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A SIMPLE PRODUCTION TECHNIQUE FOR MAKING AIR STABLE CsI + DMFc PHOTOCATHODE

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Abstract

We describe the development of a simple, non-vacuum deposition technique for making air stable CsI + DMFc photocathods. Such photocathodes could be used in demountabvle gaseous detectors for the detection of photons in the wave length region between 105 and 300nm.

Key Words: Photocathode, CsI, DMFc, Gaseous Detectors.

Introduction

The recent observation of high quantum efficiency of CsI photocathode in gaseous detectors has stirred a wide interest because of its possible impact on many applications foreseen for the light sensitive gaseous detectors (1). Fast position sensitive gaseous detectors with Csl (2) and other solid photocathodes (3,4), sensitive in the spectral region around 230 nm may find applications in cherenkov ring imaging (5), readout of vuv scintillators (6-8) and positron emission tomography(9). The development in photocathodes has been made by Seguinot et al. (10), who found that an adsorbed layer of TMAE on the CsI photocathode increases its quantum efficiency, as it does for metal surface. They also demonstrated that the adsorbed TMAE effect did not diminish when the TMAE vapour was removed from the system nor when the photocathode was flushed for three weeks with clean methane. However, an expensive vacuum deposition system is required for making CsI photocathodes. The disadvantage of TMAE is that it is very reactive to oxygen. Further more, this compound is corrosive for many materials. By contrast, decamethylferrocene (DMFc) is not air sensitive or corrosive, it is easy to prepare as a solid photocathode and has a low work function of 4.7eV. In this work we present a simple, non vacuum deposition technique for making CsI photocathodes. Results on the enhancement in quantum efficiency due to an adsorbed layer of DMFc are also presented.

Design and calibration

A small vacuum photodiode was constructed (fig.1) to facilitate the quick change-over of different photocathode samples. Leakage currents were minimised by using guard rings on electrical connections and selecting high resistivity materials for insulators. The chamber plateau extends from about 10 to 35 V (Fig.2). The photocurrent resulting form the incident light was measured with a keithley 514 Electometer.

We have adopted a PTE Unicam SP800 spectrophotometer to act as a calibrated source of light in the wavelength region 190-280nm. The wavelength calibration was performed using the peaks associated with a holmium glass transmission spectrum. Eight standard peaks in the wavelength interval 190-250 nm were matched against a sample spectrum provided by the manufacturer.

These were found to be within the recommended tolerances of ±2%. The ultraviolet beam intensity was monitored in real time by a photodiode (Hammatsu S 1723-05) connected to akeithley 612 Electrometer. To ensure that the beam flux was the same in both incident and referemnce beams, two photodiodes were used to monitor both beams simultaneously and interchanged to eliminate differences in their quantum efficiencies. The photon flux was calculated from the manufacturer's quoted spectral sensitivity curve for the diode and was checked by comparing photoemission curves obtained with freshly prepared copper and gold surfaces with previously published work (11,12).

Photocathode Preparation

Photocathodes were prepared from CsI powder obtained from Aldrich chemical company, Inc. and had a claimed purity of 99.99%. A 10% solution (by weight) of CsI was made in distilled water. This solution was then diluted to about four times its volume by the addition of ethanol. To rapidly evaporate the solvent during deposition, a freshly prepared Cu substarate was heated from behind with hot air or from the front with heat lamps. The CsI solution was then sprayed on with air brush until the desired thickness was achieved. To estimate the thickness, a thickness monitor was placed next to the substarate. The sample was loaded into the test chamber which was then transferred to the SP 800 spectrophotometer. The chamber was evacuated to a pressure of 10^{-4} Torr and the sample tested over the wavelength interval 190-280 nm.

Two separate methods of depositing DMFc layer on Csl were employed. The first samples were produced by dissolving DMFc in diethl ether (DEE) and applying the resulting solution to freshly prepared Csl surface. The DEE component of the solution evaporated rapidly, leaving a yellow coating of DMFc on the Csl. The sample was loaded into the test chamber and tested. In a second series of experiments, a DMFc film was sublimated in air by Joule heating DMFc cystals placed in a large area molybdenum boat. When the boat attained a temperature of 140°C, the Csl substrate was placed a few millimetres above the crystals and exposed for a set period. The sample was then loaded into the test chamber and tested as described above.

