CPC(HEP & NP), 2010, **34**(10): 1636–1638 **Chinese Physics C** Vol. 34, No. 10, Oct., 2010

Study of bulk micromegas detector*

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Abstract In this paper, we present a study of a micromegas detector prototype built with bulk technology. Following a short discussion of the micromegas detector's structure and working mechanism, the bulk fabrication process is described, and some testing results of the prototype are presented.

Key words micromegas, bulk, energy resolution

PACS 29.40.Cs

1 Introduction

With a small material budget, the gaseous detector is always used as the inner tracker in particle detector systems. While the new generation colliders are to be built for particle physics experiments, especially the Super Large Hadron Collider (SLHC) and the International Linear Collider (ILC), the luminosity becomes very high. The detectors are required to have a much higher rate capability and radiation resistance than before, in addition to more precise time and position resolution. The flux capabilities of conventional gaseous detectors, such as multi-wire proportional chamber (MWPC) detectors, are always limited by the positive ion space charge caused by the low drift velocity of the ion. Thus the Micro-Pattern Gaseous Detectors (MPGD) were invented in the 1990s. They solve the problem by reducing the distance between the anode and the cathode to achieve a fast induced signal.

The MICRO Mesh Gas Structure (Micromegas) is a type of MPGD, which was invented in 1996 [1]. It is constructed from two asymmetric parallel-plate parts, called the conversion area and the avalanche area, as shown in Fig. 1. Bulk Micromegas technology was invented in 2006 [2]. This fabrication method is babe made at lower cost. The Institute of High Energy Physics has been developing this method since 2007, and has made a prototype detector successfully. The processing is introduced in this paper, and some results of the prototype detectors are presented.

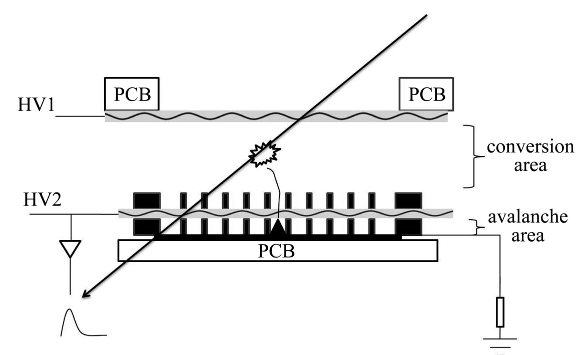

Fig. 1. A schematic diagram of the prototype detector.

After an incident particle enters the conversion area, the electric field drives the ionization electrons, which are produced by the particle to drift through the electrode into the avalanche area. In this area, the electric field is always kept to ∼40 kV/cm and is strong enough to lead an avalanche. The narrow gap is nearly 128 μm, so the induced signal collected by the anode is as fast as 150 ns. Because of its excellent abilities, such as high rate capability, good time, spatial resolution and easy product, it is widely used in many experiments.

Received 9 November 2009, Revised 12 January 2010
* Supported by NSFC (10775156)
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The bulk method is the main fabrication process for the micromegas, and it has already been used in T2K TPC [3]. It uses woven mesh from the commercial market and print circuit board technology, so the cost can be kept down and the detector can be made larger easily. In 2007, the Institute of High Energy Physics started to make the prototype detector of the micromegas. We set up a laboratory for the lithography of photoresistive films, and did some work in making the single-pad prototype bulk Micromegas. There are two main advantages of bulk fabrication:

1) The micromesh, which is used as a filter in industry, can be bought from the market. It is much cheaper and more robust than the usual electroformed nickel mesh. Furthermore, the mesh in a roll can be used in large area detectors.

2) The lithography of photoresistive films is commonly used in PCB manufacture. It is easy to expand the area and ensure the height of the spacers.

In the following sections, we will describe the fabrication process, and show some results from the prototype detectors.

2 Detector construction

Our prototype detector is made by the process shown in Fig. 2.

