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Ageing results of *N,N′*-Bis (3-methylphenyl) -*N,N′*-diphenylbenzidine (TPD) and 8-Hydroxyquinoline (Alq_3).

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Abstract: Ageing results of *N,N′*-Bis(3-methylphenyl)-*N,N′*-diphenylbenzidine (TPD) and 8-Hydroxyquinoline (Alq_3) are presented in this work. Photocathodes were investigated under accumulated photon and ion bombardment. QE of degraded photocathodes were compared with QE results of freshly prepared photocathodes. Negligible change in QE of photocathodes was observed as compared to the results of CSI photocathodes under similar experimental conditions.

Keywords: Ageing, Photocathodes, Quantum Efficiency, Photon Impact, Ion Bombardment

I. INTRODUCTION

The Photosensitive Gaseous Detectors (PGDs) with high quantum efficiencies and low energy thresholds have been developed since years (Séguinot, and Ypsilantis, 1977) (Bogomolov, *et al.,* 1978). Early designs of Photosensitive Gaseous Detectors were wire chambers filled with vapours sensitive to ultra violet (UV) photons like triethylamine (TEA), tetrakis–dimethylamino–ethylene (TMAE) (Séguinot, and Ypsilantis, 1994). Later thins – films of solid photosensitive materials replaced these photosensitive vapourssuch as CsI photocathode (Iacovellag, 1995). (Breskin, 2002). (Chechik, *et al.,* 2005). (Gallas, 2005). (Bondar, 2007). These devices having solid photocathodes are fast with good position resolution and have single–photon imaging capability. The photon detection efficiency of these devices depends on three factors: the photocathode quantum efficiency (QE), the electron back–scattering from the gas into the photocathode (Breskin, 2003). and the efficiency of detecting single electron with the detector (Breskin, 1999).

Stable operation for long run of these solid photocathode coupled devices depends upon the photocathode itself, which degrades either by chemical reaction with gas impurities (Charpak, 1989). or by accumulated impact of photons and avalanche–oriented ions bombardment on photocathode surface (Breskin, 1977).. Most practical photocathodes such as Cesium iodide (CsI), Cesium Bromide (CsBr) (Singh, 2000). and Chemical Vepour Deposited (CVD) diamond films (Breskin, 1997). are relatively chemically stable. CsI can withstand against short exposure to air which allows convenience while assembling the detector. But, CsI photocathode degrades in terms of quantum efficiency for very high rate environments (Va'vra, 1997). (Krizan, 1997) (Braem, 2003). (Francke, and Peskov, 2003). (Breskin, *et al.,* 1995). (Mughal, 1991).

Under such limitations, search of new photocathode materials that can be used as solid photocathodes seems to be a choice for their utilization in practical applications for UV and visible photon detection. Quantum efficiency results of TPD and Alq_3 (Iftekhar, 1977) allowed to further investigate these materials for their ageing studies. In this work ageing of TPD and Alq_3 photocathodes due to photon impact and ion bombardment are presented and are compared with the ageing results of CsI photocathodes performed under similar experimental conditions.

2. EXPERIMENTAL SETUP

Experimental setup for measurement of QE is same as in (Laghari, *et al.,* 2014).. Photon induced ageing studies is performed by exposing the photocathode prepared outside the test chamber and transported into it for exposure to UV sample beam for few days (time = T) and operated under vacuum in such a way that this continuous exposure to photon beam of "n" photons per second may impinge on the 1mm × 10mm area of photocathode producing the photon flux of "N" photons/sec.mm^2 and extract charge from the photocathode equivalent to 3μC/mm^2.

The QE of the aged photocathode was then measured for determination of any change in QE as compared to the QE of freshly evaporated photocathode (at time T=0). Percent degradation in the QE values of aged photocathode due to photon impact was compared with the results of equally thick CsI photocathode studied under similar conditions (Anderson, 1992).

