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Synthesis, Structure and Spectral-Fluorescent Properties of Organic-Inorganic Perovskite $CH_3NH_3PbI_3$ Films

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Organic-inorganic halide perovskites $APbX_3$ (A – CH_3NH_3, X – Cl, Br, I) attract now extensive scientific interest as a potent photoactive matrix for solar energy harvesting [1]. These compounds demonstrate high photovoltaic conversion efficiencies in laboratory conditions at relatively low costs of production and processing, having the only major drawback to overcome, viz. low durability.

Hitherto, there are no data in the literature about the effect of the $CH_3NH_3I : PbI_2$ ratio in the starting work solution on the structure and properties of organic-inorganic films of halide perovskites $CH_3NH_3PbI_3$. In this work, the microstructure, phase composition, and spectral-fluorescent properties of thin films of this organic-inorganic perovskite deposited on a glass substrate via spin-coating and heat-treated at 80 °C or 150 °C were studied at different reagent ratios in the initial solutions.

The shape and particle size of the films depend strongly on the reactants stoichiometric ratio. When the $CH_3NH_3I : PbI_2$ ratio is 1 : 1, the film consist of needle-like particles located along the substrate plane. For the ratio 2 : 1, the round-shaped particles were obtained. With the further increase of methyl ammonium iodide content (3 : 1), a smooth transition from round to polyhedral particles was observed. In all three cases, the $CH_3NH_3PbI_3$ particles are predominantly located in a single layer.

It is found that as the CH_3NH_3I content increases, the UV/Vis absorption spectra become more selective – the intensity increases in the region of 350-400 nm while the absorption in the visible spectrum range decreases. In the initial solution in DMF, the absorption range does not exceed 350 nm, with the most long-wavelength band at 327 nm indicating partial complexation of the mixture components in solution. Relative fluorescence intensity of the studied $CH_3NH_3PbI_3$ films increases with the higher content of CH_3NH_3I in the initial solution. This regularity is observed for films after heat treatment at both 80 °C and 150 °C, although in the latter case the fluorescence is abated substantially, probably because of partial destruction of perovskite [1].

[1]. Y. Zhao, K. Zhu. Organic–inorganic hybrid lead halide perovskites for optoelectronic and electronic applications // Chem. Soc. Rev. – 2016. – V. 45. – N. 3. – p. 655 – 689.