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Influence of solution concentration on the structural and electronic properties of PbI2 films

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Abstract – The N.N-dimethylformamide (DMF) organic solvent was used for dissolution of the PbI_2 with high efficiency on the grow material using the spray pyrolysis deposition method. The PbI_2 solution concentration was varied in the range of 10 g/l up to 50 g/l with consumption solution rate kept constant at 0.16 cm^3/min and deposition temperature at 225ºC during the deposition time of 2.5h. The thicknesses of the samples were calculated using cross-section SEM pictures. An average growth rate varying from 22 $Ås^{-1}$ up to 56 $Ås^{-1}$ was obtained. In this work we discuss also the structural and electronic properties of the obtained films.

Researchers in the whole world search alternative methods that minimize the time of deposition of thin films of promising semiconductor candidates for medical applications, such as X-rays detectors for digital radiography. The spray pyrolysis method was used as an alternative way for the fabrications polycrystalline PbI_2 thin films with potential applications in X-ray detector [1-3]. Some materials such as PbI_2, HgI_2, TlBr, CdTe, CdSe and CdZnTe are good photoconductors and can be used at room temperature. As a good candidate, PbI_2 presents a wide band gap (above 2.0 eV), what leads to low noise, low leakage current and large charge collection when the device is operated at room temperature.

A PbI_2 powder produced and commercially available by Aldrich Chem. (99.999%) was used without more purification steps. This material was dissolved in N.N-dimethylformamide (DMF) organic solvent at room temperature for solution preparation. The PbI_2 solution concentration was varied in the range of 10 g/l up to 50 g/l with consumption solution rate kept constant at 0.16 cm^3/min and deposition temperature at 225ºC during the deposition time of 2,5h.

The thicknesses of the samples were calculated using cross-section SEM pictures. An average growth rate varying from 22 $Ås^{-1}$ up to 56 $Ås^{-1}$ was obtained. The average growth rate increases linearly with the solution concentration used in each deposition. This result indicates that there is direct proportionality between the growth rate and the material amount on top of the substrates. Figure 1 presents the results of XRD experiments for different solution concentration. The results from XRD indicate that the film growths preferentially along the (001) direction. A X-ray diffraction shift (scattering angle 2θ) as a function solution concentration can be observed. Other less important peaks shows that the variation of the solution concentration leads to variation of the final structural properties (see figure 1 (b)). We used Scherrer's formula [4] to evaluate the size of the crystalline grains, and the obtained mean values from 33 nm up to 40 nm as a function of increase of solution concentration. Figure 2 shows the dark current as a function of the inverse temperature for two sample deposited at 10 g/l and 50 g/l. Both samples exhibit semiconductor behavior where the dark current of the films increased with increasing temperature and the plot of the function $\ln I_{dc} = f(1/T)$, indicates that there are two main transport mechanisms (see figure 2). For the sample deposited using solution concentration of 10 g/l, an activation energy (E_a) of about 1.12 eV was measured for temperatures above 50ºC approximately. Low values of solution concentration leads to better quality materials as will be discussed.

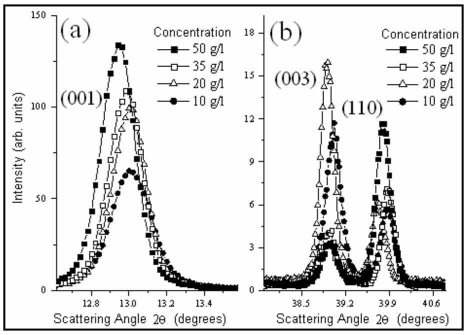

Figure 1: X-ray diffraction experiments of PbI2 thin films. The solution concentration was varied in the range of 10 g/l up to 50 g/l **a)** Main peak (001) **b)** (003) and (110) peaks.

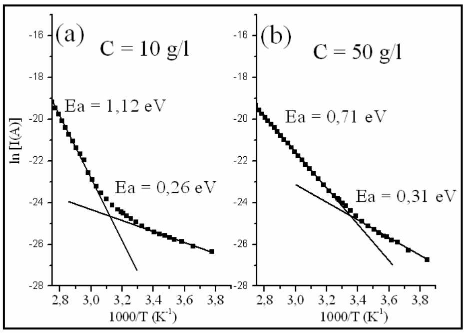

Figure 2: Dark current as a function of inverse of temperature **a**) Film deposited with solution concentration of 10g/l **b)** Film deposited with solution concentration of 50 g/l.

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