R4-P-008501

RADIATION DEFECTS IN MgO SINGLE CRYSTALS IRRADIATED WITH SWIFT IONS*

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Crystals of magnesium oxide and calcium fluoride are widely used and promising materials in various fields of science and technology. Magnesium oxide also has a wide range of uses. MgO crystals exhibit high resistance to irradiation and prolonged residence in a radiation medium. This property determines the prospects of MgO in nuclear applications, such as nuclear fuel, waste storage, fission reactor materials, and even as promising materials for diagnostic windows in future deuterium-tritium fusion reactors [1].

Highly pure MgO single crystals were irradiated with 0.23 GeV ^{132}Xe ions and Ar^{40} at fluences of $\Phi = 5\times10^{12}–3\times10^{14}$ ions/cm^2 at the DC-60 cyclotron in Nur-Sultan. The spectra of optical absorption were measured in a spectral region of 1.5-6.5 eV using a spectrometer СФ2000. The photoluminescence and excitation spectra were measured on a universal spectrofluorimeter CM2203 Solar. The luminescence spectra upon excitation by synchrotron radiation were measured at the MAX IV Lab synchrotron (Lund, Sweden).

Irradiation with ions creates many defects in the crystal, both in bulk and on surface. Induced defects form additional energy levels in the bandgap of the energy structure of crystal, which leads to its coloration and the appearance of radiation-induced optical absorption (RIOA). Therefore, one of the effective methods for studying radiation defect formation is optical absorption spectroscopy. By the area of the absorption band, we can talk about the relative concentration of defects responsible for this band.

The absorption spectrum contains a wide non-elementary band with a maximum at about 5 eV. In this area F and F^+ centers (oxygen vacancies with two and one captured electron, respectively, maxima at 4.92 and 5.03 eV, respectively [2]) are responsible for optical absorption. With an increase in the irradiation fluence, we see a noticeable increase in this structural absorption band. F_2 centers (two neighboring F centers, maximum at 3.48 eV [3]) are created in a very low concentration. In addition, the spectrum contains a weak band at about 2.17 eV, a detailed study of which is given in [1].

Upon excitation by photons with an energy of 5 eV (near the absorption band of F^+ centers), a broad non-elementary emission band at about 3.25 eV is observed in the spectrum. The main contribution to this structural emission band is made by F^+ centers (emission at 3.2 eV [4]). Upon excitation at a point of 5.4 eV, a shift of this emission band to the short-wavelength side of the spectrum takes place, where the emission of F_2 centers can contribute [3]. In the excitation spectra (curves 3-5, Figure 3), bands of F, F^+ and P centers are noticeable. The excitation band at 4.36 eV is presumably associated with iron ions, which are always present in MgO as a residual impurity.

Luminescence spectra were also measured for MgO crystals upon excitation by synchrotron radiation. It can be seen that for a sample irradiated up to a fluence of 10^{12} Xe/cm^2, when the energy of the exciting light is shifted to the long-wavelength side of the spectrum, the maximum of the intensity shifts to the short-wavelength side. Under exciting with 4.8 eV light where F^+ centers are excited more, the emission in longer wavelength side gives rise. Excitation at 5.75 eV, where the P centers are absorbed, gives an intense glow with a maximum of about 2.97 eV. For a sample irradiated up to fluence of 6.7×10^{13} Xe/cm^2, excitation at a point of 5.4 eV gives a luminescence of about 3.3 eV.

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*This research has been/is funded by the Science Committee of the Ministry of Education and Science of the Republic of Kazakhstan Grant No. AP08052050 and Grant No. AP13067816.