

STUDY OF OPTICAL ABSORPTION OF LEUCOSAPPHIRE AND RUBY IRRADIATED WITH ELECTRONS WITH ENERGY OF 12.5 MeV

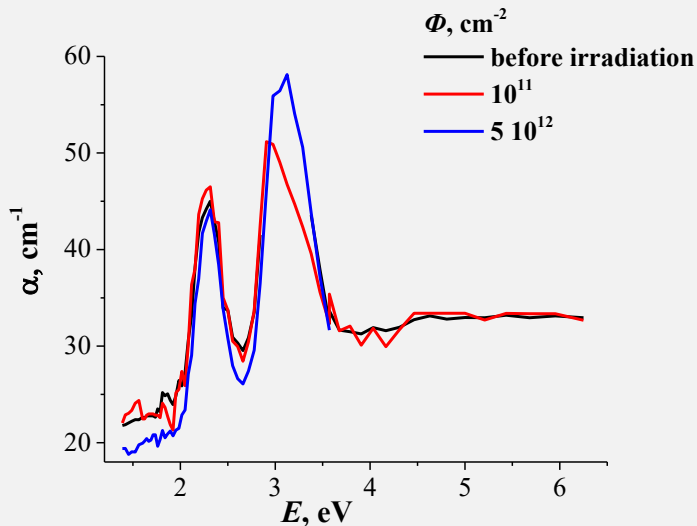
O.M. Pop, V.T. Maslyuk, I.G. Megela, I.Yu. Roman

Institute of Electron Physics of the NAS of Ukraine, Uzhhorod

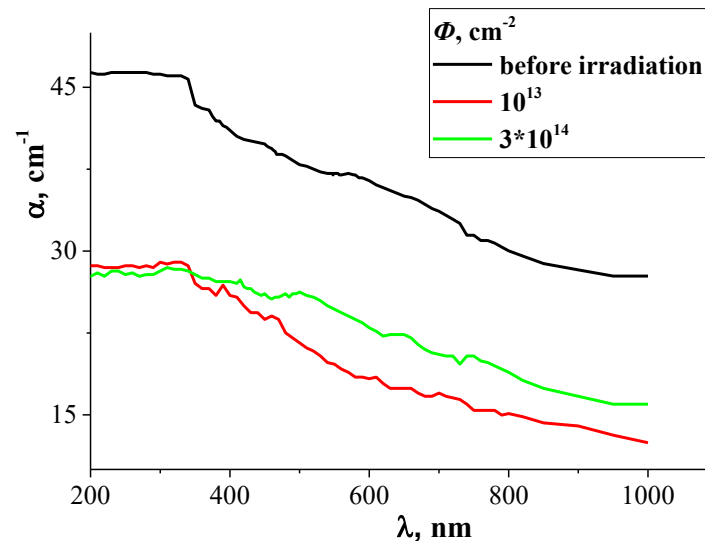
Relevance. Leucosapphire and ruby are varieties of corundum ($\alpha\text{-Al}_2\text{O}_3$) that have the same crystal structure, but differ significantly in their optical properties due to the presence of impurity centers.

Ruby is an Al_2O_3 crystal activated by impurities, in which Cr^{3+} ions replace part of the Al^{3+} ions. It is these impurity ions that form localized energy levels in the band gap, which cause absorption in the visible region of the spectrum, a characteristic red color, and the presence of narrow R-lines.

Leucosapphire (pure Al_2O_3) contains practically no impurities; it demonstrates high transparency in a wide spectral range, and its optical properties are determined mainly by interband transitions and intrinsic defects of the crystal lattice.



Changes in optical absorption of ruby ($\text{Al}_2\text{O}_3:\text{Cr}^{3+}$) samples with irradiation dose



Changes in optical absorption of leucosapphire (pure $\alpha\text{-Al}_2\text{O}_3$) samples with irradiation dose

Purpose of the work: The presence of Cr^{3+} ions in ruby changes the electronic structure and spectral characteristics of the sample relative to leucosapphire, which makes comparative analysis in the context of optical absorption studies advisable.

Research methodology: In the presented work, crystals of leucosapphire (Al_2O_3) grown by the Stepanov method and ruby ($\text{Al}_2\text{O}_3:\text{Cr}$) grown by the Verneuil method were studied. The irradiation of the studied samples was carried out at room temperature in the field of scattered electron radiation with an energy of 12.5 MeV on the M-30 microtron of the Photonuclear Processes Department of the Institute of Electronic Physics of the NAS of Ukraine. After irradiation, the phosphorescence decay kinetics were measured. The optical absorption of the studied samples was measured with a SF-46 spectrophotometer after phosphorescence decay.

Results:

1. The optical absorption of ruby ($\text{Al}_2\text{O}_3:\text{Cr}^{3+}$) differs significantly from the absorption of leucosapphire (pure Al_2O_3), which is due to the presence of impurity ions Cr^{3+} in the crystal lattice of corundum.

2. In the studied ruby crystals, intense bands are observed in the visible region $\sim 400\text{--}450$ nm (3 eV) and $\sim 550\text{--}560$ nm (2.3 eV) (which corresponds to intraconfigurational d–d transitions of Cr^{3+} ions).

3. As a result of irradiation of the studied samples, a slight decrease in optical coefficients is observed, which corresponds to a relative change of approximately 4–5%. The small magnitude of the changes indicates the preservation of the crystal lattice and the insignificant effect of ionization on the radiation effect.

4. Unlike ruby crystals, undoped leucosapphire samples show virtually no absorption in the visible region and high optical transparency. After irradiation, a decrease in absorption is observed in the entire wavelength range of 200–1000 nm. This is explained by the low-dose effect, which results from a decrease in crystal defects due to radiation-stimulated diffusion of existing technological defects to the drains during irradiation.