

STUDY OF RADIATION STIMULATED PROCESSING IN CORUNDUM MONOCRYSTALS BY SYNCHROTRON RADIATION EXCITATIONV.V. Harutunyan¹, V.N. Makhov², M. Kirm³, S. Vielhauer³¹Yerevan Physics Institute, Yerevan, Armenia; ²Lebedev Physical Institute, Moscow, Russia;³Institute for Experimental Physics, University of Hamburg, Hamburg, Germany

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The wide-band ion corundum crystals are of great interest because of their applications as optical materials in the UV-VUV region, as well as luminescence materials, such as scintillators for ion emission detectors, luminophors for memory screens, laser active media, and materials for radiation defense. The development of radiation technologies needs materials stable to the effects of high energy particles –electrons, neutrons, ions, and synchrotron radiation-SR. So, the understanding of physics of luminescence in corundum crystals is very important. The well-know 7.6eV intrinsic broad-band emission of Al₂O₃ is effectively excited at the direct creation of excitations in the region 8.8-9.3eV or at the recombination of free electrons and free holes under high –density excitation by electron beam. Since no evidence of self-trapping for both electrons and holes has been obtained for Al₂O₃, the 7.6eV emission was interpreted in references as the radioactive decay of self-shrunk excitons. However the reasons for practically complete absence of the 7.6eV emission under the weak excitation in the region of band-to- band transitions are still under discussion. In the present report the VUV luminescence of corundum single crystals, non-irradiated and irradiated with 50 MeV electrons, has been studied with time-resolved spectroscopy under synchrotron radiation excitation at the SUPERLUMI station of HASYLAB at DESY. Emission spectra were analyzed by using a 0,5 Pouey –type VUV monochromator equipped with a solar-blind photomultiplier R 6838. The time correlated single-photon counting was used for the measurements of luminescence decay curves and time-resolved spectra with time resolution ~1ns. The nominally pure stoichiometric Al₂O₃ single crystals were grown by the horizontal-oriented crystallization method. As expected, the intensity of 7.6eV emission for the non-irradiated crystals was extremely low at the excitation in the region of band-to-band transitions, whereas for the electron irradiated crystals the relatively high efficiency of excitations for the 7.6eV emission extends for several eV towards the region of band-to- band transitions .The 7.6eV emission in the non-irradiated crystal shows a single-exponential decay with $\tau \sim 8.5$ ns at the excitation in the low-energy part of the main excitation band 8.8-9.3eV, whereas at the excitation in the high-energy side of the same band the decay contains a considerable fraction of the slow component, without any changes in shape of the emission spectrum. The decay of 7.6eV emission for the irradiated crystal is slightly non-exponential with the presence of the slow component for all excitation energies. The obtained results clearly show that the 7.6eV emission of Al₂O₃ can be effectively excited in the region of band – to- band transitions in the presence of defects. Unfortunately, all Al₂O₃ crystals(grown at high temperatures) contain a considerable concentration of intrinsic defects, namely F⁺ and F centers the emission of which was clearly observed for the non-irradiated crystal under the intra-center excitation in the region 4.5-6.5eV.As a result the weak 7.6eV emission is always observed in the region of band-to-band transitions for any Al₂O₃ sample. However the model of the decay of self-shrunk excitons for the 7.6eV emission gives a self-consistent explanation for the properties of the 7.6eV emission in Al₂O₃. At excitation photon energies $E > 25$ eV the 7.6eV emission reappears but with much lower quantum efficiency than at the direct optical creation of excitons, and the decay kinetics of the 7.6eV emission becomes strongly non-exponential with a considerable fraction of the slow component.