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Gas VUV photosensors operating face to face

C.D.R. Azevedo [a], C.A.B. Oliveira [a], H. Natal da Luz [a], L.F. Carramate [a], A.L. Ferreira [a], J.M.F. dos Santos [b], J.F.C.A. Veloso [a,*]

[a] I3N, Physics Department, University of Aveiro, 3810-193 Aveiro, Portugal

[b] GIAN-Physics Department, University of Coimbra, 3004-516 Coimbra, Portugal

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ABSTRACT

The operation of two CsI-Micro-Hole and Strip Plate (MHSP) photosensors in pure xenon is presented. The photosensors operate face to face having the xenon medium in between. To produce VUV scintillation photons, a cluster of 7 stainless-steel grids is placed in the xenon medium and voltage is applied between the grids to establish an electric field higher than the xenon excitation threshold. The scintillation is triggered by electrons produced in xenon following *X*- or γ-ray interactions. The depth of the interaction position of *X*- or γ-photons in the xenon gap can be determined by weighing the signal amplitude from both photosensors. Experimental studies of the interaction position along the xenon gap, in the direction perpendicular to the photosensors, as a function of the actual position will be presented.

1. Introduction

Recent developments in high-pressure xenon gas detectors based on microstructures operating in avalanche mode triggered the possibility for a fair detection of hard *X*- and γ-rays [1,2]. Also, advances in VUV photosensors operating within the xenon medium allow an efficient detection of the VUV photons resulting from xenon scintillation [3,4].

A new γ-ray gaseous detector for medical imaging purposes is being developed [5].

The detector uses two photosensors based on Micro-Hole and Strip Plates (MHSP) [4] positioned face to face and a stainless-steel grid cluster in between, Figs. 1 and 2. The grids are alternated biased at high voltage and ground potential. The detector is filled with high-pressure xenon, acting as γ-rays absorption medium.

The MHSP integrates, in a single element, two successive independent charge amplification stages: a GEM-like (Gas Electron Multiplier) and a MSGC-like (Micro-Strip Gas Counter) stage [6]. Like the GEM, the MHSP is manufactured with printed circuit board technology from a 50 μm Kapton foil, metalized with 5-μm-thick copper layers on both sides (Fig. 3).

In CsI-MHSP photosensors, a 500 nm CsI photocathode is deposited on the top of each MHSP, operating in reflective mode [4]. When VUV photons hit the CsI surface, photoelectrons can be extracted and focused into the MHSP holes, undergoing multiplication in the strong electric field. Then, avalanche electrons are extracted from the holes towards the MHSP anode strip placed on the bottom side, where they are multiplied once more and collected.

In this work we present the operation of two CsI-Micro-Hole and Strip Plate photosensors operating face to face having the xenon medium in between. Experimental studies of the interaction position and position resolution along the xenon gap, in the direction perpendicular to the photosensors, as a function of the actual position for xenon at one bar will be presented.

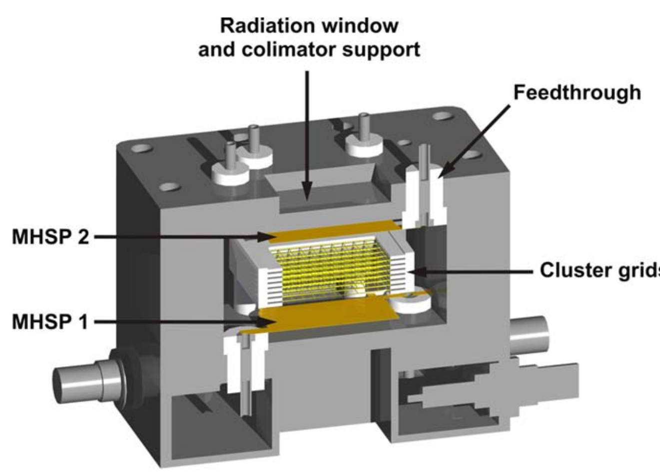

Fig. 1. Vertical cross-section of the new γ-ray detector.

* Corresponding author. Tel.: +351 234 370 356; fax: +351 234 378 197.
E-mail address: joao.veloso@ua.pt (J.F.C.A. Veloso).

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2. Operation principle

The detector operation principle is depicted in Fig. 2.

The interaction of the γ-ray with the gaseous xenon produces a primary electron cloud between intercalated grids. By applying a reduced electric field E/p (where E is the electric field and p is the gas pressure) between the grids, primary electrons could be accelerated and get enough energy to excite the xenon atoms between collisions [7].

When the de-excitation process occurs, 170 nm photons are emitted (secondary scintillation) [8], the emission intensity being proportional to the number of primary electrons and to the reduced electric field [9].

