New developments of Micromegas detector.

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Abstract

A new type of micromesh, based on etching techniques, has been developed for the Micromegas detector. In this paper, we will briefly describe this new design and give some results about the performances obtained in different gas mixtures. The geometry of the mesh allows good uniformity of the electrostatic field. An energy resolution of 11.7 % (FWHM) is obtained with X-rays at 5,9 keV and 5.4 % at 22 keV in a Argon/Isobutane (90%/10%) gas mixture. This is a significant improvement for a gaseous detector operating at high gain (about 5000).

1 Introduction

Micromegas [1] is a new gaseous detector based on a two-stage parallel plate avalanche operation. It consists of two gaps delimited by a thin micromesh : a conversion stage and a narrow (50 to 100 microns) amplification stage. The anode plane is a simple Printed Circuit Board on which have been printed, by standard lithography, strips and epoxy pillars ensuring the parallelism between the two planes. The mesh is a metallic grid, made of nickel, obtained by electroforming technique. Recent developments of etching techniques, widely used for other micro-pattern detectors [2], had opened the way to a novel technology for the fabrication of the micromesh that is a key element of the Micromegas detector. This new type of mesh is based on simple chemical etching techniques on a single foil of Kapton copper plated on each side. The manufacture process relies on the high accuracy of the photolithography technique reached in CERN that allows to print on a 5 micron copper a grid with 25 micron openings and a pitch of 50 microns; the Kapton is then removed by etching. In a second fabrication the Kapton is partially removed leaving Kapton pillars that are used as spacers for the amplification gap of the detector (see figure 1). The detailed procedure is the following (figure 2):

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- a double side Kapton foil, 50 micron thick, is stretched on a Stesalite frame.
- a solid photoresist of 15 microns thick is applied on the two faces of the copper clad.
- two lithographic masks are used for both faces of the kapton: one side with the holes pattern and the other with the pillars pattern.
- Copper and Kapton are then etched providing the final mesh and pillars.

The optical transparency of this mesh is about 20%.

2 Experimental set up and results

The new micromesh is mounted on top of a copper plane which defines the anode-grounded electrode (figure 3). The drift gap is 15 mm wide and can be filled with several gas mixtures. The signal is read on the mesh trough a calibrated amplifier chain. We have used two radioactive sources, ^{55}Fe and ^{109}Cd, for calibration, gain, electron transmission and energy resolution studies. The gas filling was either a standard Argon and Isobutane mixture, or a heavier CF4 gas adequate for high resolution minimum ionising particle detection [3], or a lighter helium mixture that provides a very high gain which is usually used for single electron detection purposes [4]. In the latter case a UV pulsed-flash lamp was used as excitation source producing about four photoelectrons per pulse on the micromesh. The measured gain as a function of the mesh voltage (HV2), for various gas mixtures is represented in the figure 4. We must point out that the Helium mixture provides the highest achievable gain as it has been already observed [3]. It allows confortable single electron detection with quite high efficiency as it is shown in figure 5. The pure CF4 gas filling also provides a high gain of about 50000, higher than its mixture with Isobutane. Figure 6 shows a pulse height spectrum obtained with a iron source in an Ar/iC4H10(10%) gas mixture. The energy resolution is about 11.8% (FWHM) at a X-ray energy of 5.9 keV. At higher energy (22 keV) using the ^{109}Cd source the energy resolution is 5.4% (see figure 7). Compared to our previous measurements using an electroformed Ni mesh or generally to other gaseous detectors this is a significant progress. It can be attributed to the higher quality of the circular openings and to the low optical transparency (20%) of the new micromesh that results to a better uniformity of the amplification gap.
Indeed, the energy resolution in a gas detector like Micromegas depends essentially on three factors: the uniformity of the amplification field, the field ratio ($\rho = Ea/Ed$) which influences the optimal electronic transparency of the mesh and the gain. Because of fluctuations during the multiplication process the energy resolution is degrading with gain. The effect of the gain on the energy resolution is shown in figure 8. This result has been obtained for ρ=200 and in an Ar/iC4H10(5%) gas mixture. It presents an optimum for a gain around 5000, and a degradation at higher gains. This effect provides, proba-

bly, the explanation of the relative improvement (normalized to the deposited energy) of the resolution observed from 5.9 keV to 22 keV X-ray energy; at higher deposited energy the gain of the detector is lowered.
Figure 9 shows the energy resolution as a function of ρ. The optimal energy resolution is obtained for $200 < \rho < 300$, which is in good agreement with the simulation results calculated for an optical transparency of 20%.