Ion induced ageing of the sample photocathode was performed by operating the test chamber filled with pure Methane at 10 Torr of pressure. The test chamber was operated in avalanche mode at a gain of $10^3$for some time (T) so that the photocathode may receive accumulated ion bombardment of ions equivalent to 26 µC/mm charge. Later the aged photocathode was investigated for QE and the results are compared with QE of freshly evaporated photocathode for any change in efficiency. Percent degradation in the QE of aged photocathode due to ion bombardment was compared with the results of equally thick CsI photocathode studied under similar conditions.

3. RESULTS AND DISCUSSION

Ageing of sample TPD photocathode due to accumulated impact of intense photon flux was carried out very carefully by exposing a freshly prepared TPD photocathode to the photon flux of 3.39×10^9 photons/sec.mm^2 for a period of 8.5 days so that 3µC/mm^2 charge may be extracted from the sample.

Another sample of freshly evaporated TPD was exposed to intense ion bombardment of 26µC/mm^2 charge for ion ageing studies. The QE of both aged photocathodes are studied and compared with freshly evaporated photocathode. Results of both the samples are presented in **(Fig. 1 and 2).**

Results show some decrease in QE of aged photocathode by 5% due to impact of photon flux over the spectral range from 190 to 220 nm as compared to the QE of freshly evaporated photocathode. This decrease in QE due to photon induced ageing seems negligible as compared to equally thick CsI photocathode degraded under similar investigation conditions i.e. 15 – 30%.

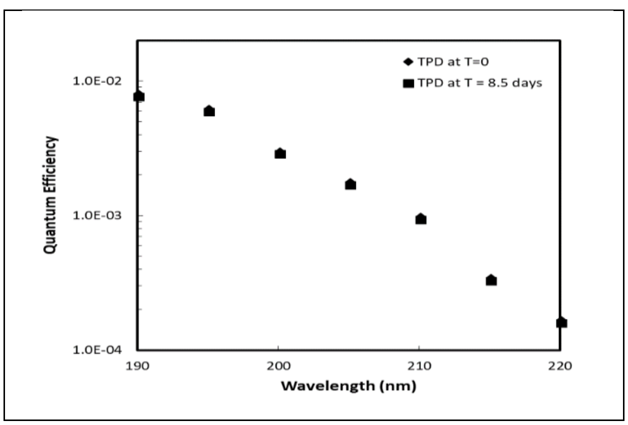

Fig. 1. QE of aged TPD after extracting 3µC/mm^2 charge after exposure of 3.4×10^9 photons/mm^2 photon flux for 8.5 days.

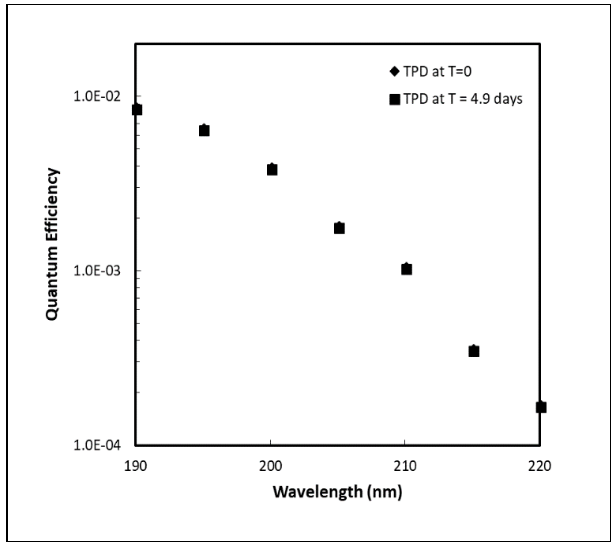

Fig. 2. QE of aged TPD photocathode after 26µC/mm^2 ion bombardment.

Impact of ion bombardment on the QE of aged TPD photocathode is observed as 2.5% decrease in it as compared to freshly prepared TPD sample photocathode over the spectral range from 190 to 220 nm. This decrease in QE of aged photocathode due to ion bombardment is negligible as compared to equally thick CsI photocathode i.e. 15%, investigated under similar conditions. Results revealed that the TPD photocathode possesses good ageing properties as compared to CsI.