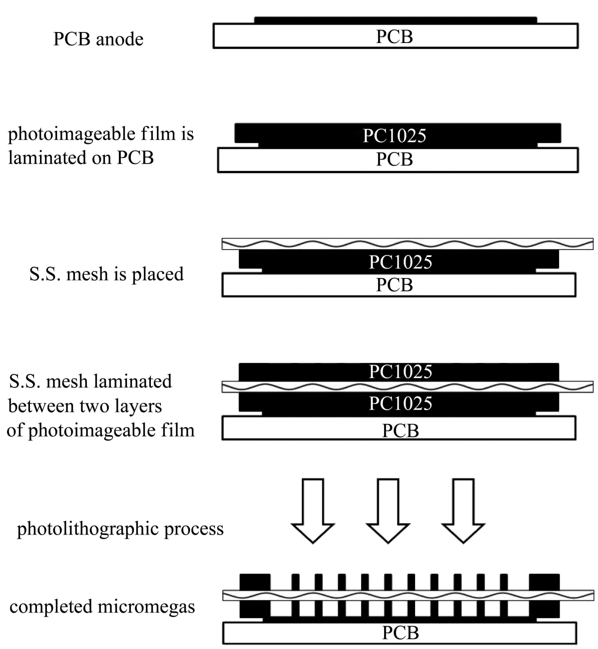

Fig. 2. The process of bulk micromegas fabrication.

The avalanche electrode is made of micromesh, which is 400 LPI (lines per inch) woven mesh, and made from stainless steel lines with diameter 22 μm. Before the start of the photolithographic process, the mesh is rolled with a roll squeezer, then stretched with the power of 2 kg/cm. These pretreatments reduce the thickness of the mesh and make the woven mesh much flatter.

The simple pad anode is made of gold with a 3 cm×3 cm area, printed on an FR4 board. The photon-resist film is PC1025@Pyralux (64 μm per sheet) produced by Dupont Company. After the photolithographic process, the micromesh is fixed to the PCB with a double layers of PC1025. The active area is 2.5 cm×2.5 cm with a diameter of 300 μm and 128 μm pillars of the photon-resist film every 2 mm. The drift electrode is made from the same woven micromesh, which is attached to an FR4 frame with a 3 mm conversion distance to the avalanche electrode.

3 Test results

In the test, a ^{55}Fe source is placed on the window of the chamber. The signal collected by the avalanche electrode is amplified by an ORTEC 142IH charge sensitive preamplifier then into the spectrum amplifier ORTEC 572 A, and acquired by an MCA of ORTEC ASPEC 927.

We have tested with two different proportions of gas mixtures: 95% argon+5% isobutane, and 90% argon+10% isobutane. Fig. 3. shows the gain curves with the avalanche voltage, and Fig. 4. shows the energy spectrum of ^{55}Fe. The gain of the detector can reach more than 10^4 and the energy resolution is better than 16% (FWHM). For other similar structure detectors, such as a T2K TPC, the gain can reach 10^4 and the energy resolution is 23% [3]. Comparing the data, we get similar gain and better energy resolution.

Figure 5 shows another plot of energy resolution with gain. To explain the plot, we first suppose that the energy resolution of the micromegas is mainly

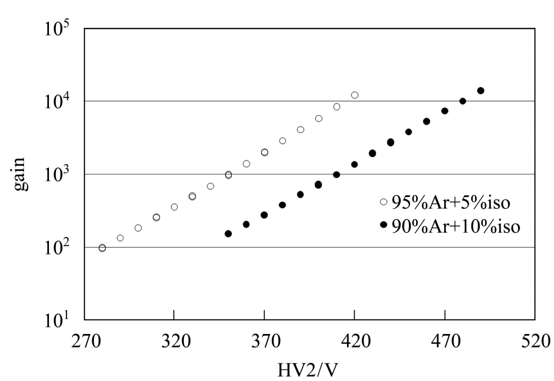

Fig. 3. The plot of detector gain with voltage.

