Chapter 7

Summary and Conclusions

This thesis work has established the procedure of thin film production in a high vacuum environment by thermal evaporation technique. In present thesis work, the performance studies of CsI photocathode is carried with VUV monochromator. Photoemission measurement is performed in the VUV wavelength region. Al substrate is found to be the best UV reflective material for CsI deposition. Reflective (thicker) CsI film is found to have higher QE values than the semitransparent (thinner) one. Maximum QE achieved for reflective CsI photocathode is $\sim 40\%$ at a wavelength $\lambda = 150$ nm. QE data achieved at our lab is comparable with other experimental group in lower UV wavelength regions.

The optical properties measurement has been performed in the spectral range 190 nm to 900 nm. The transmittance result of CsI films for thicknesses more than 100 nm, depicts that they are opaque in the spectral region 190 nm to 225 nm and having transmittance of $\sim 2-3\%$. CsI films of thickness below 50 nm, found to be semitransparent in the spectral region 190 nm to 225 nm, where transmittance varies from 20% to 40%. Thinner and thicker CsI films are found to be transparent in the spectral region 225 nm to 900 nm, having more than 80% transmittance.

Appearance of interference fringes pattern for 500 nm thick CsI film in transparent spectral region indicates, existence of continuous and homogeneous grain like morphology with maximum surface area coverage. The optical band gap energy has been calculated from absorbance data and is found to be $\sim 5.4$ eV. The values of refractive index calculated from envelop plot of transmittance data varies from 1.93 to 1.46.
in the spectral range of 275 nm to 900 nm. This variation of refractive index indicates, dispersive behavior of CsI film.

Surface morphology and crystallographic nature of CsI are studied by TEM, AFM and XRD techniques. TEM and AFM results reveal that the CsI film have homogeneous and continuous grain like morphology, with more than 95% surface area coverage by CsI grains. Average grain size (composed of many coherent domains) of CsI film, obtained from TEM and AFM micro structure is comparable and found to be about \( \sim 300 \) nm. Average roughness of CsI film estimated from AFM micrograph is \( \sim 39 \) nm. The diffraction pattern as obtained from the XRD and TEM measurement reveals that CsI thin film is purely crystalline in nature and is having body centered cubic (bcc) structure. The value of lattice constant obtained is about \( a = 4.66 \) Å. The coherent scattering domain size (crystallite size) calculated using Scherrer’s method is found to be \( \sim 55 \) nm.

A modified W-H method (such as UDM, UDSM and UDEDM models) is used to estimate the crystallite size, and strain induced broadening due to the lattice deformation. Further, the origin of internal stress in a thin film comes from lattice defects such as dislocations, due to lattice misfit with it’s substrate and due to differential thermal expansion between the film and it’s substrate etc. In the present work, small values of stress suggest less density of lattice defects in our prepared CsI thin films. TEM and XRD results suggests that for very small grain size regime there is a good correlation between TEM and XRD but in larger grain size regime TEM counting provides a larger average grain size than crystallite size from XRD. It suggest that as we increase the thickness, the coherent domains start merging and make a bigger grain. Also by increasing the thickness from 100 nm to 500 nm, although the grain size increases, but the coherent scattering domains start decreasing.

Exposure to humid air upto several hours in the atmospheric air (relative humidity \( \sim 65% \) at room temperature) leads to decrease in quality. The decrease of QE is
correlated with an increase in grain size. No change in crystalline properties of CsI photocathode is observed, even after long time exposure to humid air. EDAX spectrum of both, “as-deposited” and “humid air exposed” CsI photocathode exhibits that the cesium(Cs) and iodine(I) are present in an atomic ratio of $\sim 51:49$ (thus the Cs:I ratio is found to be $\sim 1:1$), which is consistent with the stoichiometry of CsI. Elemental composition results show that CsI film stoichiometry remains unchanged even after long term exposure to humid air.

Angle-resolved X-ray photoelectron spectroscopy is used in this study to characterize accurately “as-deposited” and “UV-irradiated” CsI layers. Surface analysis by means of XPS and SEM have shown higher concentration of carbon in the “UV-irradiated” CsI photocathodes ($30\mu C/mm^2$) however the elemental composition of Cs/I ratio remains the same (1:1) in both cases (“as-deposited” and “UV-irradiated” CsI) which may indicate that the degradation of the CsI photocathode is due to the gradual destruction of the ideal polycrystalline structure through the creation of lattice defects. Due to the build up of the lattice defects, a CsI thin film is degraded layer by layer resulting in a reduction of electron transport properties and so the degradation of photocurrent or absolute Q.E. 20% loss in photocurrent is observed after $5\mu C/mm^2$ for 600 nm thick CsI photocathode. XRD pattern of “UV-irradiated” CsI confirmed the presence of (poly)crystalline structure even after 90% loss of photocurrent during the entire ageing measurement.
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List of Publications

In referred Journals:

1. VUV-induced radiation ageing processes in CsI photocathodes studied by microscopy and spectroscopy techniques

2. Influence of humidity on the photoemission properties and surface morphology of cesium iodide photocathode
   Triloki, B. Dutta, B.K.Singh

3. Structural characterization of “as-deposited” cesium iodide films studied by X-ray diffraction and transmission electron microscopy techniques
   Triloki, P.Garg, R.Rai, B.K.Singh

4. Optical and structural properties of CsI thin film photocathode
   Triloki, R.Rai, B.K.Singh

5. Photoemission and optical constant measurements of Cesium Iodide thin film photocathode
   Triloki, R. Rai, Nikita Gupta, Nabeel F. A. Jammal, B.K.Singh
6. Effect of humid air exposure on photoemissive and structural properties of KBr thin film photocathode
R. Rai, Triloki, N. Ghosh, B.K. Singh


In Conference Proceedings:

1. Photoemission properties of CsI photocathode: new results
Triloki, P. Garg, A. Prakash, V. Singh, C. P. Singh, B. K. Singh

2. CsI Photocathode: New results on photon ageing
Triloki, B. K. Singh

3. Absorbance and Transmittance measurement of CsI thin films
Triloki, Richa Rai, B. K. Singh

4. Influence of humidity on KBr photocathode
R. Rai, Triloki, B. K. Singh