Results

The quantum efficiency as a function of wavelength for Csl photocathodes of different thickness is shown in fig. 3. The optimum results were obtained with thickness of 600 nm films. Therefore, the DMFc films were deposited on 600nm thick Csl photocathodes. Fig.4 shows the QE of DMFc deposition from a solution in diethylether on Csl and direct sublimation of DMFc on Csl surface. The enhancement in QE of CsI due to ublimation of DMFc is higher than the DMFc + DEE method. But since the spray-on technique offers a much simpler way to manufacture large-area photocathodes, it would therefore seem worthwhile sacrificing a little of the quantum efficiency in order to ease the fabrication process. This also offers a simple way for those without access to a vacuum-deosition system to make Csl photocathodes.

Conclusion

The preliminary results obtained with "Spray-on" technique to produce Csl+DMFc photocathodes are encouraging. They indicate that it is possible to build

demountable gaseous detectors with large-area photocathodes at a reasonable cost. Such detectors can operate at gas gain up and above 10^4, high enough to detect single electrons. They may find applications in BaF_2 Calorimetry, in RICH detector, in plasma diagnostics and in astrophysics.

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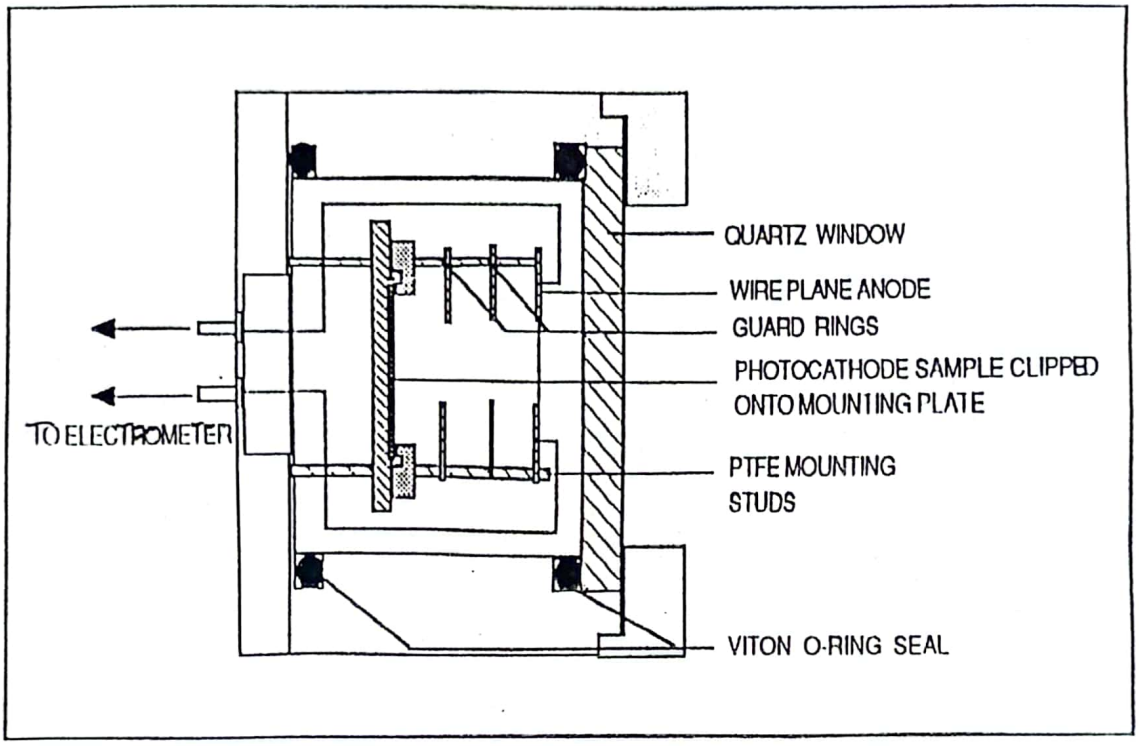

Fig. 1. Vacuum photodiode test chamber.

