Research Paper - Electronics

Investigations on Gel Grown Lead Iodide and Thin Films of Gel Grown Lead Iodide Single Crystals

- D. S. Bhavsar
P. G. Dept. of Physics, Pratap College

Abstract

Observations on Surface Microtopography of gel grown PbI_2 crystals and thin films of gel grown PbI_2 crystals are reported. Initiation of growth layers, interlacing pattern, dendritic growth, symmetry and asymmetry hexagonal arms and natural triangular etch pits were seen. The surface topography, of gel grown PbI_2 crystals and of thin films of gel grown PbI_2 have been related to the growth parameters. Crystals grown at constant temperature (30^0c) have been reported to be dendritic crystals. Growths patterns and etch pits formation on them are interpreted. It is established that the gel grown PbI_2 and thin films of gel grown PbI_2 grow by two-dimensional nucleation mechanism and by spreading and pilling of growth layers.

Keywords: Gel grown $PbI_{2;}$ thin films of $PbI_{2;}$ optical studies

1. Introduction

Lead Iodide is a member of IV-VII semiconducting compounds. It posses a wide fundamental band gap (2.55eV) and has been extensively used in photoconducting (DUGAN et. al., HENISCH et.al.), photodecomposition (DAWOOD et.al.), photoluminescence (SATOSHI et.al., LIFSHITZ et.al.) and many more. Recently, it has already been reported by BHAVSAR that, the growth of the PbI_2 single crystals by gel method takes place by screw dislocation.

In the present investigation, PbI_2 have been grown by gel method and the thin films of gel grown PbI_2 were deposited on the glass substrates by thermal evaporation technique. With the help of XRD and Surface Topography, it is established that the gel grown PbI_2 and thin films of gel grown PbI_2 grow by two-dimensional nucleation mechanism and by spreading and pilling of growth layers.

2. Experimental

PbI2 crystals were grown by gel method. The thin films of these grown crystals were prepared by thermal evaporation technique. These crystals were crushed in standard size (150 mesh), and then the evaporation is carried out in a conventional vacuum coating unit of 10^{-5} torr, at constant substrate temperature of 80^0C. The thickness was measured by quartz crystal monitor make by HindHivac DTM model number 101. Care must be taken to avoid the overheating the stock of the Lead Iodide during the sublimation. Otherwise thermal decomposition will give rise to non-stoichiometry in the films, apart from this no special precaution are necessary. The X-ray diffraction patterns were obtained for these films with a Philips X-ray diffractometer (Model PW-1730) using CuK (1.5418 Å) radiation with Ni filter. The angle range of scanning was $20\text{-}90^0$. Then, the Surface Topography of PbI_2 crystals and of thin films of gel grown PbI_2 crystals was studied by Optical Microscope (Carl-Zeiss Epignost 2HD model).

3. Observations and discussion

Fig. 1 and Fig. 2 represents XRD pattern of gel grown PbI_2 and the thin films of gel grown PbI_2 respectively. The gel grown PbI_2 crystals and vacuum evaporated thin films are polycrystalline having hexagonal structure irrespective of their substrate temperature and thickness. It is confirmed by comparing the peak positions (2θ) of the XRD pattern of the films with the standard X-ray powder diffraction data file (ASTM data card 7-235). The XRD pattern of these films was taken from 20 to 90^0 (2θ). The lattice parameters 'a' and 'c' of PbI_2 and the thin films of gel grown PbI_2 have been computed from the observed 'd' values by the method of successive refinement. Mean values of lattice parameters are given in Table 1.

Represents the triangular growth hillocks. It can be seen that, the growths of these triangular growth hillocks are layered growth. The attachments of tiny microcrystals having symmetry and asymmetry arms of the hexagonal structures are seen on the face of the $PbI_{2.}$ This is due to the fact that the growth of the crystals has been taken place by either two-dimensional nucleation or by mutual attachment of crystallites. The growth layers often bunch together to form thick layer as seen from Fig. 3. Fig. 4 illustrates that the growth layers radiating from the corner of the crystal to the center of the crystal forming triangular growth mechanisms. This growth of the layers seems to be zigzag. Such structures are seen only for those crystals, which are nearer to the interface of the gel, since at the early stages of the growth supersaturation is very high.

