Synthesis of nanocrystalline PbS for promising solar cells using microwave-assisted chemical bath deposition

M. Hisham[1] and Z. Hassan[2]

1 Department of Physics education, Education Faculty, Ishik University

2 INOR, Universiti Sains Malaysia (USM), Malaysia

E-mail: mhjupm@gmail.com

Abstract

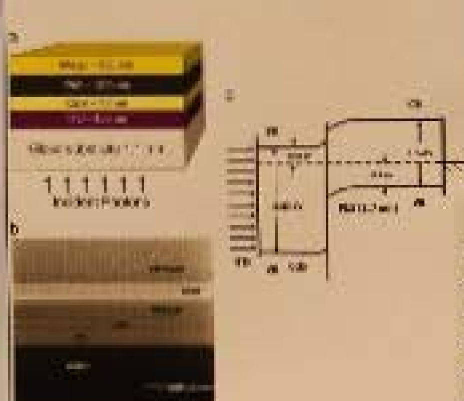
Lead sulifed (PbS) Nano cubes have been successfully deposited onto glass substrate via microwave assisted chemical bath deposition technique. Morphological, structural and optical analysis revealed that high quality nanocrystalline PbS were obtained using microwave-assisted chemical bath deposition technique. Optical studies indicated that the energy band gap has significantly increased for the prepared PbS thin films due to the confinement effect. A promising material for solar cell applications using low cost fabrication method in a relatively short deposition time was introduced.

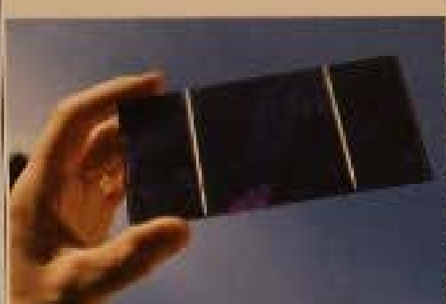
Objectives/ Motivations

The study aims to:

1. Synthesis of nanocrystalline PbS as a promising candidate for photovoltaic applications.
2. Produce high quality nanocrystalline PbS in a relatively short deposition time.
3. Optimize the use of microwave as a heating source for the preparation of Nano-based materials in a low cost approach.

Introduction

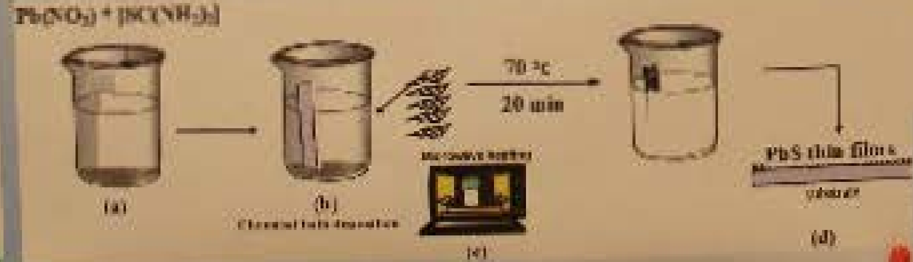




Narrow band gap semiconductors are of interest for photovoltaic (PV) solar energy conversion as they can absorb the "IR tail" of the solar spectrum, which is not absorbed by commonly used PV materials. The use of such absorbers in semiconductor sensitized solar cells allows the integration of low cost device configurations and broad spectral response, which may also be utilized in IR and near-IR (NIR) photodetectors. Chemical bath deposition (CBD) is a promising technique that produces homogeneous and high quality PbS thin films [1]. It is a simple and cost effective method. However, PbS thin films prepared using CBD require a long preparation time. Microwave (MW) irradiation has been widely applied as a heating method in chemistry and material syntheses. Using microwave as a heating source, the heat is created from inside the material unlike conventional methods whereas heat flows inward [2]. The direct interaction between the radiation and materials facilitate very short reaction times moreover, less energy is consumed.