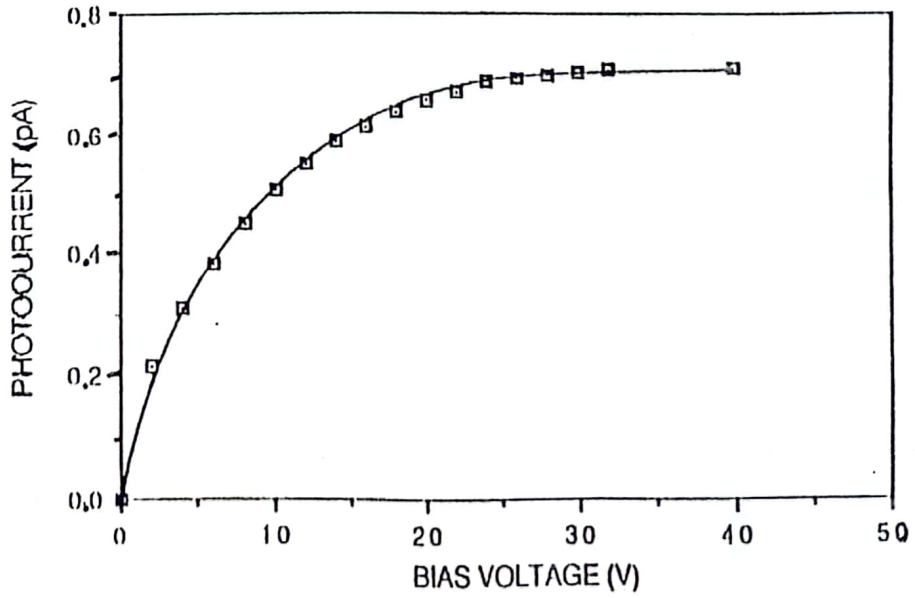

Fig. 2. Plateau measurement of test chamber in vacuum.

