TOWARDS GASEOUS DETECTORS FOR VISIBLE PHOTONS

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ABSTRACT

NaI protective coatings on visible cesium-antimony photocathodes have been studied. Protected photocathodes are shown to withstand exposure to considerable doses of oxygen and dry air. This opens ways to their handling and operation in gaseous detectors for visible photons.

Since the venue of wire chambers, scientists have dreamt to replace vacuum photomultipliers by photosensitive gaseous detectors. Compared to vacuum photomultipliers, such devices can be made very large and should be considerably less sensitive to magnetic fields. Gaseous detectors of photons have been successfuly operated so far only in the far ultraviolet (UV) range [1–3]. This progress is due to a large extent to a relative stability of the photosensitive materials in a counting gas and under short exposure to air.

However, no effective photoconvertors above 210 nm has been found, which could withstand contact with even minute amount of oxygen, water and other impurities. In order to operate such devices, it was suggested to protect sensitive photocathodes by their coating with various solid dielectric films [4–6]. However, the few attempts [7,4] to protect visible photocathodes were not successful so far.

In this letter we show for the first time that cesium-antimony (Cs_3Sb) photocathodes, sensitive in the close UV and visible range, can withstand contact with considerable amount of oxygen and dry air, when coated with thin NaI films. More complete description of the results are presented elsewhere [8].

The experimental setup for preparation and characterization of visible photocathodes consists of a high vacuum (10^{-9} Torr) chamber coupled to a monochromator (Fig.1). The system permits a displacement of the photocathode substrate between three positions inside the vacuum chamber:

for the preparation of the photocathode, the evaporation of the protective film and the measurement of the quantum yield (QY). In the present work the absolute QY was measured in a reflective mode in vacuum. The exposure of the photocathode to gas was performed inside the chamber at room temperature.

Fig.2 shows the QY drop of a Cs_3Sb photocathode, coated with a 151 Å thick NaI film, as a function of the residual oxygen pressure inside the chamber; the exposure time at each data point is 5 min. At each wavelength the QY is rather stable up to an oxygen pressure of about 0.1 Torr and then decreases gradually. One should note that an oxygen pressure of 150 Torr (the last pressure point in Fig.2) corresponds approximately to its partial pressure in air. It is important to remark that an uncoated photocathode was found by us to completely desintegrate already at an oxygen pressure of 10^{-5} Torr.

We compared the protection capability of NaI films with that of CsI (see Fig.3). The protection capability of CsI films was found to be comparable with that of NaI, for an equal post-coating attenuation of the photoyield and for oxygen pressures below 10^{-2} Torr. However for higher pressures it is appreciably smaller compared to NaI.

We have tried to protect Cs_3Sb photocathodes with other dielectric films, such as CsF, NaF, SiO and hexatriacontane. However the electron transmission of these films was lower and the protection capability was much smaller, compared to that of NaI and CsI. Thus, for the time being NaI can be considered the most successful protective film among those investigated by us.

In conclusion, one can state that the concept of protection of visible photocathodes has been proven [8]. This can open new avenues in light detection techniques. The realization of this concept in the present work resulted in the creation of a relatively efficient and air-stable photoconvertor sensitive in the wavelength region of 250-450 nm. This can be regardered as a considerable step forward in this field, since the introduction, more than 15 years ago (see refs. in [1,3]), of air-stable photosensitive materials in the wavelength region below 220 nm. The search for other protective layers, with better photoelectron transmission and higher protection capability, is being carried out in our laboratory.

