SYNTHESIS AND OPTICAL PROPERTIES OF Ag-NANOPARTICLES IN WIDE-GAP DIELECTRICS

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Results of studies of luminescent centers originated from irradiation of several fluoride crystals with silver ions are presented. The samples were irradiated with ion beam of fluencies varied in the range 2×10^{13} - 10^{18} ions / cm^2 and 150 keV energy. A pulsed ion beam with a duration of 200 μs was formed using a three-grid accelerating system from the plasma of a vacuum-arc discharge. The spectral kinetic characteristics of the irradiated samples were investigated using an SF-56 spectrophotometer and a MicroTime 200 confocal scanning microscope combined with an OceanOptics 6500 spectrometer.

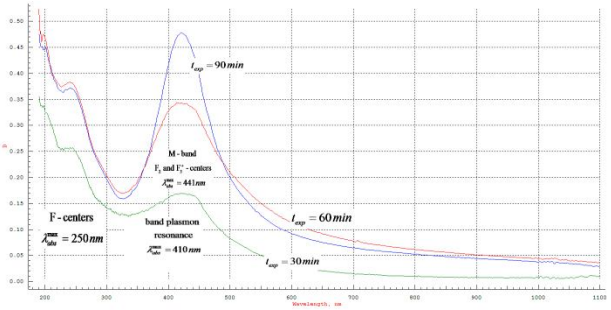

Fig. 1. Absorption spectra of LiF crystals irradiated with Ag ions with a fluence of $1.5 \cdot 10^{15}$; $1.5 \cdot 10^{16}$; $5 \cdot 17^{17}$ ion/cm^2 (t_{exp}= *30 min,* t_{exp}= *60 min and* t_{exp}= *90 min* respectively).

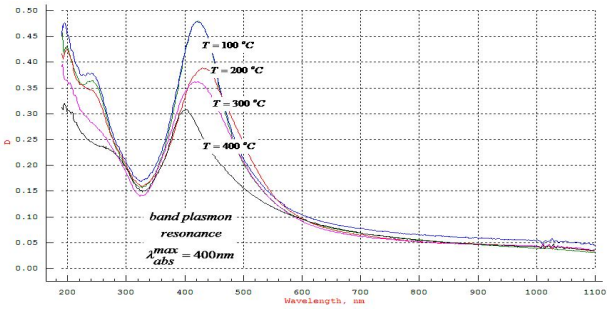

Fig. 2. Dynamics of changes in absorption spectra during thermal annealing of a LiF crystal irradiated with Ag ions with a fluence $1.5 \cdot 10^{16}$ (t_{exp}= *60 min*).

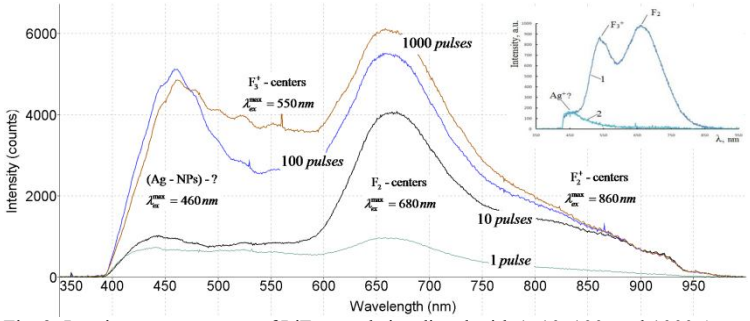

Fig. 3. Luminescence spectra of LiF crystals irradiated with 1, 10, 100, and 1000 Ag ion pulses, respectively. The inset shows a comparison of the luminescence spectra for a crystal irradiated with 100 ion pulses before and after annealing (luminescence was excited by a pulsed picosecond laser with a wavelength of 375 nm).

