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The Micro Slit Gas Detector

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Abstract

We describe the first tests with a new proportional gas detector. Its geometry consists in slits opened in a copper metallized kapton foil with 30 μm anode strips suspended in these openings. In this way the multiplication process is similar to a standard MSGC. The fundamental difference is the absence of an insulating substrate around the anode. Also the material budget is significantly reduced, and the problems related to charging-up or polarization are removed. Ageing properties of this detector are under study.

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[a]Work supported by Comisión Interministerial de Ciencia y Tecnología (CICYT), projects AEN96-1671 and AEN97-1706-E.

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We describe the first tests with a new proportional gas detector. Its geometry consists in slits opened in a copper metallized kapton foil with 30 μm anode strips suspended in these openings. In this way the multiplication process is similar to a standard MSGC. The fundamental difference is the absence of an insulating substrate around the anode. Also the material budget is significantly reduced, and the problems related to charging-up or polarization are removed. Ageing properties of this detector are under study.

1 Introduction

A new generation of proportional gaseous detectors based on advanced printed circuit technology (PCB) has been introduced during the last year. Important efforts in the research and development of these kind of detectors are justified because of their low cost and robustness. Examples of these detectors are the Gas Electron Multiplier (GEM) [1], the Micro-Groove Detector (MGD) [2], and the WELL detector [3]. They have in common the use of thin kapton foils and PCB techniques in order to implement the multiplication structure. The flexibility of the readout is precisely another advantage of these detectors, allowing in some cases two dimensional device. Detector charging up and operation stability are important issues that need to be studied. We present here indications of a good performance for the Micro Slit Gas Detector.

[b] Work supported by Comisión Interministerial de Ciencia y Tecnología (CICYT), projects AEN96-1671 and AEN97-1706-E.

2 Detector description

The development of kapton etching techniques (commonly used for GEM production) has made possible the easy construction of new detector geometries.

In this case one of the metallic layers, of a kapton foil copper clad on both sides, is litographically etched with a matrix of rectangular round-corner slits, 105 μm wide and 8 mm long (repeated in the transverse direction with a spacing of 200 μm). In the opposite side, a pattern 30 μm wide strips with 200 μm pitch is etched, ensuring that the strips run along the slits.

When kapton is removed, the final device has 30 μm strips suspended only by 200 μm kapton joints regularly spaced at 8 mm (to provide mechanical stiffness). In this way a "substrate-free" MSGC is achieved, and the detector resembles a wire-chamber.

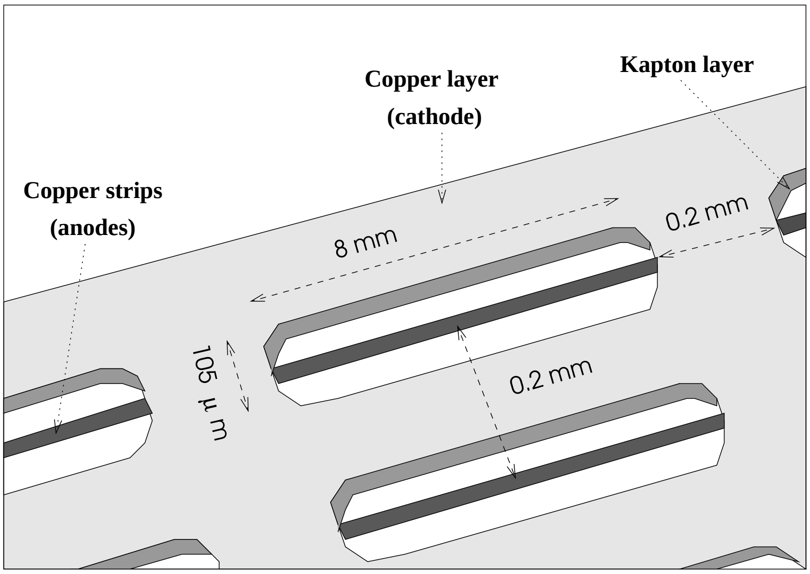

Figure 1: *Scheme of the copper clad kapton (top view).*

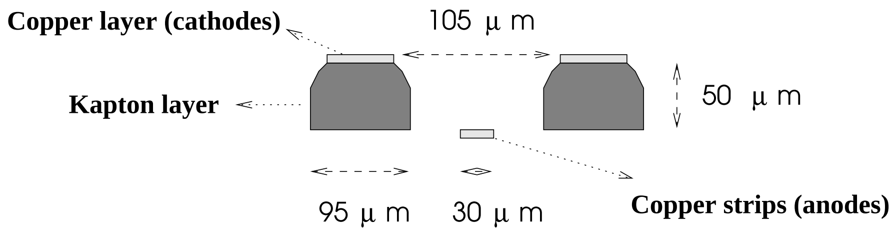

Figure 2: *Scheme of one slit (transverse section). The copper layer is 15 μm thick.*

