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Purification of HgI_2 Crystals from Physical Vapor Transport for Application as Radiation Detectors

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Abstract. The establishment of a technique for mercury iodide (HgI_2) purification and crystal growth is described, aiming this crystal future application as room temperature radiation semiconductor detectors. Repeated Physical Vapor Transport (PVT) technique was studied for purification and growth of the crystal. To evaluate the purification efficiency, measurements of the impurity concentration were made after each growth, analyzing the trace impurities. A significant decrease of the impurity concentration, resulting from the purification number, was observed. A significant improvement in the HgI_2 radiation detector performance was achieved for purer crystals, growing the crystal twice by the PVT technique.

Introduction

A great interest has been focusing on the development of a room temperature radiation detector, using semiconductor materials that have high atomic number and wide band gap. This type of detector has a large applicability as X ray and gamma ray spectrometer, operating at room temperature [1,2,3]. Layered semiconductor materials have a number of properties that make them attractive for such application. However, the role of crystal impurities on the detector performance is crucial, then improvements on the chemical purification and the impurity reduction analysis should be achieved [2,3].

HgI_2 is a layered semiconductor material with a wide band gap energy (Eg = 2,13 eV), high resistivity (($>10^{14}$ Ωcm), high density (7.5 g/cm^3) and high atomic number elements (Z_{Hg}=80 and Z_I=53): besides, it is suitable for use as X ray and gamma ray spectrometers at room temperature [1-3].However, problems still exist and to grow HgI_2 crystals with suitable purity to be used as a room temperature radiation detector is a technological challenge. The impurities, which act as a charge carrier trap, influence the charge carrier lifetime, affecting the detector efficiency [2-4]. There is agreement in the literature on the difficulty in growing crystals with high crystallographic perfection, high chemical purity and good stoichiometry, suitable to be used as room temperature semiconductor detectors [1,3-6].

In this work, the purification and growth of HgI_2 were carried out by the physical vapor transport (PVT) [3,4,6,7] methods. The efficiency of removing impurities was evaluated by inductively coupled plasma mass spectroscopy (ICP-MS) and scanning electron microscopy, with back-scattered electrons (SEM-BSE) techniques. The influence of purity on the crystals developed was studied, evaluating their performance as a radiation detector.

Experimental procedure

The commercially available HgI_2 powders (Alpha Aesar), with nominal purity of 99.9%, was used as the starting material for growing crystals. The crystals were grown by PVT technique.

The borosilicate glass ampoules were filled with 5 g of HgI_2 salt, evacuated at 90 ° C for 15 min and, subsequently, sealed. Hence, the salt is dehumidified, but also prevented to be re-hydrated. The ampoule filled with HgI_2 salt at the bottom is placed in the bath of silicone oil, wrapped in a metal