPTICAL AND EPR TECHNIQUES

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Résumé. — Les centres V_k ont été observés dans CsI : Na et CsI : Ti après irradiation X à la température de l'hélium liquide par des méthodes optiques et de RPE. Leur transition principale est située à 410 nm et ils sont orientés dans les directions [100]. Nous avons trouvé deux types de migration thermique : un déplacement linéaire le long d'un axe du cube (saut de 0°) et une migration par saut de 90°. Ces deux migrations sont associées à deux pics de thermoluminescence à 60 K et 90 K respectivement et correspondent à une recombinaison radiative des centres V_k mobiles à l'endroit des trappes électroniques (Na⁺ : λ = 420 nm, Ti⁺ : λ = 560 nm). Des expériences similaires ont été effectuées dans CsI coloré additivement. La recombinaison radiative V_k-F donne lieu à une nouvelle luminescence située à 495 nm.

Abstract. — V_k centers have been observed in CsI doped with Na⁺ and Ti⁺ after X ray irradiation at LHeT using optical and EPR techniques. Their main optical transition is located at 410 nm and they are oriented in [100] directions. Two types of thermal migration have been found: a linear displacement along the cubic axis (0° jumps) and a migration with 90° jumps. They are related to two glow peaks at 60 K and 90 K respectively and which correspond to the radiative recombinaison of mobile V_k centers at the site of the electron traps (Na⁺ : λ = 420 nm, Ti⁺ : λ = 560 nm). Similar experiments have been done in CsI additively colored. The radiative recombinaison V_k-F gives rise to a new luminescence at 495 nm.

The existence of V_k centers in alkali halides with CsCl structure has never been explicitly demonstrated although it can be inferred indirectly. In pure CsI for instance the fact that the intrinsic luminescent components at 290 nm and 338 nm excited by UV light in the excitonic bands can also be observed under ionising irradiation (X, β) shows that the relaxed exciton states produced directly (without the isolated Λ⁺ molecular ions) is identical to the metastable states formed by an electron in presence of a preexisting V_k center [1]. The formation of stable self-trapped holes must necessarily be accompanied by the trapping of an equal amount of electrons on specific traps. These traps may either be created during the ionising irradiation (anionic vacancies for instance) or may preexist in the crystal as impurities. The first possibility is ruled out for CsI, since no structure defect has been ever observed in a stable configuration under the most severe ionising irradiation conditions. We have therefore used CsI doped with Na⁺ (200 to 300 ppm in the melt, Teledyne Isotopes) or Ti⁺ (1 000 ppm in the melt, K. Korth) [2].

Figure 1 shows the absorption spectra observed after X irradiation (20 min for CsI : Ti and 1 min for CsI : Na) at 10 K. The band centered at 410 nm is found independent of the nature of the impurity and has been attributed to the UV transition

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Fig. 1. — Optical absorption after X-ray irradiation at LHeT.

a) CsI : Na⁺, b) CsI : Ti⁺.
renders dichroic the $V_K$ absorption at 410 nm. We report in figure 2 the dichroic spectrum of non aligned $V_K$ centers. The eleven lines marked on the figure suggest indeed an interaction with a total nuclear spin of 5 (nuclear spin of $^{127}I$ is 5/2, natural abundance 100%). Similar polarized bleaching results in an almost completely aligned $V_K$ center system along a [100] direction.

These properties can be explained by a double migration of thermally activated $V_K$ centers followed by a radiative recombination with the trapped electrons. The first peak is associated to a linear migration of $V_K$ centers (0° jumps). The dichroic optical absorption and EPR spectrum of aligned $V_K$ centers measured at LHeT after a thermal annealing at 70 K present only a global reduction of their intensity. This means that the remaining $V_K$ centers have conserved their alignment. The second glow peak however associated with $V_K$ migration with reorientation by 90° jumps.

Preliminary experiments give evidence that the same double mobility mechanism is common to $V_K$ centers in all alkali halides with CsCl structure. Similar experiments [6] in crystal additively colored i.e. containing F centers confirm the above ideas. They give rise however to a new emission band at 2.5 eV which can be observed in thermoluminescence and radioluminescence experiments at temperature at which the $V_K$ centers are mobile. This new luminescence is attributed to the radiative recombination of mobile $V_K$ centers with F centers. This work has been supported by the Swiss National Foundation for Scientific Research (FNSRS).

References

DISCUSSION

G. Reuter. — The $V_\alpha$ band in CsI shows dichroism after bleaching with polarized light. Is this behavior due to reorientation of the centers or to recombination with electron traps?

M. Aegerter. — It depends on the wavelength of bleaching. In CsI: Na we have bleached with polarized light at 406 nm, i.e., in the UV transition of the $V_\alpha$ centers. In this case the dichroism is due to a destruction of $V_\alpha$ centers aligned in the direction of the electric field of the polarized light. For CsI: Tl the wavelength of bleaching was 606 nm. In this case the $V_\alpha$ centers can be oriented but a partial bleaching occurs also.