References

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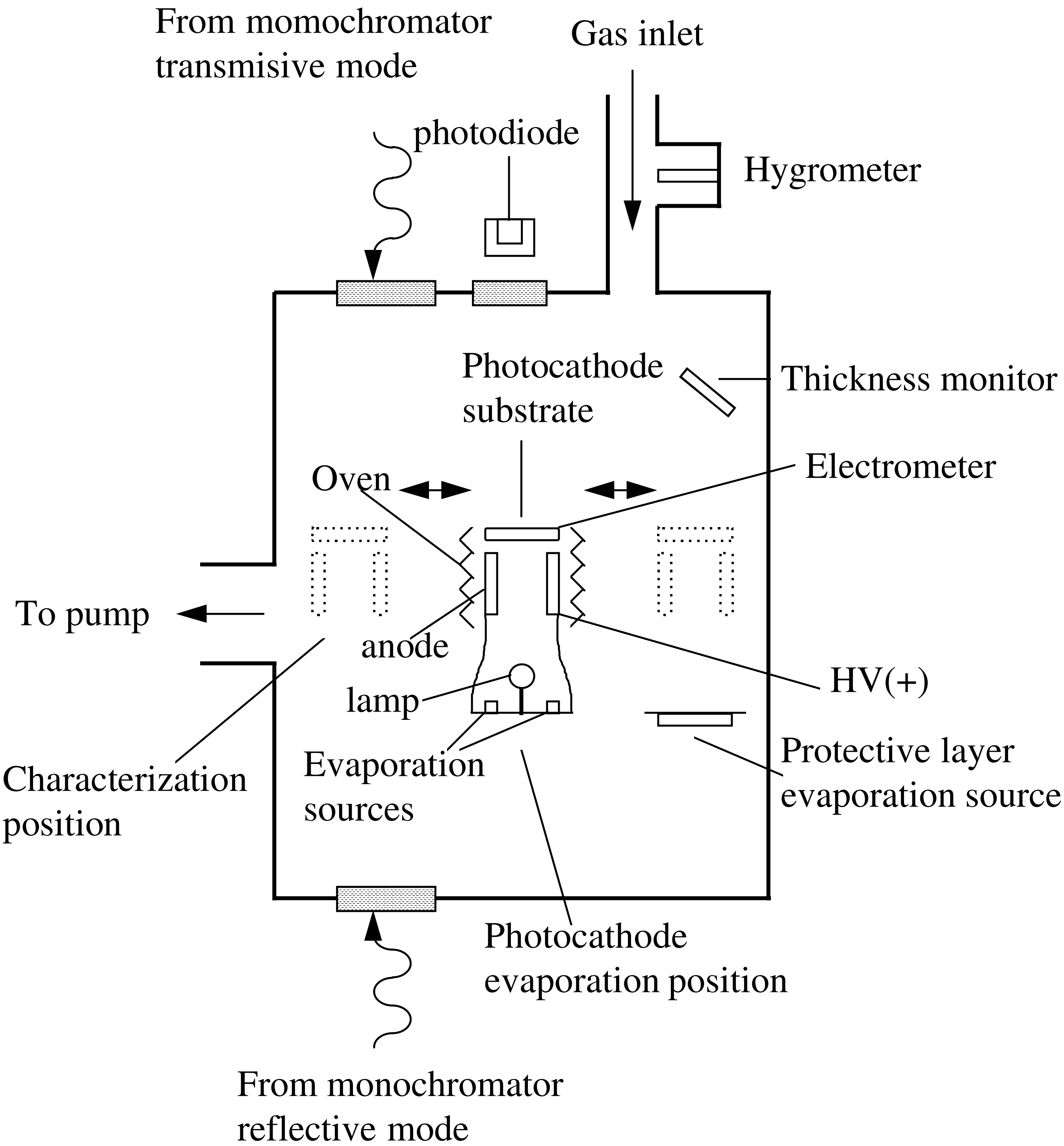
Figure captions

Fig.1 Experimental setup the preparation of visible photocathodes, evaporation of protective films and their characterization.

Fig.2 Evolution of a NaI-coated Cs_3Sb photocathode under exposure to oxygen. Shown are the absolute quantum yield values of a Cs_3Sb photocathode coated with 151 Å thick NaI film, measured at different wavelengths, as a function of the residual oxygen pressure during the exposure. Exposure time at each data point is 5 min.

Fig.3 Comparison of the protection capability of NaI and CsI coating films. Shown are the absolute quantum yield values of Cs_3Sb photocathodes coated with 155 Å thick NaI and 250 Å thick CsI films, at 312 nm, as a function of the residual oxygen pressure. Exposure time at each data point is 5 min.