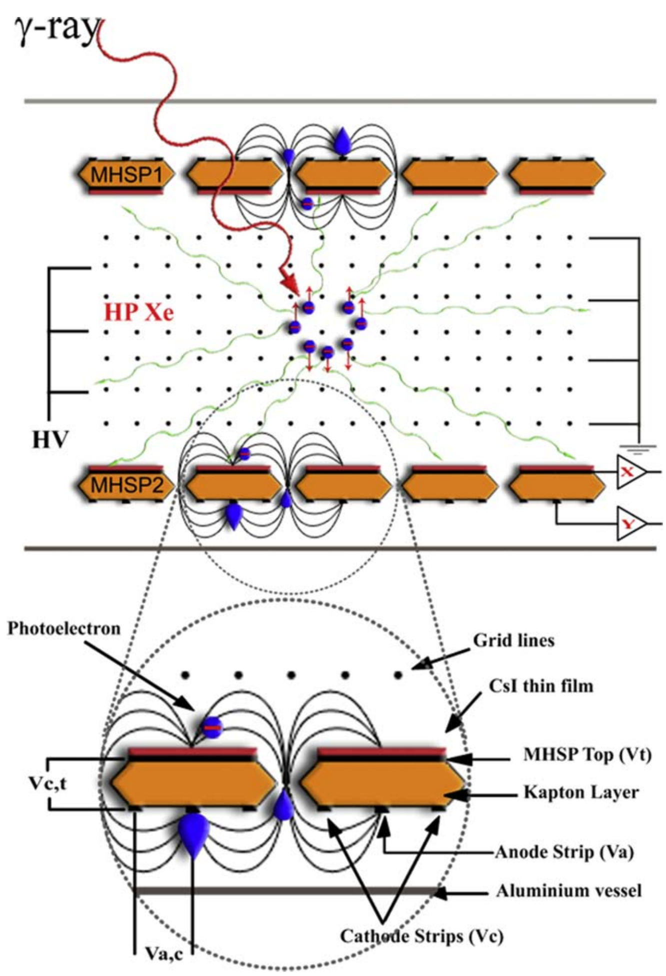

Fig. 2. Schematic diagram of the γ-ray detector and its operation principle.

The VUV photons produced hit the CsI photocathode deposited on the MHSP-top and photoelectrons can be extracted and focused into the MHSP holes, where they are multiplied [4].

The vertical interaction position along the xenon gap, Z, orthogonal to the detector window, can be given by the relation between the signals of each MHSP:

$$Z = k\frac{A1 - A2}{A1 + A2} \quad (1)$$

where $A1$ and $A2$ are the signal amplitudes of MHSP1 and MHSP2, respectively, and k is a calibration constant.

3. Experimental set-up

The present MHSP has an active area of $2.8 \times 2.8\,cm^2$. The bi-conical holes, around $\varnothing 40/70\,\mu m$, are implemented in the Kapton/copper film, arranged in an asymmetric hexagonal lattice of 140 and 200 μm pitch parallel and perpendicular to the strips, respectively.

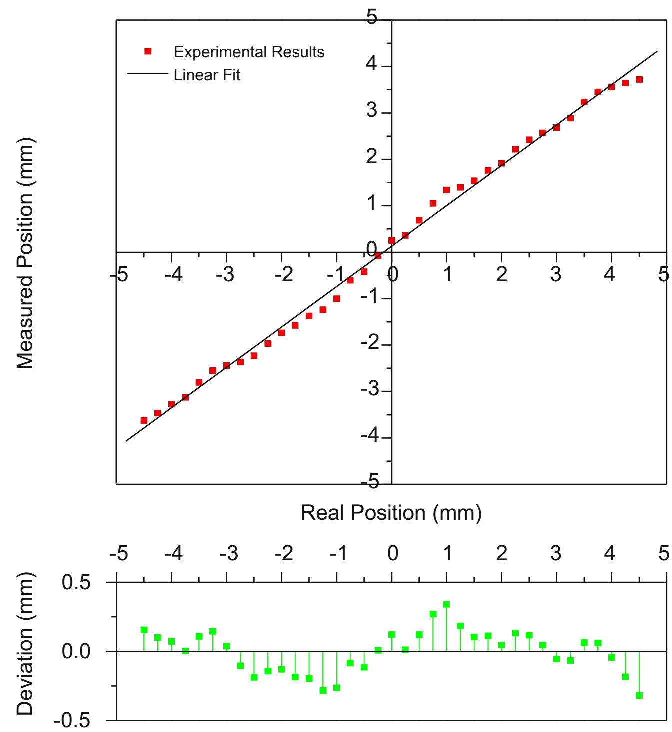

Fig. 4. Measured position as a function of the real position (250 μm step).

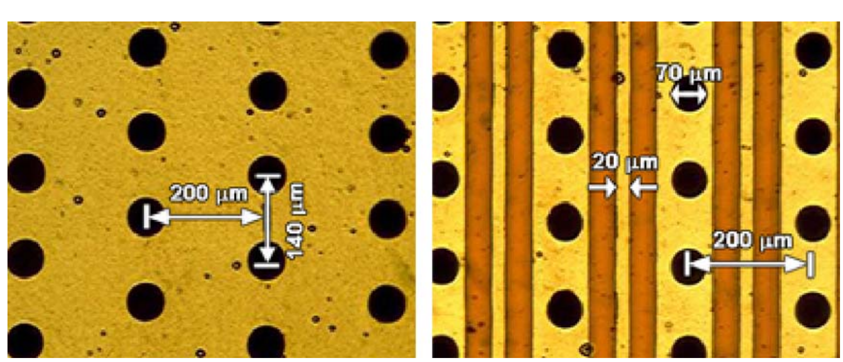

Fig. 3. Photomicrograph of the MHSP electron multiplier, top (left) and bottom sides (right).