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Specific features of heat-treated GSO:Ce single crystals

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Effect of the heat treatment in a medium with controlled chemical potential on the defectness and luminescence of gadolinium orthosilicate single crystals has been studied. The crystal heat treatment in a reducing atmosphere has been found to result in the formation of capturing centers associated with the luminescence ones through the recombination interaction. In those complexes, the light sum accumulation and decay processes take place. It has been shown that in general case, the absence of the thermoluminescence peaks cannot be considered as the criterion of the light sum accumulation.

Исследовано влияние термообработки в среде с регулируемым химическим потенциалом на дефектность и люминесценцию монокристаллов ортосиликата гадолиния. Обнаружено, что термообработка кристаллов в восстановительной атмосфере приводит к образованию центров захвата, связанных с центрами люминесценции через рекомбинационное взаимодействие. В этих комплексах происходят процессы накопления и высвечивания светосуммы. Показано, что в общем случае отсутствие пиков термолюминесценции нельзя рассматривать как критерий накопления светосуммы.

Cerium-doped single crystal of gadolinium orthosilicate (GSO), Gd_2SiO_5:Ce, is an effective scintillation material for γ-radiation detectors. The crystals grown from the melt using the Czochralski technique contain as a rule structure defects, the density and distribution of the latter defining the detector quality [1, 2]. In this work, one of possible ways to improve the crystal structure perfection by treatment in a controlled phase changing the charge state of the activator ions and the density of the structure defects.

The purpose of the work was to study the heat treatment effect in a medium with controlled chemical potential on the defectness and luminescence characteristics of the gadolinium orthosilicate single crystals.

The GSO:Ce (0.6 % mass Ce) single crystals (27 mm in dia., about 100 mm long) were grown by the Czochralski technique from an iridium crucible in the induction-heated growing unit provided with an additional heater placed in the upper part of the crystallization assembly. The growing was performed in nitrogen (argon) medium where up to 1.5 % (vol.) oxygen was added. Special purity (at least 99.995 %) gadolinium, silicon, and cerium oxides were used as raw materials. The heat treatment was done in a furnace with sealed operating chamber. The heating and cooling rate at the heat treatment did not exceed 60 K/h, the annealing temperature was 1500 °C. This anneal has been proven experimentally to provide the complete stress relaxation in the crystal. The annealing medium chemical potential determined as described in [3] was 40 kJ/mol. For spectral measurements, samples of 27 mm in dia. and 90 mm length were cut out of the crystals. The sample surfaces were polished up to the roughness of $Rz = 0.05$ μm.

The temperature dependences of photoluminescence (PL), photostimulated current (PSC), thermostimulated current (TSC), and