3 Conclusions

The new type of mesh, obtained by etching techniques, is a significant progress of Micromegas detector. The manufacturing is well known and cheap and the performances of the detector are preserved or improved. Very high gain are reached, particulary in Helium-Isobutane mixtures, allowing a good single electron detection. Moreover, an energy resolution better than 12% is obtained at 5.9 keV and studies shows that this result depends of the detector gain and of the field ratio. At lower gain, the energy resolution at 22 keV is about 5.4%.

References

[1] Y.Giomataris et al., Nucl. Instr. and Meth. A 376 (1996) 29-35.

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[3] J.Derré et al., Spatial resolution in Micromegas detector, DAPNIA-00-03, submitted to Nucl. Instr. and Meth. A.

[4] J.Derré et al., Fast signals and single electron detection with Micromegas photodetector, DAPNIA-00-08, to be published in Nucl. Instr. Meth. A.

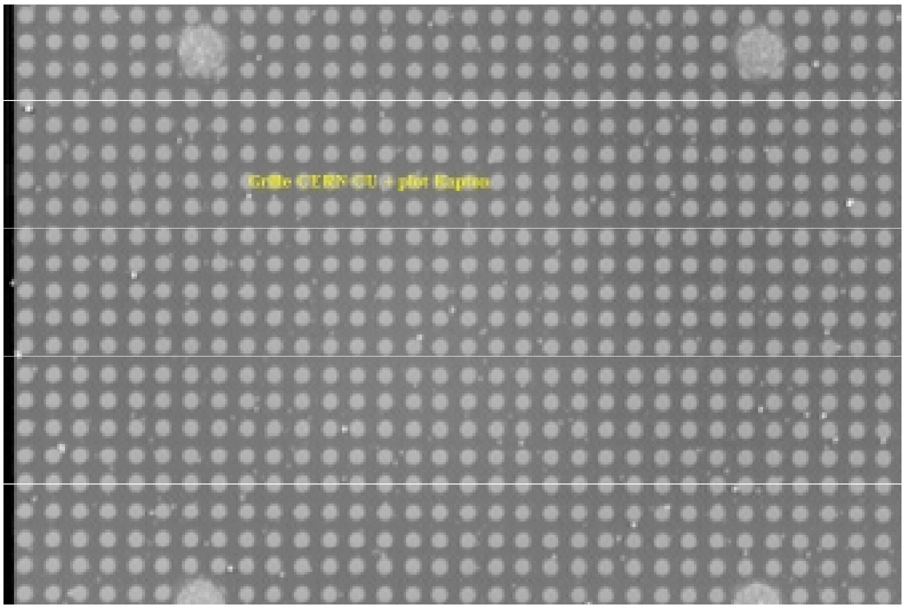

Fig. 1. Photography of the new mesh.

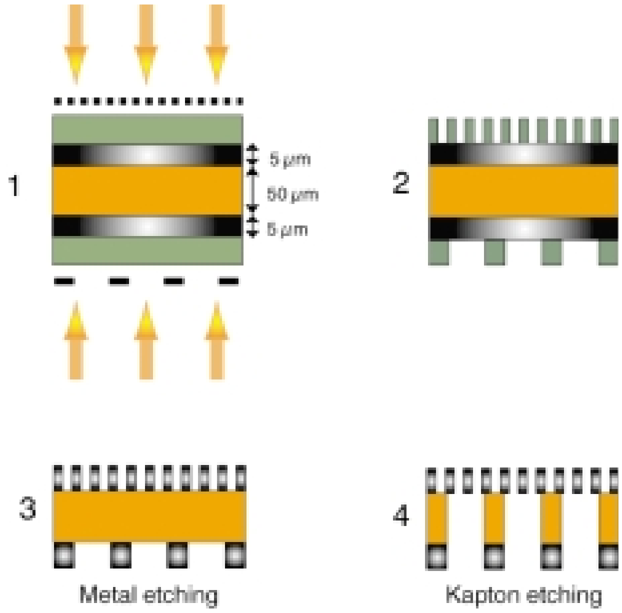

Fig. 2. Fabrication etching process of the mesh.