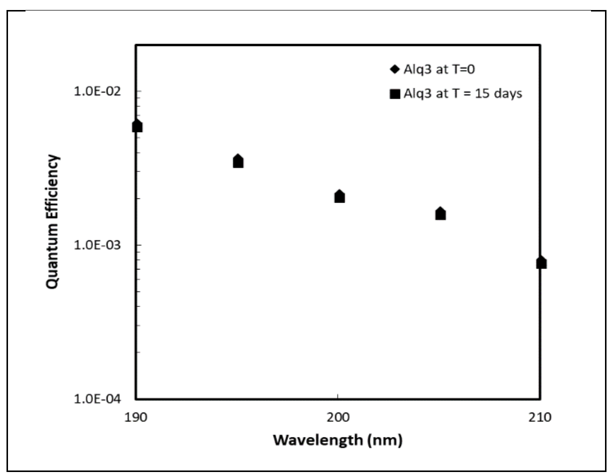

Fig. 3. QE of aged Alq_3 after extracting 3µC/mm^2 charge after exposure of 3.4×10^9 photons/mm^2 photon flux for 15 days.

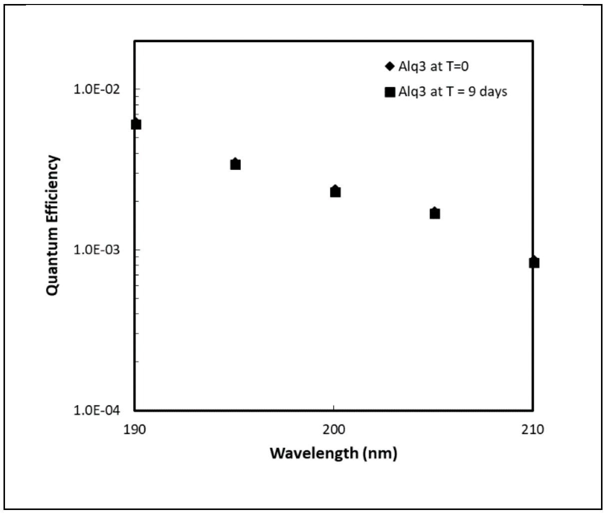

Fig. 4. QE of aged Alq_3 photocathode after 26µC/mm² ion bombardment.

Similarly, in order to study the UV photons impact on an Alq_3as evaporated photocathode sample, the sample was exposed to monochromatic photons of flux 3.39×10^9 photons/sec.mm² during 15 days. A 6% photocurrent loss was observed after an accumulated charge density 3µC/mm². Results of ageing due to impact of photon flux are presented in **(Fig. 3).** This loss in photocurrent due to photon flux impact is lower than approximately equally thick CsI photocathode i.e. 15–30% degradation and studied under similar conditions

Also, another as evaporated sample of Alq_3 photocathode was exposed to intense ion bombardment of 26µC/mm², a 4% loss in photocurrent was observed. This loss of photocurrent, of as evaporated Alq_3 sample is un-noticeable when compared with equally thick CsI photocathode i.e. 15%, when investigated under similar conditions. Results of ageing due to ion exposure are presented in **(Fig. 4).**

4. CONCUSION

In this effort we have presented QE results of freshly evaporated TPD and Alq_3 photocathodes. Also ageing results of these photocathodes due to accumulated impact of photons and ion bombardment are presented in this work. Results show the reduction in QE of aged photocathodes of TPD and Alq_3due to intense photon flux of 3µC/mm² on both the photocathodes by 5% for TPD and 6% for Alq_3 photocathodes over the spectral range from 190 to 220 nm for TPD and 190 to 210 nm for Alq_3. Ion ageing results show the reduction in QE of aged photocathodes of TPD and Alq_3 due to intense ion bombardment of 26µC/mm²on both the photocathodes by 2.5% for TPD and 4% for Alq_3 photocathodes over the spectral range from 190 to 220nm for TPD and 190 to 210nm for Alq_3.

Ageing properties of TPD and Alq_3 are found to be better than CsI photocathode. However, ageing properties need to investigated for understanding, preferably the surface and structure studies of aged photocathode material.

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