Properties and Peculiar Features of Application of Isoelectronically Doped A2B6 Compound Based Scintillators

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Among 26compounds, zinc selenide and zinc sulfide crystals are, due to their physico-chemical properties, the best optimized matrices for creation of luminescent materials with output parameters characterizing them as efficient scintillators (high lightoutput, fast response, high radiation stability, etc.). The first successful experience in this direction was the development of scintillator ZnSe(Te), which has been already shown to be one of the most suitable materials for low-energy X-ray introscopy [1,2]. With the aim of expanding the application fields of ZnSe and ZnS-based scintillators, we have studied the defect formation processes and luminescent properties of zinc selenide and zinc sulfide crystals doped with anionic (Zn, Cd, Hg) and cationic (O,S,Te) isoelectron dopants (IED). Data are presented on the effect of oxygen, cadmium, tellurium and sulphur upon spectral-kinetic luminescence characteristics of A2B6compound based scintillator crystals (see Table).

Table. Light output *S*, afterglow , decay time , and luminescence maximum max of isovalently doped A2B6 crystals

№	Crystal	Light output *S*, rel. un.	Afterglow η(%), after (ms)		Decay time	Luminescence maximum
			5 ms	20 ms	τ, μs	λ_{max}, nm
1	ZnSe(Te)	1.0	1.0	0.05	30-120	630-640
2	ZnSe(O)	0.90	0.05	0.005	1-3	590-600
3	ZnSe(Cd)	0.7	0.5	0.03	0.5-2	615-630
4	ZnSe(Hg,S)	0.6	0.1	0.008	0.3-1	610-620
5	ZnSe(Cd,Te)	1.30	0.2	0.01	10-30	620-640
6	ZnS(Se,Te)	0.3-0.5	1.5	0.2	0.1-0.3	445; 550
7	ZnS(Cd,Te)	0.4-0.6	0.03	0.001	0.2-0.5	500; 580

Thus, the properties of A2B6 based scintillators are varied within very broad limits. E.g., maximum of the luminescence spectrum of ZnSe(IED) crystals max 595-640 nm, decay time - 0.3-120 s, afterglow level (after 5 0.005-0.5 % (3-5% for CsI(Tl)) the relative light output *S* was 0.6-1.3 (*S*=1 for CsI(Tl)), quantum yield up to 75000 ph/Mev. One should specially note very high radiation hardness of ZnSe-based scintillators (>500 Mrad, which is more than 1000 times higher than for CsI(Tl)). This ensures not only high stability of the detecting systems of radiation introscopes, but also allows their use for dosimetry of powerful fluxes of ionizing radiation.

Due to their relatively low atomic number Zeff, which leads to lower efficiency of detection of high-energy radiation and high sensitivity to short-range types of radiation (alpha-, beta-particles, soft X-ray, etc.), ZnS-based scintillators (including ZnS(Te)-type of scintillator) are promising for their use in combined multi-energy and selective detection systems (introscopy, dosimetry radiometry, etc.) in combination with both semiconductor photodiodes and PMT as photoreceivers.

_It has been shown that at low IED concentrations, for all types of the dopants the most thermodynamically stable defects are duplets or triplets based on the intrinsic structure defects VZn, Zni and the introduced isovalent dopants, which play the role of radiative recombination centers in ZnSe:(IED) and ZnS(IED) crystals. The spatial configuration of objects that form these triplets depends upon crystallochemical radiuses of the dopant ions, as well as upon their electronegativity (effective charge), and is determined by the predominance of either Coulomb or elastic interaction between the components. The total effective charge is different for triplets of VZnOSeZni, VZnSSeZni, VZnSeSZni, ZniVZnTeSe, CdZnVZnZni (or dZnZni VZnSe) and HgZnVZnZnitype. The value of this charge determines the depth of acceptor-like recombination levels within the band gap of zinc selenide (sulfide), causing the observed differences in spectral-kinetic properties of the studied semiconductor scintillators. It has been shown that one of the decisive factors is the method of preparation of raw material for initial charge. The most suitable for practical scintillator production is introduction of the dopants in the form of cadmium and zinc chalcogenides.

_Data are presented on application fields, specific features and advantages of new scintillation materials on the basis of A2B6compounds.

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2. B.Grynyov, V.Ryzhikov, Jong Kyung Kim, Moosung Jae. Scintillator crystals, radiation detectors & instruments on their base. Ukraine-Kharkov, 374(2004).