The first detector prototype was enclosed in a gas volume, which was sealed symmetrically by two thin conductive foils, at 3 mm distance from the kapton plane. The first provides the drift field towards the multiplication region (drift plane), and the second was given, in the test, a certain potential with respect to the anodes, which we discuss later (backplane).

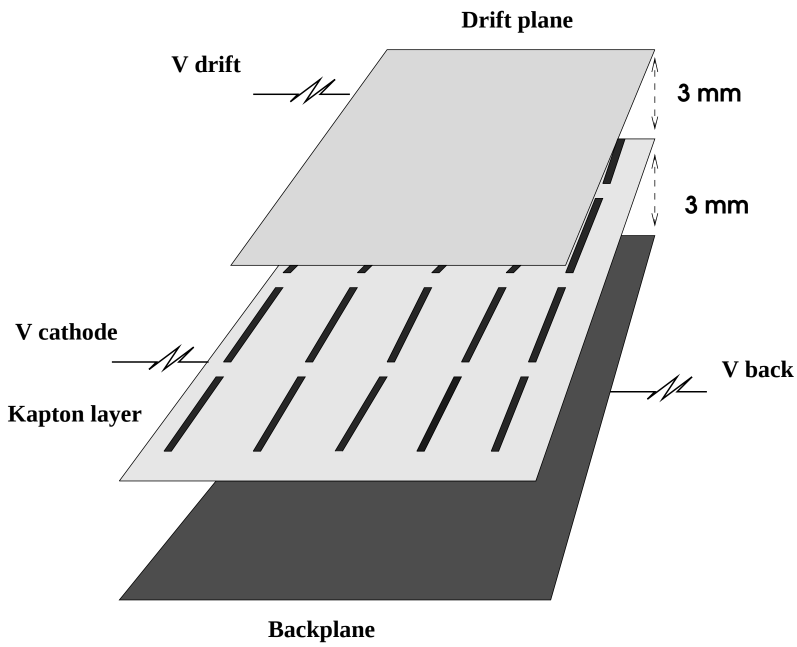

Figure 3: *Schematic view of the tested prototype.*

3 Detector performance

The signal development takes place in a similar way as in a standard MSGC. Drifting electrons reach the E-field region between anode and cathode, and are then multiplied inside the rectangular slits. The electron avalanche produced in this region is collected by the anode strips. The ion charge is collected by the cathode and the drifting plane, in a proportion depending on the operating voltages. In this case anodes were grounded through a bias resistor while a negative potential was applied to the cathode.

The detector was irradiated with X rays coming from an Cr X-ray tube and the gas mixture used was composed by Ar and DME in different proportions.

The signal was extracted from an OR of 32 anodes and amplified by a ORTEC 142PC preamplifier followed by an AFT Research Amplifier Model 2025. The output was digitized in a Tektronix TDS 684A Oscilloscope.

3.1 Operation voltages

Typical operating voltages in the first prototype are very similar to MSGCs. Detector gains obtained are somewhat lower. This is understandable due to the width of the anode strips (still limited by the PCB production technique), and also as a consequence of the extended gap between anode and cathode because of the non planar geometry and the cathode width [c]. The detector gain exhibits an exponential dependence on the voltage applied to the cathode (Figure 6).

A pulse height spectrum can be seen in figure 4. The voltage applied to the backplane does not affect significantly the anode signal, as illustrated also in figure 4.

