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Acoustic shock wave-induced phase transition of Indium Selenide from orthorhombic to rhombohedral crystal system

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Abstract

Indium selenide is a semiconducting material that has a layer-by-layer crystal structure. The present work treats Indium selenide with dynamic shock waves using a Semi-automatic Reddy tube as 100, 200, 300, and 400 shock pulses. In4Se3 switched from orthorhombic to rhombohedral (α- In2Se3) phase at 100 shock pulses and remained in the same phase up to 400 shock pulses by applying 2.0 MPa of pressure and a temperature of 864 K. The crystal structure was examined using Powder X-ray diffraction, and Raman analysis. The morphology and optical properties of the material are investigated using Scanning Electron Microscope, and UV-DRS. The results from XRD and Raman confirm the phase transition through the formation and disappearance of the peak. While increasing the shocks, the morphology produces a layered shape, and optical investigation revealed that the band gap of the material changed from semi-conducting to insulator.

Keywords: *Indium selenide, Dynamics shock wave, UV-DRS*

1. Introduction

Indium Selenide is a semiconducting material of the III-VI semiconductor family that has a layer-by-layer crystal structure. It belongs to the class of layered transition metal dichalcogenides (TMDs). Indium Selenide has a straight bandgap, which allows it to absorb and emit light efficiently. Its high mobility of charge carriers and high sensitivity to infrared radiation makes it suitable for use in detectors and sensors. Because of its layered crystal structure, it is a potential material for the development of 2D materials and nanotechnology.

Moreover, indium selenide exhibits various chemical compositions with different ratios of Indium (In) and Selenium (Se). Some common combinations of ratios are InSe, In2Se, In2Se3, In3Se2, In5Se6, In3Se4, In2Se3, In6Se7, In2.5Se4 [1-5]. Even indium selenide has undergone phase change at high pressure of several GPa. Schwarz et al reported that InSe-I undergoes a rock salt cubic phase (InSe-III) at 10 GPa and also with standard up to 30 GPa [6]. Also, Iwasaki et al reported that InSe-I undergoes a phase change to a monoclinic structure of low pressure 1-3 GPa at a high temperature of 500-700K [7]. Errandonea et al got a tetragonal phase InSe-IV from monoclinic InSe-II at the pressure of 19 GPa and, a temperature of 300K [8].

Segura et al reported that further when pressure is increased above 30 GPa i.e., 35-37 GPa at a temperature of 300K both InSe-III and InSe-IV can transform their phases as Cubic CsCl (InSe-V) [9]. Also, Bipanko Kumar Mondal et al achieved a phase change from β- In3Se2 to ɣ- In2Se3 and also showed an increase in band gap was observed when the annealing temperature was raised to 300°C along with mechanical stress [10].

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2. Experimental details

Indium selenide is purchased from Sigma-Aldrich with a purity of 99%. The powdered sample, weighing approximately 0.5gm, was packed in the sample packer. The packed sample was subjected to 100, 200, 300, and 400 shocks at regular intervals of time using a semi-automatic Reddy tube given in Fig. 1.

Semi-automatic Reddy tubes consist of three parts: the driver section, the driven section, and the diaphragm section. In the driver portion, compressed air pressure is raised. At a certain pressure, the diaphragm ruptures, causing shock waves in the driven section [11].

As a diaphragm, the current work utilizes non-carbon copy paper with an 80 GSM. Shock pulses are applied to samples in sample containers at Mach number 2.2, 2.0 MPa pressure, and 864K temperature.

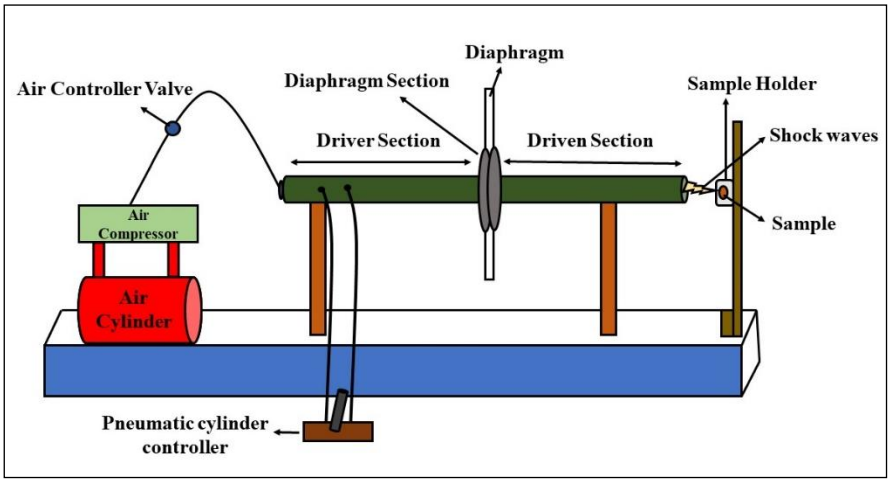

Fig 1. Schematic diagram of synthesis of Ce-$BaTiO_3$ NPs

3. Results and discussion

Detailed discussion will be elaborated during the session.

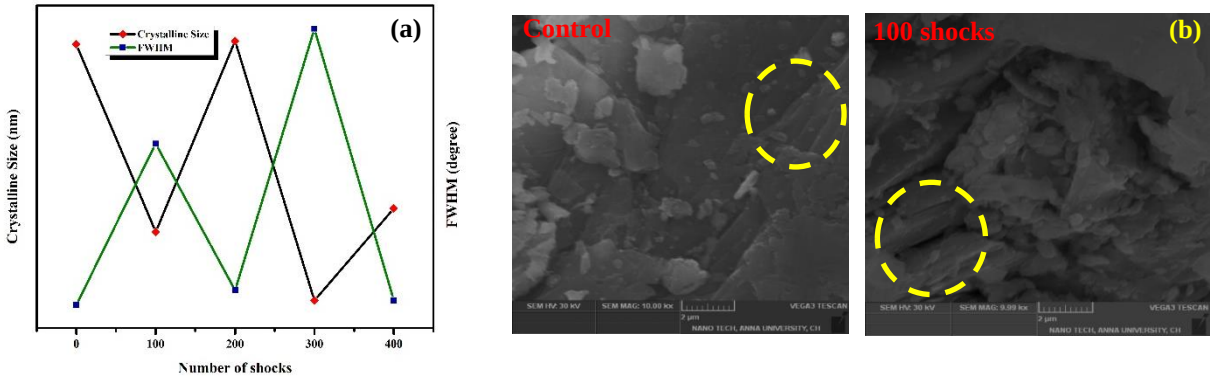

Fig 2. a) Number of shock pulses vs. crystalline Size b) SEM Images of control and 100 shock-loaded Indium Selenide.

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