From momochromator
transmisive mode
Gas inlet
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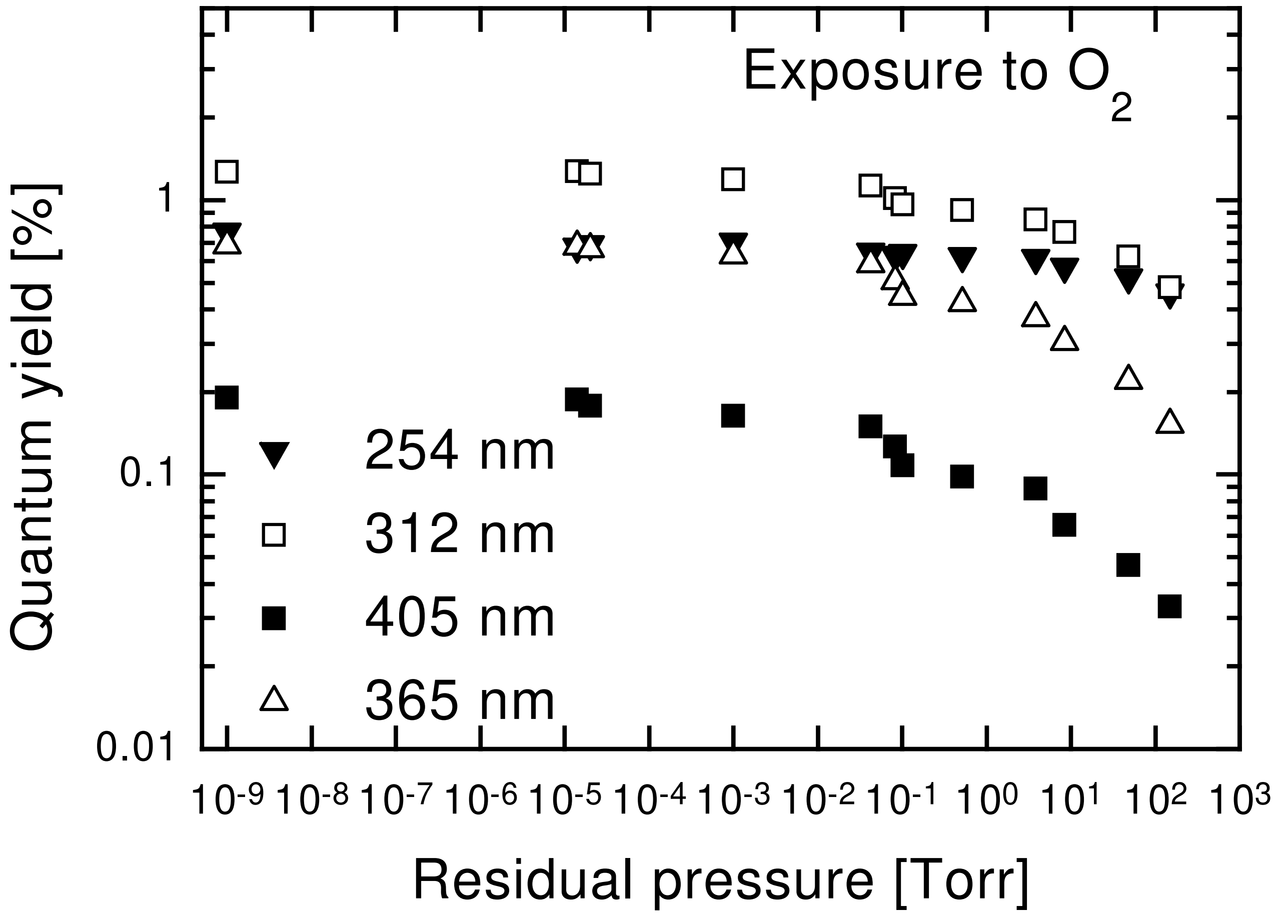
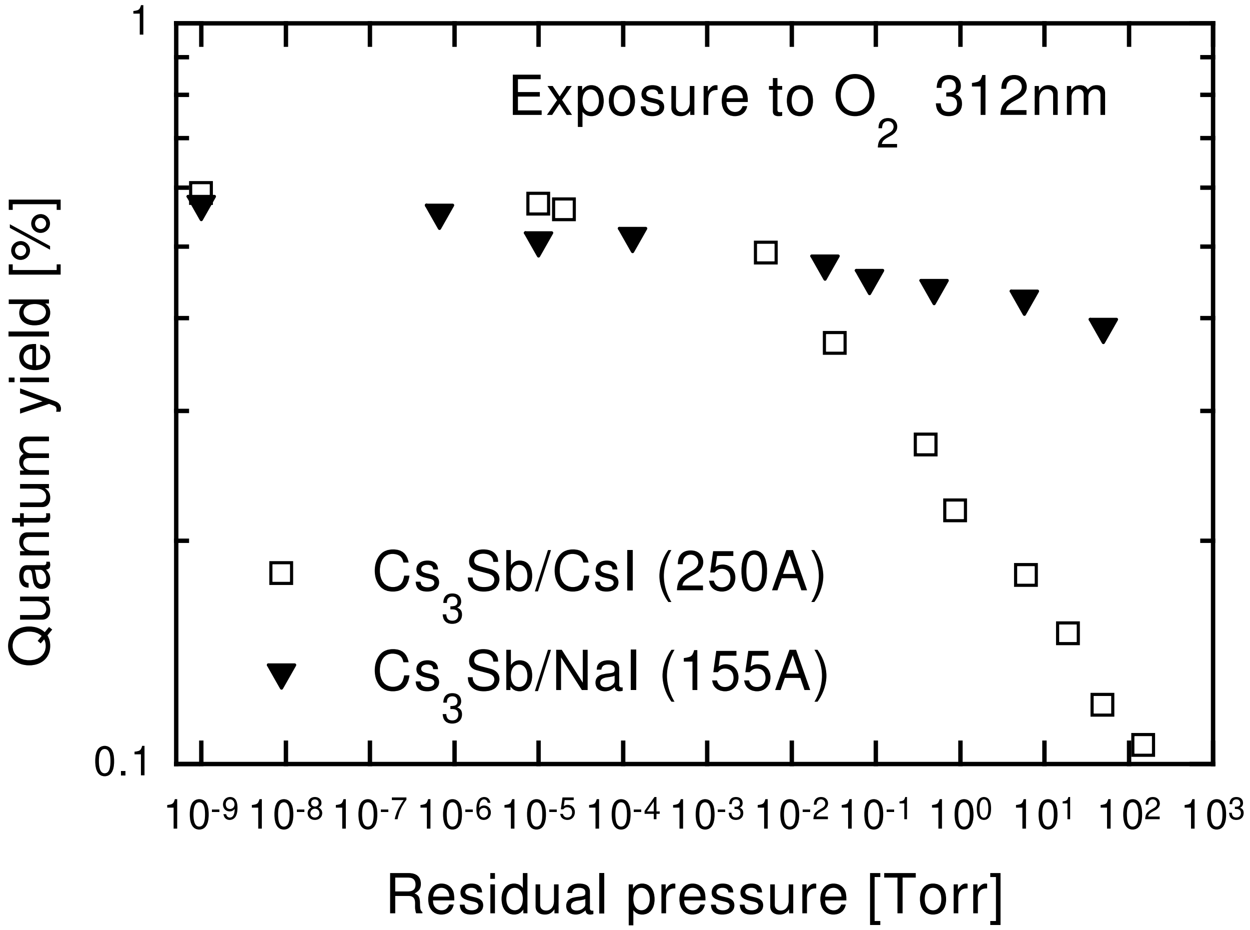
Hygrometer
Photocathode
substrate
Thickness monitor
Electrometer
Oven
To pump
anode
HV(+)
lamp
Evaporation
sources
Characterization
position
Protective layer
evaporation source
Photocathode
evaporation position
From monochromator
reflective mode

Fig. 1


Exposure to O2
Quantum yield [%]
1
0.1
0.01
254 nm
312 nm
405 nm
365 nm
10-9 10-8 10-7 10-6 10-5 10-4 10-3 10-2 10-1 100 101 102 103
Residual pressure [Torr]


Exposure to O2 312nm
Quantum yield [%]
1
0.1
Cs3Sb/CsI (250A)
Cs3Sb/NaI (155A)
10-9 10-8 10-7 10-6 10-5 10-4 10-3 10-2 10-1 100 101 102 103
Residual pressure [Torr]