# Absorbance and Transmittance measurement of CsI thin films

Triloki,* Richa Rai, and B.K. Singh

*High Energy Physics Laboratory, Banaras Hindu University, Varanasi - 221005, INDIA*

## Introduction

Various photocathodes are currently used to improve the sensitivity of photon counting or imaging detectors. The choice of photocathode material is determined by the spectral range where the device sensitivity is crucial. Alkali halides have been shown to be very efficient photoconverters in the ultraviolet (UV) wavelength range. CsI is known to be one of the most efficient among them, and therefore it is widely used in many detecting devices. It is also relatively stable under short exposure to atmosphere, which substantially simplifies production and handling of detectors. The optical characterization of CsI films in UV and visible spectral range is necessary for optimization of the quantum efficiency.

In present work we have studied the influence of thicknesses on absorbance and transmittance of CsI film in the UV/Vis spectral range. In current work we also estimated optical energy band gap of CsI thin films.

## Experimental details

CsI thin films were deposited under high vacuum of the order of $4 \times 10^{-7}$ Torr on quartz (Qz) substrate. Prior to CsI deposition residual atmosphere of the chamber was monitored through a residual gas analyzer (SRS RGA 300). The CsI thin films were deposited at a typical rate of 1 nm to 2 nm per second by evaporation of a high purity (5N from Alfa Aesar) CsI crystal from a tantalum (Ta) boat. The thickness of the film was controlled by a quartz crystal thickness monitor (sycon STM 100 thickness/rate monitor). After the film preparation, vacuum chamber was purged with nitrogen gas, in order to avoid the effect of humidity on the prepared sample. Immediately after the chamber opening under constant flow of nitrogen gas, CsI thin films were placed into a vacuum desiccator and moved to characterization setup. UV/Vis measurement of CsI films was carried out on Perkin Elmer $\lambda$ 25 UV/Vis spectrometer system, in the wavelength range 190 nm to 900 nm at physics department,BHU.

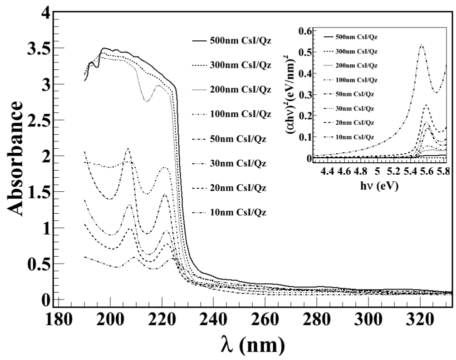


FIG. 1: Absorbance and Tauc plot (inset) of CsI thin films deposited on Qz substrate.

## Absorbance of CsI thin films

UV/Vis absorption of CsI films, deposited on quartz substrate were performed in spectral range 190 nm to 900 nm as shown in FIG. 1. It is observed that the absorbance of CsI films varies in between 0 to 2 for the thicknesses 10 nm to 100 nm, while for thicknesses more than 200 nm absorbance varies in between 0 to 3.5. Two strong absorption peaks was observed in the UV-region at a wavelength smaller than 225 nm, which are in general agreement with those reported previously in the literature[1]

Absorption in the UV region is attributed

*Electronic address: `triloki.bhu@gmail.com`

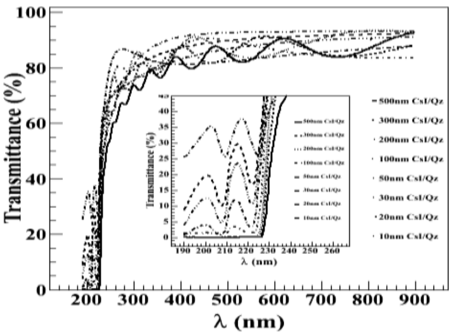


FIG. 2: Transmittance of CsI thin films deposited on quartz substrate.

to band gap absorption of CsI thin film. The absorption band gap ($E_g$) has been calculated by using the Tauc relation [3].

$$(\alpha h\nu)^n = A(h\nu - E_g) \tag{1}$$

where A is proportionality constant, h is the Planck's constant, $\nu$ is the frequency of vibration, $h\nu$ is the photon energy, $\alpha$ is the absorption coefficient and n is either 2 for direct band transitions or 1/2 for indirect band transitions. The absorption coefficient ($\alpha$) has been calculated using the relation $\alpha = 2.303(A/t)$, where t is thickness of the film and A is optical absorbance of film.

The direct band gap energy $E_g$ estimated from a Tauc plot of $(\alpha h\nu)^2$ versus photon energy $h\nu$ (shown in inset of FIG. 1). The value of photon energy ($h\nu$) extrapolated to $\alpha = 0$ gives an absorption edge which corresponds to a band gap $E_g$. The extrapolation gives band gap energy $E_g$ lies in between 5.4 eV to 5.5 eV for the thicknesses 20 nm to 500 nm while for 10 nm CsI film extrapolation gives band gap energy $E_g$ is about 5.3 eV, for first intense absorption peak of CsI film . The band gap energy is found to increase with increase in thickness of the films. The band gap determined from Tauc relation are in close agreement with those reported in article [2].

## Transmittance of CsI thin films

Optical transmittance of CsI films were derived from absorbance, using the relation $T = exp(-A)$, are shown in FIG. 2. Several transmittance peaks are observed in the wavelength region 190 nm to 900 nm, as already shown in reference [4]. CsI films, of thicknesses more than 100 nm, were found to be opaque in the spectral region 190 nm to 225 nm, having transmittance is about 2-3% (see inset of FIG.3), while for thicknesses less than 50 nm, found to be semitransparant in the spectral region 190 nm to 225 nm, where transmittance varies from 10% to 40%. A sharp increase in transmittance was observed at wavelength $\lambda = 225 \pm 2$ nm and CsI films was found to transparent in the spectral region 225 nm to 900 nm, having more than 80% transmittance.

## Conclusions

Photon absorbance by thermally evaporated CsI films on Qz substrate were performed in the spectral region 190 nm to 900 nm, which varies in between 0 to 3.5. Two strong absorption peaks was observed at a wavelength smaller than 225 nm. Optical energy band gap for CsI films are determined from absorbance data using the Tauc plot, are found to in between 5.4 eV to 5.5 eV, which increases with thickness of films.

Optical transmittance derived from absorbance of CsI film in the spectral range 190 nm to 900 nm shows CsI films are opaque in the spectral range 190 to 225 nm, having transmittance is about 2-3% for film thicknesses more than 100 nm, while CsI film of thicknesses lesser than 50 nm are found to be semitransparant in the spectral range 190 to 225 nm, where transmittance lies in between 5-40%. In the spectral range 225 nm to 900 nm films were found to be transparant, and having more than 80% transmittance.

## References

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