PHOTOLUMINESCENCE IN $MgIn_2S_4$ SPINEL CRYSTALS

V.F. Zhitar*, E.D. Arama, and T.D. Shemyakova***

Institute of Applied Physics, Academy of Sciences of Moldova, 5, Academiei str., MD-2028, Chisinau, Republic of Moldova
**The State Medical and Pharmaceutical University "Nicolae Testemitanu", 165, Stefan cel Mare ave., MD-2004, Chisinau, Republic of Moldova*
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Abstract

The ingot of $MgIn_2S_4$ with a spinel structure was synthesized. The photoluminescence of this semiconductor material was studied at room temperature. The bell-shaped photoluminescence spectra with peaks at 1.35 and 1.49 eV were observed; their possible interpretation is suggested.

1. Introduction

As noted in numerous publications, the $CdIn_2S_4$ semiconductor with a spinel structure is known as a material exhibiting high photosensitivity and bright photoluminescence (PL). The majority of the research was concerned with the PL of this material. The doping with chromium or rear earth elements can enlarge its possible application as active media for tunable optical lasers [1, 2]. For the first time, the laser generation was observed in this material at high excitation levels for the case of two-photon pumping [3]. In some papers, the results were described related to the preparation of single crystals and characterization of a similar spinel compound $MgIn_2S_4$ [4, 5]. The reflection and Raman spectra and the edge absorption in the crystals of this material were described in [6].

Taking this into account, the aim of the present work was to synthesize $MgIn_2S_4$ and to study its PL spectra.

2. Experimental

$MgIn_2S_4$ was synthesized in a closed evacuated quartz container. The load with its mass of 4 g consisted of especially pure chemical elements taken in the stoichiometric proportion with addition of 2 mg/cm^3 of iodine. Iodine was used with the aim to reduce the reaction temperature and to avoid explosions in this way. The synthesis was performed in a program-control muffle furnace at 900°C for 2 h. Then the prepared substance was slowly cooled; the total growth cycle lasted for ~8 h.

The PL was measured at room temperature under the excitation by argon laser radiation (λ = 488 nm). The radiation from the sample was measured using a multi-channel OVA-284 analyzer. The spectral resolution of the system was 2 nm. The experimental method is described in detail in [7].

3. Results and discussion

The obtained ingot was dark red. According to the diffractograms registered using a DRON UM1, the substance corresponds to the stoichiometric composition, crystallizes with a spinel structure, a = 10.70 Å, and exhibits PL at excitation by argon laser radiation (λ = 488

nm). The PL spectrum is shown in Fig. 1. It is a wide bell-shaped curve with the maxima at 1.35 and 1.49 eV; its width at the 50% level comprises the region of 1.23–1.70 eV.

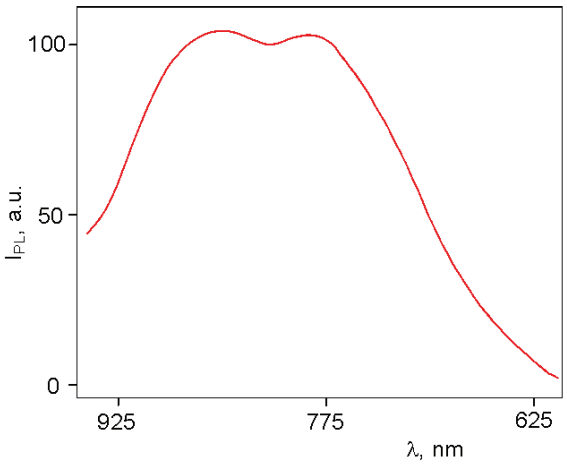

Fig. 1. PL spectra of $MgIn_2S_4$ at room temperature.

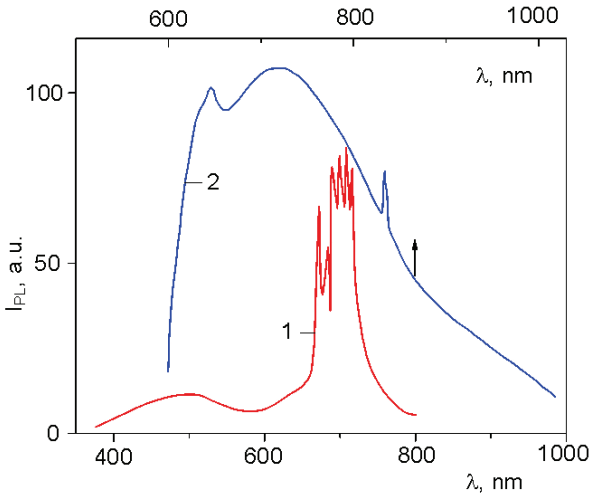

Fig. 2. PL spectra of $ZnGa_2O_4$ spinel according to the data of [6] (curve *1*) and [11] (curve *2*).

The high-energy limit of the PL spectrum occupies the region up to ~2.0 eV. This suggests that the process involves the capture of carriers on the localized centers within the forbidden gap before the emission owing to the radiative recombination. The presence of two peaks gives evidence that there are two types of such centers in the studied crystals. This can be expected, since the most similar compound $CdIn_2S_4$ possesses the same system of levels [8]. The recombination process and the model of the optical transitions in a similar compound $ZnIn_2S_4$ are described in [9]. As in many other wide-gap II-III_2-VI_4 compounds [9, 10], the radiative recombination in $MgIn_2S_4$ involves the electron traps exponentially distributed near the conduction band. The wide curve of the PL spectrum is also in agreement with this fact. According to the data of [5], the optical width of the forbidden gap in $MgIn_2S_4$ E_g = 2.21 eV; thus, the radiation transitions are of an intraband nature. The prepared compound can be doped with various impurities; this will vary the recombination properties of the material by analogy with $CdIn_2S_4$ [1, 2] and $ZnGa_2O_4$ [11].

Note that the method of growth also plays an important role. The PL spectra measured in this work for the synthesized material are similar to those of $MgIn_2S_4$ crystals [5], since the same elements and doping were used. The $ZnGa_2O_4$ spinel was prepared by a ceramic method in [11] and by a hydrothermal method using a suspension of Ga_2O_3 and $Zn(NO_3)_2 \cdot 6H_2O$ in [12]. The PL spectra in these cases are considerably different (Fig. 2). In the first case, a maximum appears at 480 nm, with its half-width of 0.67 eV, accompanied by a set of narrow peaks ($h\nu_{1/2}$ = 0.12–0.15 eV); in the second case, a wide curve appears located in the range of 1.5–2.2 eV (at the 50% level). Evidently, this will define different possible applications for these cases.

4. Conclusions

The ingot of $MgIn_2S_4$ with a spinel crystalline structure (a = 10.70 Å) was synthesized. This material can be used as a source for deposition of $MgIn_2S_4$ thin films. The peculiarities of PL were observed at 1.35 and 1.49 eV; their possible interpretation is suggested.

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