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Excitation density distribution effects on fast ZnO excitonic emission

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ZnO crystals and nanoparticles have promising scintillation properties an subnanosecond scintillator. There is huge number of publications concerning laser excitation of ZnO. Nevertheless, it is still not clear how the properties of ZnO scintillation are connected with the physics of process in this crystal, which significantly differs from traditional inorganic scintillators being mostly ionic crystals.
The intensity and kinetics of ZnO emission strongly depends on the energy and fluence of excited photons both at ambient temperature and low temperatures. We perform systematic study of ZnO time-resolved luminescence: z-scan under intense interband femtosecond excitation 266 nm (3rd harmonic of Ti:Sa laser) and excitation by X-ray synchrotron radiation.
Z-scan allows the systematic study of the luminescence intensity and decay characteristics in case when excitation density changes in space with characteristic scale of tens of microns. The results show non-monotonic behavior of luminescence intensity with excitation intensity. The possible reason of such behavior is the combination of (1) the increase of exciton production with the increase of electron and hole density and (2) the decrease of emission intensity and fastering the kinetics with the increase of exciton concentration.
The change of X-ray excitation energy result in nanometric changes in spatial distribution of excitations. The most prominent result is the excitation below (950 eV) and above (1100 eV) of Zn 2p core energy. We calculate the dramatic modification of the distribution of energy of Auger electrons created in cascade process, resulting in appearance of much higher number of Auger electrons with energy below 200 eV in case of 1100 eV excitation. Such electrons have small mean free paths (about and less than 1 nm) and therefore the spatial distribution of electrons and holes in track after 1100 eV absorption is characterized by higher number of dense regions in track structure. This analysis can be used to explain the increase of fast (about 100 ps) component in decay kinetics under 1100 eV excitation.

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