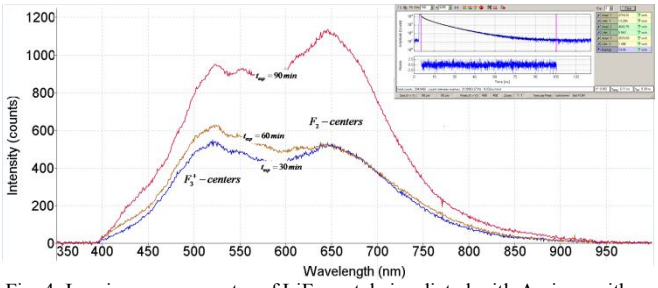

Fig. 4. Luminescence spectra of LiF crystals irradiated with Ag ions with fluence $1.5 \cdot 10^{15}$; $1.5 \cdot 10^{16}$; $5 \cdot 17^{17}$ ion/cm^2 (t_{exp}= *30 min,* t_{exp}= *60 min and* t_{exp}= *90 min* respectively) and the luminescence decay curve of a LiF crystal irradiated with Ag ions with a fluence of 1.5×10^{15} ion/cm^2 (inset). *Times of 13 and 5.5 ns are observed, which are characteristic of the surface* F_2 *and* F_3^+ *color centers, as well as a short component of 1.4 ns.*

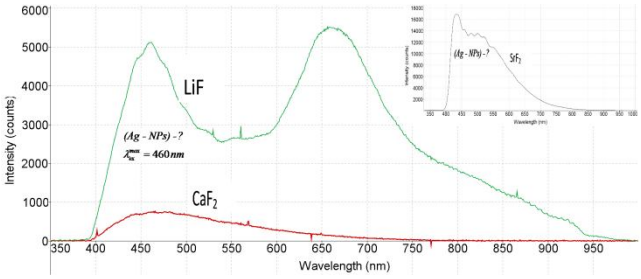

Fig. 5. Luminescence spectra of some fluoride crystals irradiated with a series of 100 pulses of Ag ions.

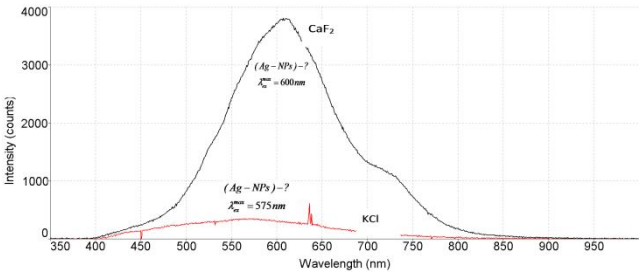

Fig. 6. Luminescence spectra of some CaF_2 and KCl crystals irradiated with a series of 1000 Ag ion pulses.

CONCLUSIONS

The luminescence spectra of irradiated crystals of lithium fluoride upon excitation by laser radiation of 375 nm showed that, along with the luminescence bands with maxima at 550 and 680 nm, a luminescence band with a maximum at 460 nm was detected. The first two bands are characteristic of F_2 and F_3^+ - color centers, respectively, which were formed in a thin surface layer as a result of ion irradiation. The luminescence band with a maximum at 460 nm and, most likely, is due to silver ions.

The kinetic luminescence curve contains three time components, namely, 13 and 5.5 ns, which are close to the characteristic decay times of the luminescence of F_2 and F_3^+ centers in the LiF crystal. In addition, there is a fast component with a decay time of about 1.0 ns, which was attributed to the luminescence of silver nanoparticles.

A luminescence band with a maximum at 460 nm associated with silver ions is also observed in CaF_2 and SrF_2 crystals irradiated with a series of 100 Ag pulses.

With an increase in the number of irradiation pulses to 1000, the maximum of the luminescence spectrum of CaF_2 crystals shifts to longer wavelengths up to 600 nm. A similar situation is observed for KCl crystals (with a small number of pulses in this crystal, a very weak glow is observed in the band with a maximum at 460 nm, but with an increase in the number of pulses to 1000, the band shifts to the 575 nm region).

Thus, it can be said that irradiation of the crystals under study with Ag ions leads to the formation of two types of luminescence centers in the surface layer of the crystal. The first of them, at low radiation energy densities, can be attributed to the formation of molecular clusters Ag_n^+ (n = 3-6) on a subnanometer scale. The second (with an increase in the radiation dose) is associated with the formation of silver particles on a nanometer scale 10 - 100 nm.