Thermal stability of color centers in LiF crystals: dependence on radiation type and dose

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Accumulation of radiation defects at irradiation is the complex result of consecutive and mutually independent events: formation of primary pair, spatial separation of its components and their transformation into stable ones under experimental conditions [1]. In ion crystals - at least, in those of alkali halide and alkali earth metal fluorides – high efficiency in formation of initial defects is observed. If the temperature is high enough, the initial genetically linked pairs are spatially separated through thermally activated movement of movable component of primary pair and this process is also highly efficient [2].

The present work is devoted to the research of thermal stability of color centers formed in LiF crystals exposed to irradiation of different doses and types. On the one hand, LiF is a typical AHC crystal; on the other hand, formation of molecular fluorine ions is possible in the crystal, which might affect stability of radiation-induced color centers.

Crystals were irradiated by beams of electrons and oxygen ions at room temperature. There were following parameters of electron irradiation produced by pulse accelerator: pulse duration – 10 nsec, average electron energy – 250 keV, energy density of initiating pulse - 15 mJ/cm^2. Electron range was 0.2 mm. The absorbed single pulse energy in LiF crystal was 8 10^2 Gy. For the procedure of irradiation by oxygen ions DC-60 accelerator (Astana) was used with 15 μm oxygen ion range; irradiation by uranium ions was performed at GSI accelerator (Darmstadt) with 94 μm uranium ion range [11]. Absorption spectra were measured by SF-256 UV spectrophotometer.

Presented results (see **Ошибка! Источник ссылки не найден.**) of stability tests of irradiation-induced color centers in pure and activated LiF crystals allow drawing the following key findings:

1. Thermal stability of color centers accumulated in LiF crystals at their exposure to electron irradiation depends on irradiation dose and rises with the increase of dose of pre-irradiation exposure.

2. Irradiation by ions of oxygen and uranium with doses up to 2.0x10^8 Gy results in creaton of color centers within LiF crystals; thermal stability of these centers is higher than that within crystals pre-irradiated with electron beams with doses up to 2.0x10^3 Gy.

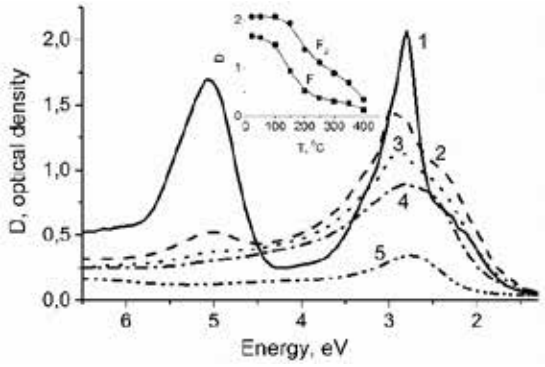

Figure 1. Absorption spectra of LiF crystal exposed to ^{16}O ion irradiation at E=28 MeV up to reaching fluence of 10^{14} ion/cm^2 and heated up to: 1 – prior to heating, 2 – 200 °C, 3 – 250 °C, 4 – 350 °C, 5 – 400 °C. The insert shows the dependence of optical density level at maxima of F and F_2 bands on the annealing temperature.

With the growth of irradiation dose, stable neutral fluorine molecules are probably formed in interstitial spaces as a result of interaction of several H-type hole centers. Fluorine molecule in the interstitial space is an equivalent of two H-centers which is a stable defect poorly interacting with other defects. Destruction of fluorine molecule in the interstitial space results in formation of instable H-centers annihilating with F-centers and complex electron color centers.

References

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