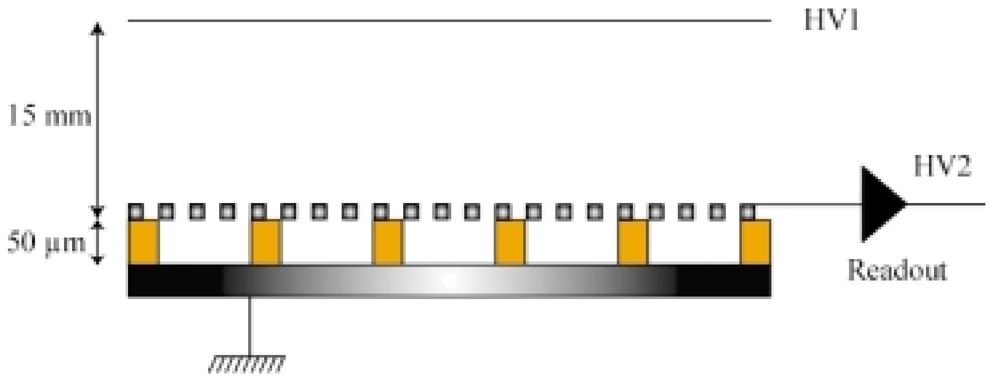

Fig. 3. Experimental setup.

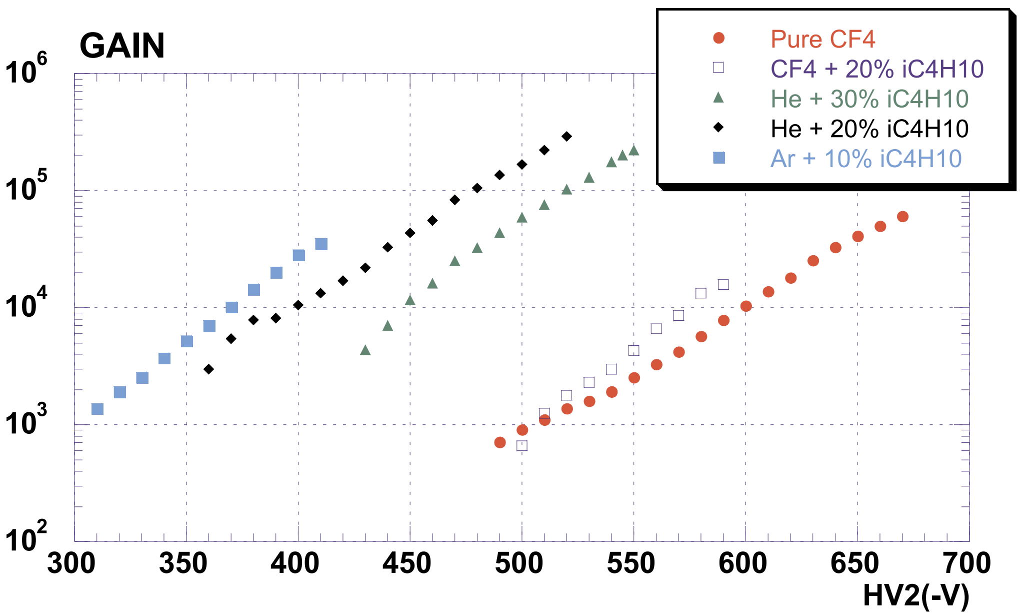

Fig. 4. Gain as a function of HV2 for different gas mixtures.