[c]New prototypes are under development with wider cathodes

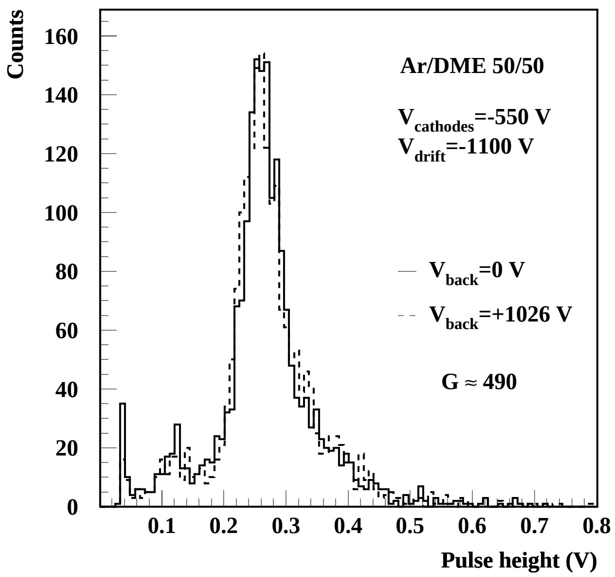

Figure 4: *Spectra obtained with different values of the voltage in the backplane.*

Figure 5 shows spectra obtained with different values of the cathode voltage. Decreasing it by 10 V, for the drift voltage V_d=-1600 V, produces a 20% drop in the gain.

In these spectra, the Argon escape peak is clearly separated from that corresponding to the K_α photon energy at 5.4 KeV. The energy resolution for the latter is a 30% FWHM.

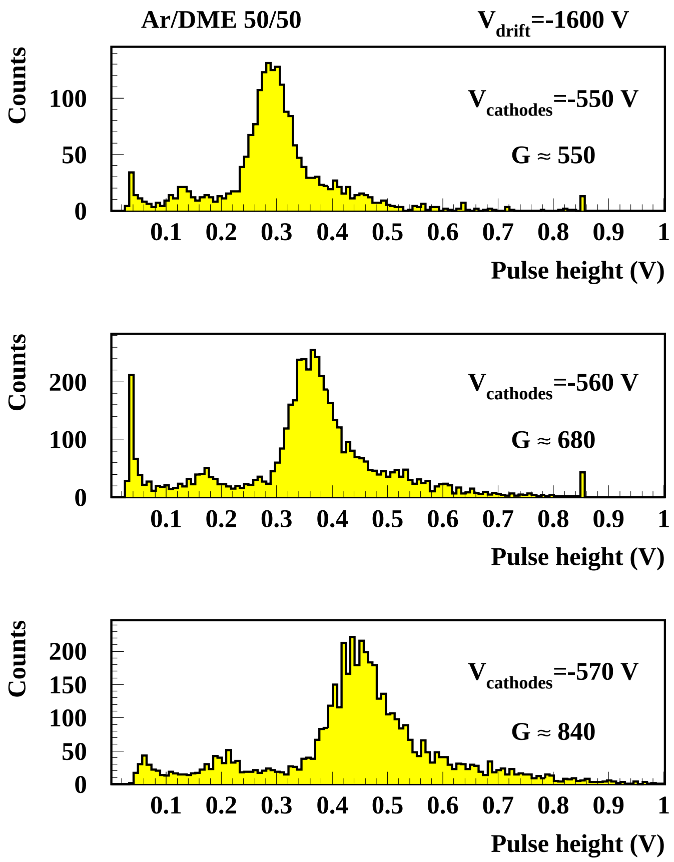

Figure 5: *Effect of the cathode voltage on the response of the detector.*

The dependence of the gain with the cathode voltage was also studied for different gas mixtures. The results of these studies (Figure 6) show that the highest gains were obtained with high argon content in the gas mixture.

