New features of hot intraband luminescence

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Intraband luminescence (IBL) is an ultrafast emission connected with the radiative transitions of hot electrons or holes between the sub-levels of the conduction or valence band of a crystal, respectively [1]. The spectrum of IBL is continuous, covering the whole transparency region of a material and growing in intensity towards NIR [2]. The characteristic decay time of IBL has not yet been accurately determined, but it is expected to be of the order of ~1 ps, reflecting the time scale of electron-phonon relaxation within the electronic bands. Despite IBL was discovered long ago, it has not been intensely studied mainly because of its very low intensity (estimated scintillation yield 20 photons/MeV [3]) and, correspondingly, unclear application perspectives. Recently, more attention has been drawn to ultrafast emissions due to increasing demands of medical and high-energy physics applications for higher scintillation time resolution [4].

Here we present a review of recent experimental and theoretical studies of IBL in various binary and complex wide-gap materials. IBL is observed typically under high-energy electron pulse (100-300 keV) excitation. We have shown that a direct observation of IBL is possible also under excitation by a low-energy (10 keV) continuous electron beam, pulsed X-rays and white-beam (3-60 keV) synchrotron radiation. The low-power excitation confirms the absence of an energy threshold for IBL creation. Excitation by X-rays allows predicting that the IBL can be excited by single photons of 511-keV energy, which makes it promising for enhancing scintillation time resolution in time-of-flight positron emission tomography (TOF-PET) [4], as IBL can provide an almost instant time marker for the event despite its low yield. The impact of various material features such as electron-phonon interaction and electronic band structure on the IBL spectrum shape and light yield will be analyzed.

References

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