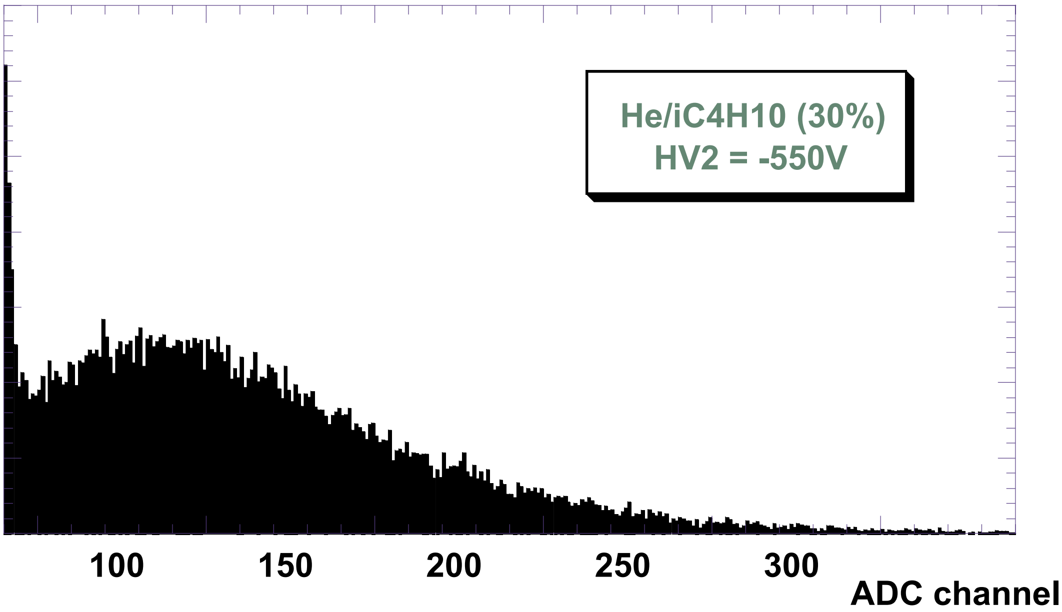

Fig. 5. Single electron spectrum in Helium/Isobutane(30%) gas mixture.

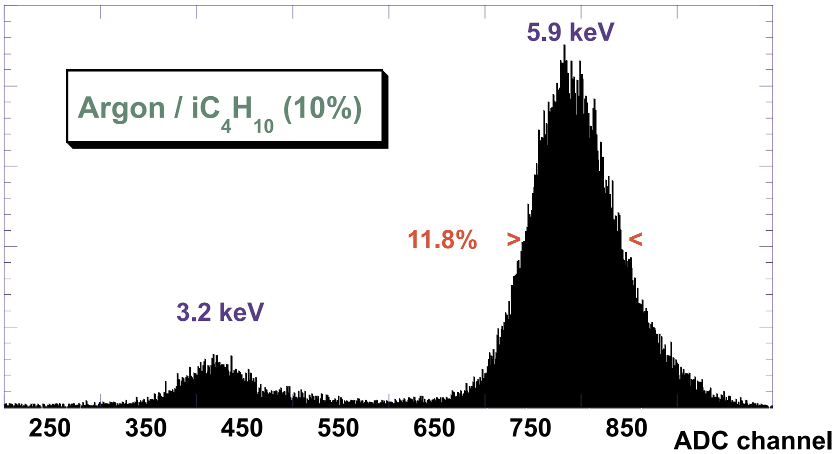

Fig. 6. ^{55}Fe source spectrum obtained in an Ar/iC$_4$H$_1$0(10gas mixture.

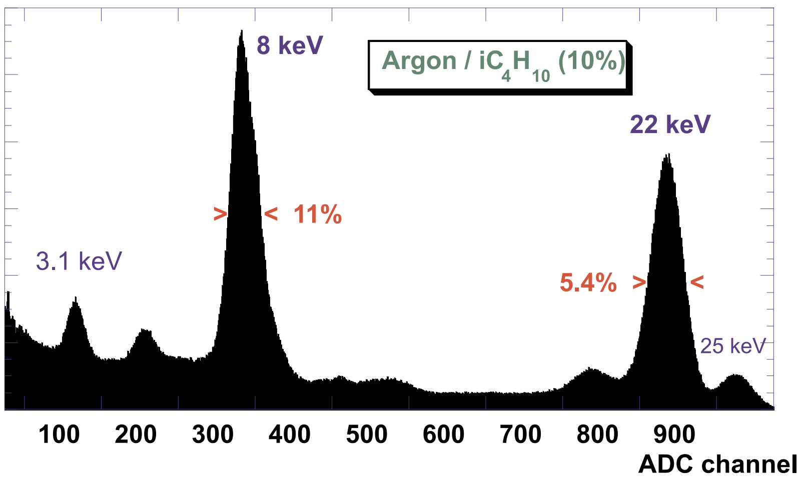

Fig. 7. [109]Cd source spectrum obtained in an Ar/iC$_4$H$_1$0(10gas mixture.