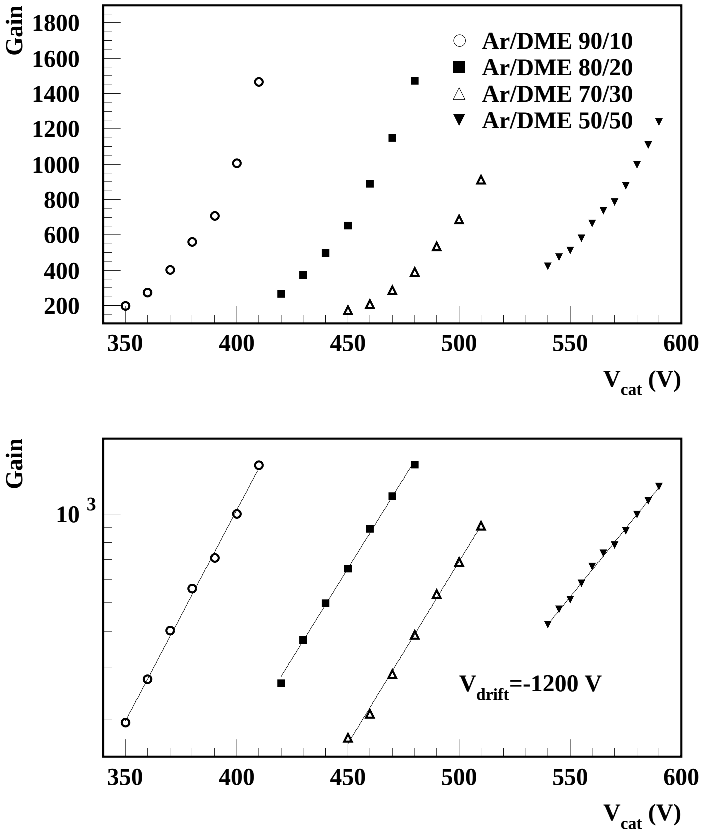

Figure 6: *Behaviour of the gain as a function of the cathode voltage for different gas mixtures.*

The dependence of gain on the drift field is shown in figure 7. Clearly an enhancement of gain is obtained with higher drift field values.

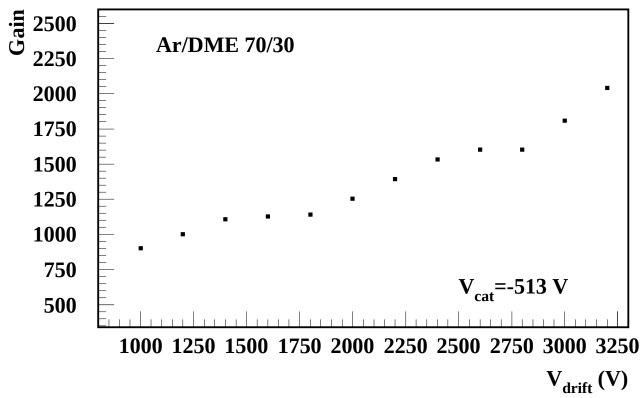

Figure 7: *Dependence of the gain with the drift voltage.*

3.2 Short term gain variation

Typically variations on the gain during the first operation moments of a gas device are manifest in those detectors using insulating substrates. This is due to the accumulation of charge on the dielectric (charging-up) and polarization, producing electric field modifications, and thus affecting the amplification process. Normally this effect has been avoided using conductive coatings (like LPVD diamond)[4] or substrates (like S8900). In the GEM, for example, kapton surface of the holes is clearly traversed by the dipole electric field thus producing an important charging up[d]. In this geometry we have designed the electrodes in such a way that the area exposed to the E-field represents only around 1% of the total. This (see below) represents a major improvement in this type of devices just simplifying the production (no coating needed).

The effect of charging up on the MSGD gain was determined by registering the pulse height spectrum and comparing the maxima from consecutive periods. Figure 8 shows the evolution of the gain during the first 57 minutes of irradiation under a rate of 10^3 Hz mm^{-2}. Variations of the gain are less than a 5%.

[d]New prototypes try to use coatings to avoid this problem. Also a small water content in the gas mixture has been demonstrated to solve it.