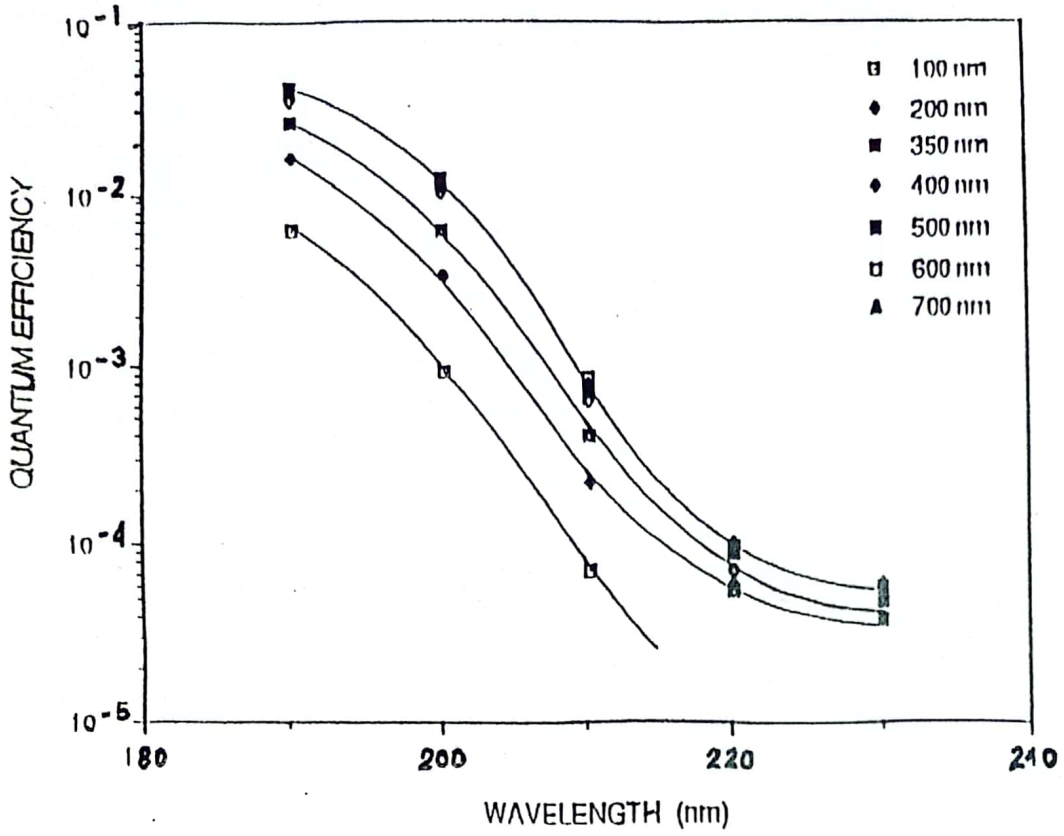

Fig. 3. Quantum efficiency as a function of wavelength for CsI photocathodes of different thickness.

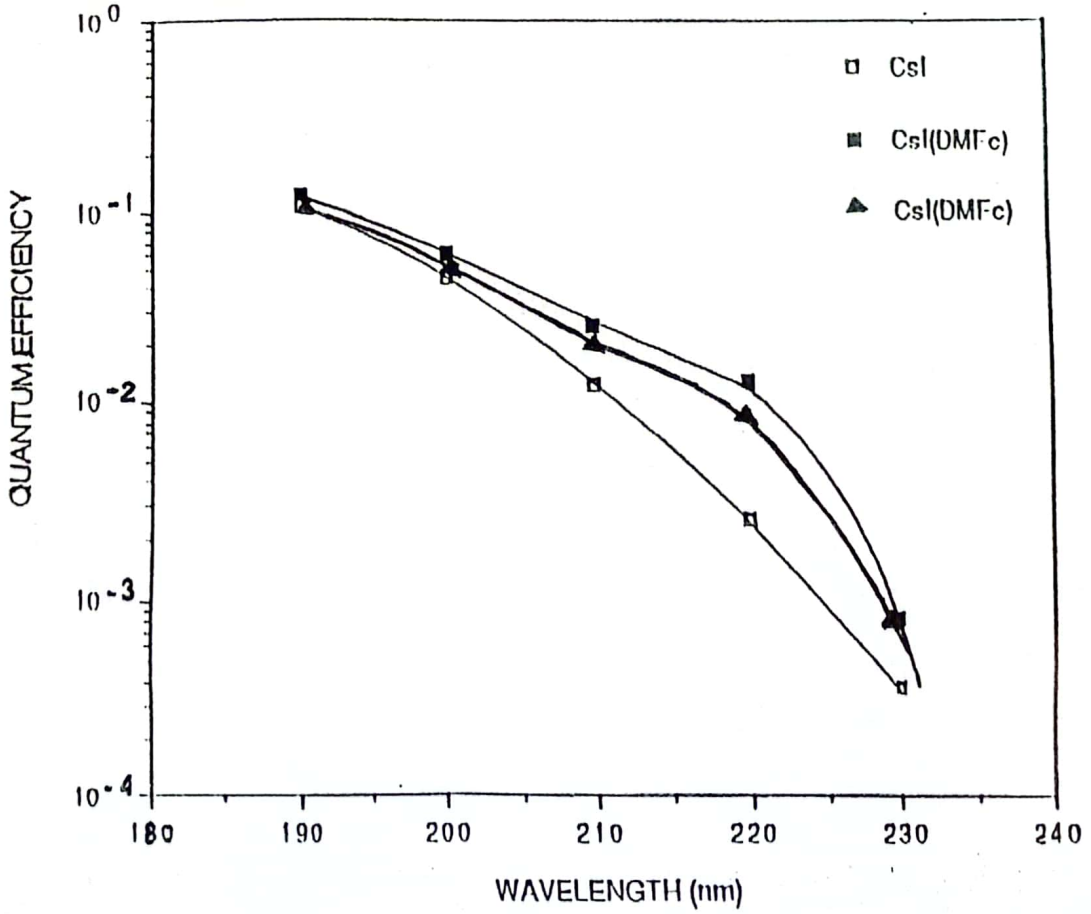

Fig. 4. Quantum efficiency as a function of wavelength for CsI + DMFc photocathodes.