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Influence of isoelectric impurities on scintillation and luminescence properties of ZnSe based scintillators

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Effect of tellurium and oxygen isoelectronic impurities as well as of the post-growth thermal annealing on the structure defect formation in ZnSe have been studied. Both annealing in zinc-enriched environment and incorporation of oxygen improve the efficiency of ZnSe and ZnSe(Te) scintillators. Depending on the growth conditions, competition of two channels of radiative recombination is observed while it is just the concentration of nonradiative recombination centers that defines decisively the light output. Incorporation of oxygen and tellurium slows the rate of luminescence decay by favoring formation not only of emission centers but also of shallow traps, whereas the additional annealing in zinc vapor enhances drastically the recombination rate.

Рассмотрено влияние изоэлектронных примесей теллура и кислорода, а также послеростового термического отжига на образование структурных дефектов в ZnSe. Как отжиг в цинке, так и введение кислорода увеличивают эффективность сцинтилляторов на основе ZnSe и ZnSe(Te). В зависимости от условий выращивания наблюдается конкуренция двух каналов излучающей рекомбинации, и величина светового выхода определяется, главным образом, концентрацией безызлучательных центров рекомбинации. Введение кислорода и теллура тормозит затухание люминесценции, благоприятствуя формированию не только центров свечения, но и мелких ловушек, тогда как дополнительный отжиг образцов в цинке нейтрализует ловушки и резко увеличивает скорость рекомбинации.

ZnSe(Te) crystals are very promising scintillators where combination two parameters of major importance are combined, namely, quantum efficiency and radiation hardness [1, 2]. Their light output may even exceed that of CsI(Tl), which can be taken as an up-to-date reference scintillator for X-ray detectors in introscopes and tomographs [1]. Meanwhile, the radiation hardness of ZnSe(Te) is up to 4 orders of magnitude higher than that of CsI(Tl) [1]. The suitability of ZnSe(Te) crystals to detect moderate energy γ-radiation and β-particles has been also demonstrated [3, 4].

Our recent study of ZnSe scintillators was aimed at improvement of ZnSe scintillation properties by optimizing composition of defects in this crystal. Emission of luminescence quanta in the vicinity of 2 eV that is used in ZnSe scintillators is well below the band gap of ZnSe and is obviously caused by optical transitions involving deep levels. Structural defects and their complexes with impurities are shown to be responsible for these deep levels [5].