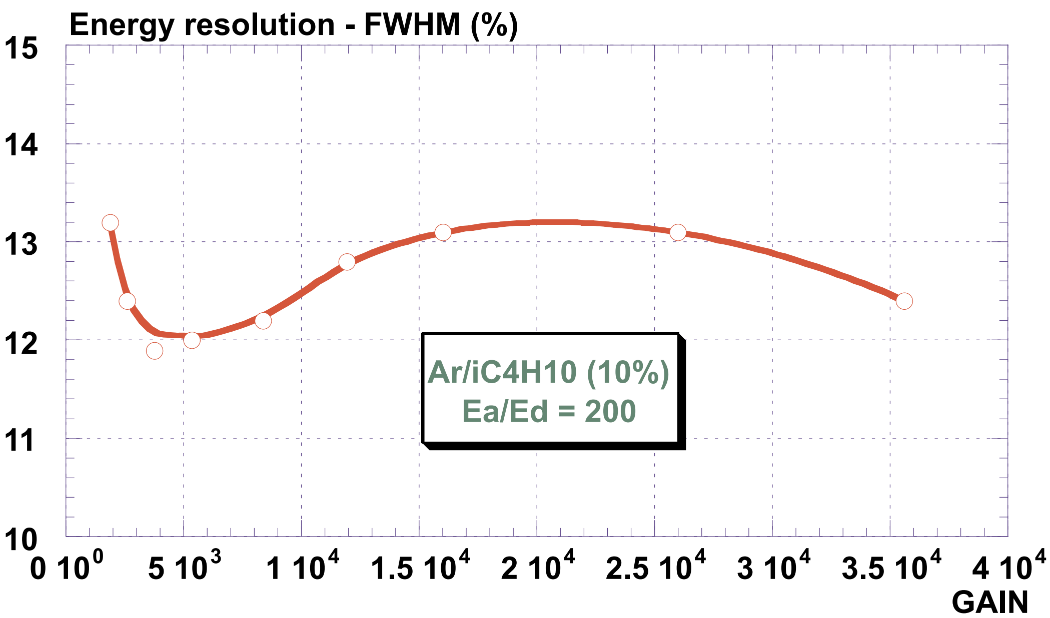

Fig. 8. Energy resolution as a function of the gain.

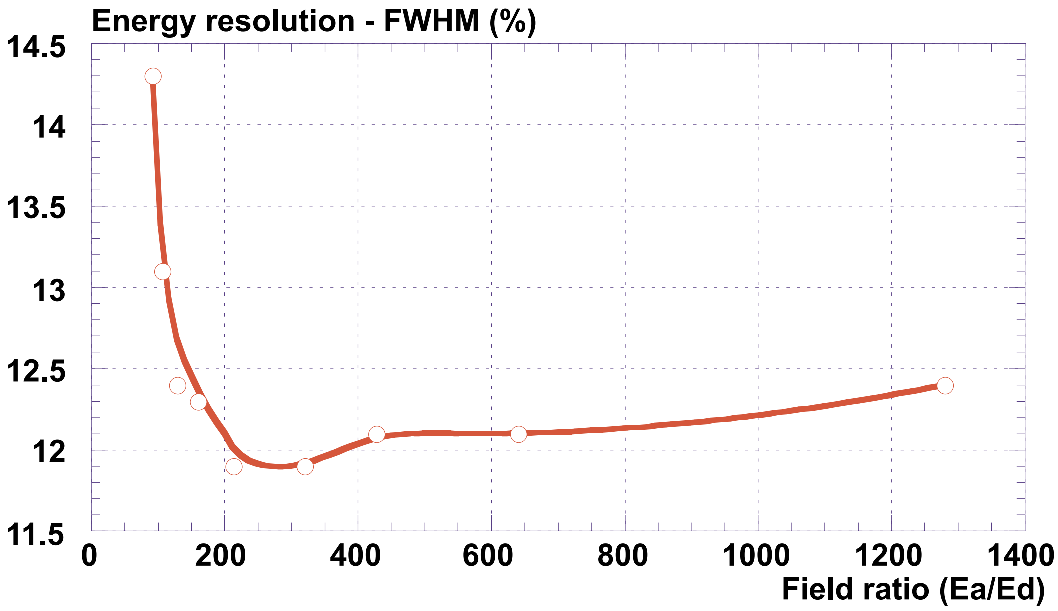

Fig. 9. Energy resolution as a function of the field ratio (ρ).