Interestingly, two-triangular spirals are seen starting from a single point (Fig. 5). Such structure is frequently observed. The black line in the Fig. 5 may be scratch produced in handling the crystal. Large no. of triangular spirals are seen on the same crystal, some of them are not completely developed. This is due to the fact that if crystals grows under a near-equilibrium conditions, their external forms defined by structural factors. Similarly, the micro-morphology of the growth spirals will reflect structural characteristics.

Although equilibrium conditions are not attained in real growth of the crystals, some crystals, especially those grown from low supersaturation conditions, grow under near equilibrium conditions. On such crystals, the morphology of growth spirals of monomolecular height reflects the structural characters. Similarly as macro-morphology follows the symmetry element of the crystal, micro-morphology follows the symmetrical elements of the face.

Fig. 6 shows interlacing pattern on the surface of the gel grown PbI_2 crystal. This pattern have observed on a vide variety of the crystals mostly on those having layer structures. From the morphology analysis of interlacing we may deduce the way the stacking formed in the structure. This is especially useful for the study of polyptism of mica or clay minerals. FRANK and BHAVSAR have reported similar interlacing pattern for Kaolinite and Lead Iodide single crystals respectively.

Fig. 7 and Fig. 8 illustrates the dendritic growth of the Lead Iodide crystals. Similar observations were reported by BHAVSAR. In the present investigations, interestingly, on the same crystal, a hexagonal spiral, dendritic growth and attachments of microcrystals are seen (Fig. 8). In Fig. 7, a dendritic hexagonal structure within the hexagon is seen. Such structures are frequently observed. Fig. 9 represents the complete growth of the hexagonal structure having symmetric arms of the hexagon. This crystal might have sufficient time to acquire its present form.

Fig. 10 depicts the natural triangular etch pits on the thin film of gel grown Lead Iodide crystals. Several investigations have observed natural etch pits on mineral crystals, and also on habit faces of laboratory grown crystals. In this case the pits are tiny and triangular oriented in a particular direction and are parallel to the growth hillocks. The pits may be considered unit pits, since their corners are sharp, their sides are straight and their size is small. Similar results were reported by PATIL for CdS crystals. Similar natural etch pits are seen on the face of the thin films of the Lead Iodide crystals (Fig. 11 and Fig. 12). But these etch pits are neither well resolved nor oriented in a particular direction. The void is seen on the deposited thin films. Also grain boundaries are seen on the surface of the thin film.

As the thickness of the thin films increased by deposition, it has been observed that the thin film deposition on the substrate try to crystallize on the substrate. So instead of observing voids and different irregular structure steps towards the crystallization i.e. grain of different size has been observed on the thin film of above 2000 Å. Fig. 13 represents a portion of thin films which is a collection of several grains with different shapes and size. Interestingly, one of the grains at the center seems to be hexagon

Sample	Thickness In Å	Lattice parameters (in Å) 'a'	'c'	c/a	V
ASTM Data	-------	4.557	6.9890	1.5335	125.69
PbI_2 crystal	-------	4.557	7.0262	1.5418	126.36
thin films of PbI_2	1000 Å	4.557	7.0030	1.5307	126.94

Acknowledgement

The authors are grateful to Dr.H.O.Deore, Principal, Pratap College, Amalner for providing laboratory facilities. D.S.Bhavsar sincerely thanks to beloved daughter Dip for her help in computer work.

References

- ASTM data for Lead Iodide (7-235)
- Bhavsar D.S., Saraf K.B., Cry.Res.Tech. 37 (1) (2002) 51-55.
- Bhavsar D.S., Saraf K.B., Tanay Seth, Cry.Res.Tech. 37 (2) (2002) 219-224.
- Dawood R.I. and Forty A.J. Phil. Mag. 1 (1962) 1633.
- Dawood R.I., Forty A.J. and Tubbs M.R. Pro.Roy.Soc. A 284 (1965) 272.
- Dugan A.E. and Henisch H.K. Phys. Rev. 171 (1968) 1047.
- Frank F.C. Phil. Mag. 42 (1951) 1014
- Henisch H.K. and Srinivasagopalan C. Solid State Commun. 4 (1966) 915.
- Lifshitz E., Yassen M., L.Bykov and I.Dag J phys. Chem. 98 (1994) 1459.
- Patil L.A., Wani P.A., Saraf K.B., M.S.Wagh Cryst. Resea. Tech. 33 (2) (1998) 233-240
- Satoshi Yamazaki and Takanavi Goto J. Physical Society of Japan Vol. 5110 (1982) 3228.