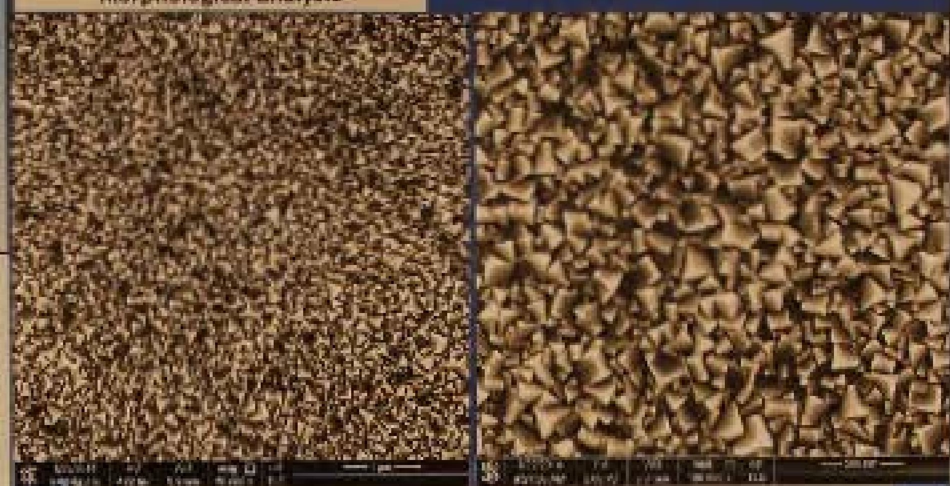
Methodology

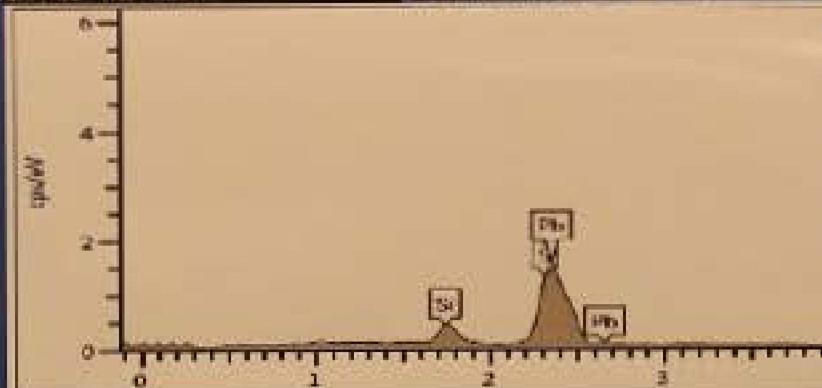
Nanocrystalline PbS were deposited onto microscopic glass slides substrates. Aqueous solutions of lead nitrate $Pb(NO_3)$ and thiorea $[SC(NH_2)_2]$ were used as sources of (Pb^{2+}) and sulfur (S^{2-}) ions, respectively. Ammonium acetate (NH_4CH_3COO) was added as a buffer solution to control the release of ions and to assure slow deposition rate [3]. pH of the final solution was fixed at 12 by adding 0.5 M sodium hydroxide (NaOH) solution. The cleaned substrates were immersed vertically inside 100 ml beakers; beakers were covered and heated in a microwave oven at 70 °C for 20 min. Mirror-like dark gray with highly adherent PbS thin films to the substrates were obtained. Morphological, structural and optical properties for the deposited thin films were studied using field emission scanning electron microscopy (FESEM) with energy dispersive X-ray spectroscopy (EDX) installed, high-resolution X-ray diffraction (HR-XRD), and UV-Vis-NIR spectrometer at wavelengths ranging from 300 to 2500 nm, respectively.



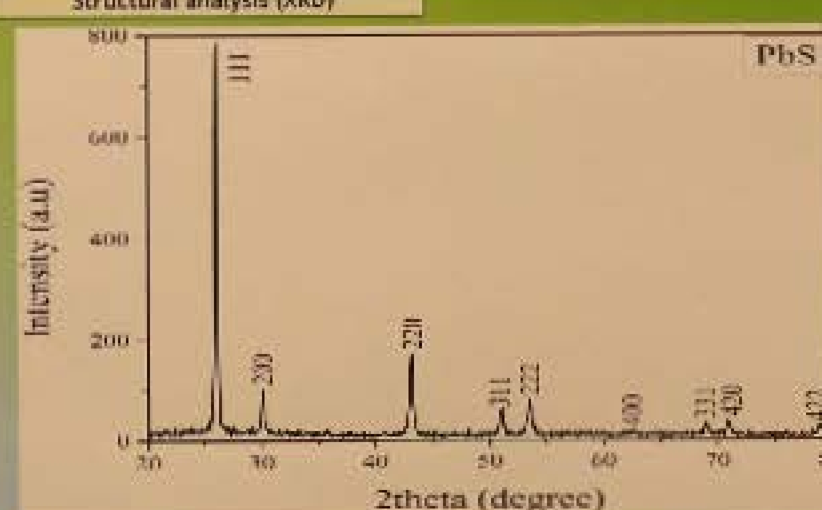
Results and Analysis

Morphological analysis

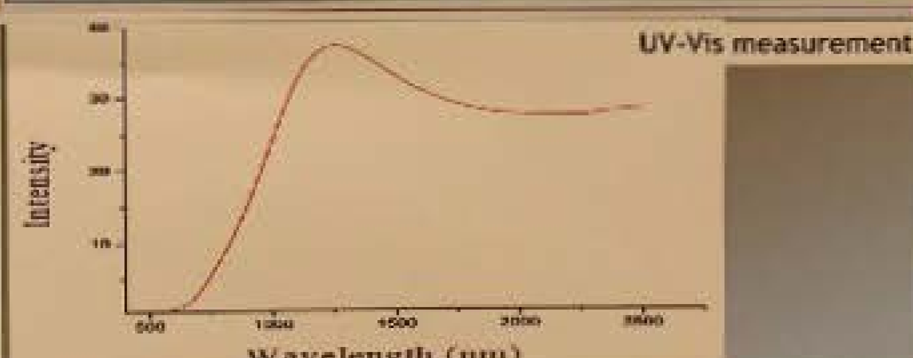




Structural analysis (XRD)



UV-Vis measurement



Conclusions

Nanocrystalline PbS thin films were successfully grown on glass substrates using MA-CBD. Structural and morphological analyses revealed that good quality PbS thin film characteristics were obtained using 0.1 M of lead nitrate and thiourea. Thin film surface morphology is uniform and compact throughout all the regions, no voids or cracks were observed. Besides, structural analysis revealed high diffraction peaks intensity indicating an improvement in thin film crystallinity. This study produced a simple and cost effective way to prepare polycrystalline PbS thin films which could be a remarkable candidate for optoelectronics applications.

References

[1] A. Cruz-Vázquez, [illegible] Fabrication and characterization of [illegible] PbS films, [illegible] 7 (2011) 89-91

[2] [illegible] Microwave-assisted synthesis of metal sulfides in [illegible], Materials Chemistry and Physics, 82 (2003) 206-209

[3] [illegible] Optimization of Chemical Bath Deposited Cadmium Sulfide Thin Films, J. Electrochem. Soc., Vol. 144, No. 7, July 1997