Vapor Phase Crystal Growth and Properties of Ag- and Cu-doped PbI_2 Crystals

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Thin-film light-sensitive PbI_2-Ag and PbI_2-Cu structures are promising detecting media [1]. Doping of lead iodide (Ag, Cu) improves its photosensitivity and enhances non-linear optical effects in it.

The purpose of this work is to examine the effect of silver and copper acceptor impurities on the vapor phase growth of lead iodide crystals in a closed system in the presence of excess iodine and on the properties of the crystals.

Under optimal conditions for the preparation of undoped lead iodide single crystals, we studied the effect of dopant concentration in the source material (0,001 to 30 at %) on the rate of PbI_2 transport and the dopant concentration in the single crystals. The present results demonstrate that, at dopant concentrations in the source material from 0,001 to 0,1 at.%, the mass transport rate is on the same order as in undoped crystals. The dopant concentration in the grown single crystals is proportional to that in the source material. The rate of mass transport decreases with increasing (0,5 to 30 at.%) dopant concentration in the source material. At dopant concentrations within 1 at. %, the mass transport rate is on the same order as in undoped PbI_2. Further increasing the dopant content in the range 1-5 at.% leads to a sharp drop in mass transport rate: from 3×10^{-5} to 2×10^{-5} mol/(m^2s). At high doping levels (10-30 at.%), the mass transport rate decreases more gradually: from $1,93\times10^{-5}$ to $1,72\times10^{-5}$ mol/(m^2s) in the case of copper and from $1,31\times10^{-5}$ to $0,88\times10^{-5}$ mol/(m^2s) in the case of silver. X-ray microanalysis results demonstrate that, at dopant concentrations in the source material from 0,1 to 0,5 at.%, the doping level of the single crystals is on the same order. At dopant concentrations in the source material from 1 to 30 at.%, the doping level of the single crystals is an order of magnitude lower. Increasing the dopant concentration in the system from 5 to 30 at.% reduces the number and dimensions og single crystals and leads to deposition of polycrystalline material.

Copper doping of PbI_2 in the range 0,001-0,01 at.% shifts the excitonic band in its low-temperature (5 K) photoluminescence spectrum to longer wavelengths, reduces its intensity, and increases its full width at half maximum. In addition, a band emerges around 600 nm, and its intensity increases with copper content. This band was assigned by Derenzo et al. [2] to a copper-related deep acceptor level.

1. Indutnyi I.Z., Kostyshin M.T., Kasyarum O.P. Fotostimulirov. vzaimodeistv. v struct. metal-poluprov. Kiev: Nauk. Dumka, 1992, 240 c.

2. Derenzo S.T., Bourret E., Yan Z. et al. Experimental and theoretical studies of donor-acceptor scintillation from PbI_2// J.Lumin.- 2013, V.134, p.28-34.