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Spectroscopic properties of $PbWO_4$:Tb^{3+} crystals

L.V.Kostyk, A.E.Nosenko, S.S.Novosad, I.V.Kayun

I.Franko Lviv National University,
50 Dragomanov St., 79005 Lviv, Ukraine

Study results of absorption, photostimulated, X-ray stimulated, and thermostimulated luminescence spectra and luminescence decay kinetics are presented for Tb^{3+}-doped $PbWO_4$ crystals. Two impurity center types have been shown to exist in $PbWO_4$:Tb^{3+} crystals. The nature of those centers is discussed. The trap concentration decrease in Tb^{3+}-doped crystals (thermostimulated luminescence peaks at 150 to 250 K) provides a higher-efficiency emissive recombination of charge carriers and shortening of the luminescence decay time.

Представлены результаты исследований спектров поглощения, фото-, рентгено-, термостимулированной люминесценции и кинетики тушения люминесценции кристаллов $PbWO_4$ с примесью ионов Tb^{3+}. Показано, что в кристаллах $PbWO_4$:Tb^{3+} могут существовать два типа примесных центров. Обсуждается природа этих центров. Уменьшение концентрации ловушек в легированных Tb^{3+} кристаллах (пиков ТСЛ 150–250 К) приводит к более эффективной излучательной рекомбинации носителей заряда и сокращению времени тушения люминесценции.

Scintillation properties of tungstate single crystals, including $PbWO_4$ ones, are known for a long time [1]. The interest in those materials was renewed in the early 90^{th} when the $PbWO_4$ single crystals were shown to be useful as scintillation medium in high-energy ionizing radiation detectors. This stimulated the intense investigations in spectral, luminescence, and scintillation characteristics of those crystals. Various dopants, when introduced in the crystal, provide specific modifications in their spectral and luminescence properties. The $PbWO_4$ single crystals modified by some trivalent ions exhibit improved scintillation characteristics and enhanced radiation hardness [2–5]. Recently, a significant luminescence yield enhancement was reported for Tb^{3+} ion doped $PbWO_4$ crystals [6] that is of interest for their application as scintillators in moderate and low energy radiation detection.

This work is aimed at the study of spectral properties of $PbWO_4$:Tb^{3+} crystals and is a continuation of investigations presented in [7].

Both nominally pure and Tb^{3+} ion doped $PbWO_4$ crystals were grown from platinum crucibles in an air-like atmosphere using Czochralski technique. The crystals were obtained from a stoichiometric melt of special purity grade oxides (PbO and WO_3). The doping Tb^{3+} ion was introduced into the blend as Tb_4O_7 oxide annealed previously at 1900 K for 4 to 5 h. The terbium concentration in the melt was 0.01 and 0.05 % mass. The nominally pure and Tb^{3+} ion doped $PbWO_4$ crystal samples were shaped as plane-parallel plates cut out in the (001) plane. The polished sample were annealed in air at 650 K for 2 h. The optical absorption spectra were studied using a Specord M40 spectrophotometer. The luminescence and luminescence excitation spectra were recorded using a SDL-2 spectrometer in the photon counting mode. The luminescence decay kinetics was measured by statistical single photon counting under excitation by X-ray pulses (Δt = 1.5 ns, U = 35 kV, f = 10 to 100 kHz) and by nitrogen laser ILGI-503 in ns-μs and μs-ms time intervals, re-