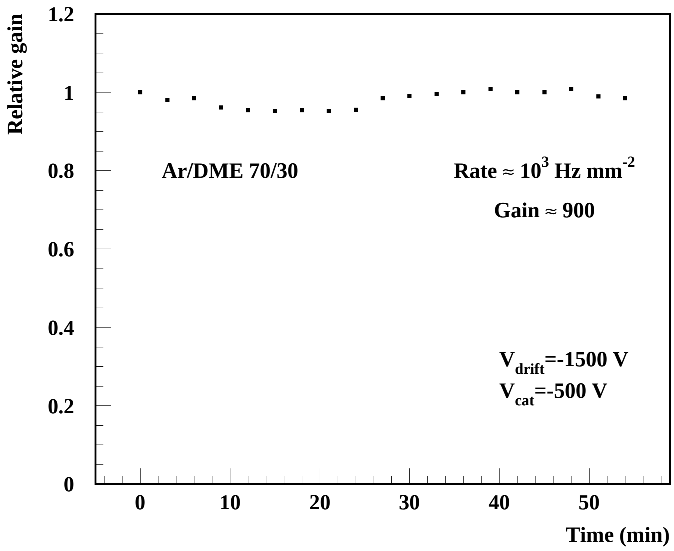

Figure 8: *Evolution of the gain during the first irradiation moments.*

In order to accelerate the effect of this possible charge accumulation, the MSGD was irradiated with a photon rate of $\approx 10^6$ during about 10 minutes. Figure 9 compares the spectra before and after the high irradiation. No appreciable change occurs. This behavior differs from that observed in detectors with dielectric substrate, like standard MSGC or GEM.

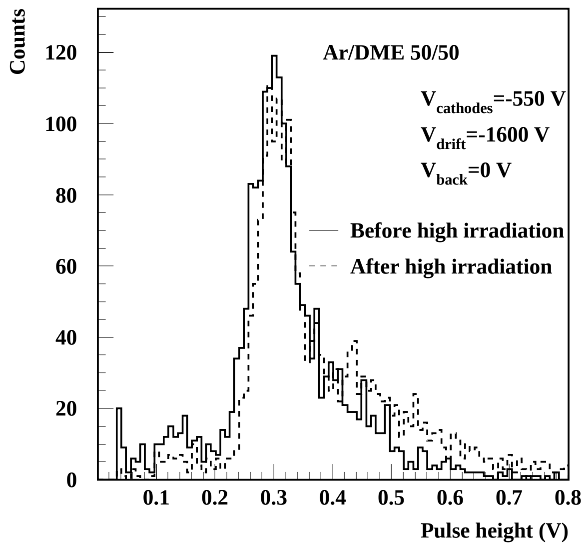

Figure 9: *Spectra before and after high irradiation obtained from the MSGD prototype.*

4 Rate capability

The rate capability of this detector was determined by measuring the current in the group of instrumented anodes for different values of the incident photon flux. Driving the X-ray tube to its maximum current, we could reach up to 2.6×10^6 Hz mm^{-2} incident photon flux, collimated over a surface of 3 mm^2. No appreciable drop in gain was observed. In figure 10 we show the relative changes in the detector gain during the irradiation test. They were determined from the observed deviations with respect to a linear fit between X-ray intensity and anode current.

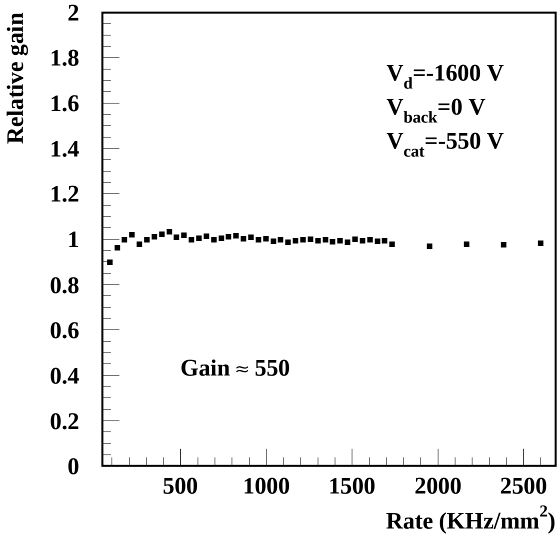

Figure 10: *Rate capability of the MSGD.*

The high rate capability observed is clearly due to the effective absence of any charging up effect in this detector. Given the anode-cathode geometry similar to an MSGC, we expected that the rate capability had to be of the same order, but in the Micro Slit detector there is no need of coating to reach values of 10^6 mm^{-2} s^{-1}.

5 Conclusions

A prototype of a proportional gas detector, based on the PCB technology, has been designed and tested.

The first tests with this detector show its high rate capability related (up to 2.5 MHz mm^{-2}) related to the absence of charging up effects.

In spite of its similarity to the MSGC in the amplification process the use of the PCB technology reduces considerably the cost and material budget. Besides, it is important to notice the supression of the substrate for supporting the anode structure.

6 Acknowledgements

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