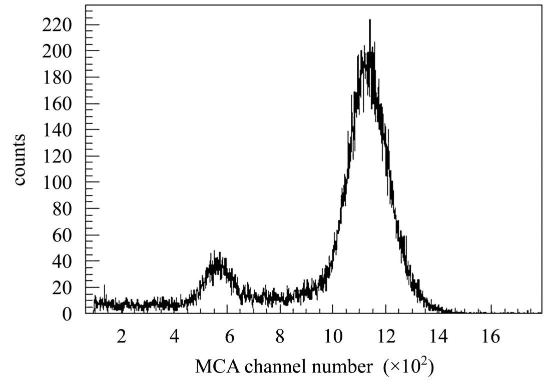

Fig. 4. The spectrum of ^{55}Fe 5.9 keV X-ray has an energy resolution of full energy peak which is 16% (FWHM). (95% argon, 5% isobutane).

affected by 3 factors:

1) The statistical quantity.

2) The sparks.

3) The leak current.

When the gain is lower than 500, the statistics determine poor resolution. While the gain is coming up to 10^3, the resolution of the gas mixture 95% Ar and 5% isobutane is better than 10% isobutane. That is mainly because with the same gain the 95% argon has a lower voltage, which causes a smaller leak current. When the gain is up to 10^4, because of the lower spark rate, the resolution of a 10% isobutane mixture is more stable than 5% isobutane.

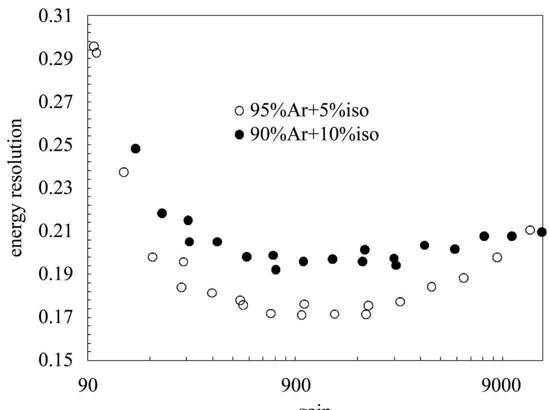

Fig. 5. The energy resolution changes with the gain.

Further testing of the prototye detector with 90% argon and 10% isobutane shows the relationship between the gain and electric fields of the conversion area and the avalanche area. The voltage of the avalanche electrode (HV2) is set to −350 V and −400 V respectively, and the drift electrode (HV1) is alterable to change the electric field of the conversion area (E_c). Fig. 6. shows that the plot of the gain and energy resolution is affected by the ratio of E_c and E_a (electric field of avalanche area). In both voltages, the maximum gain occurs at the ratio of 0.007–0.008, which means that the electron transmission is at a maximum with this field configuration.

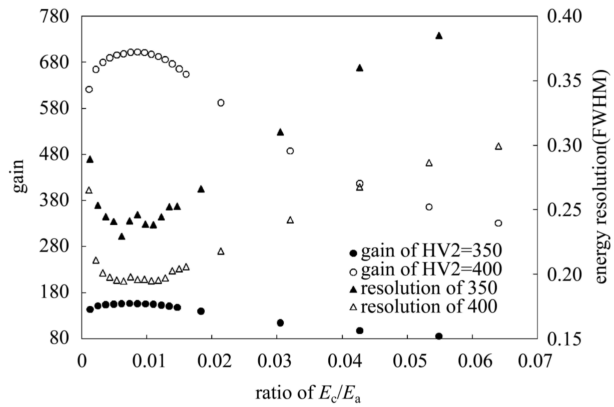

Fig. 6. The gain and energy resolution versus the ratio of E_c to E_a.

4 Conclusion

The bulk micromegas fabrication process is developed and some prototype detectors are successfully made with good results of gas gain and energy resolution. The position resolution of the prototype with strips readout is under investigation. In the future, we are going to make the larger area detector following the same method.

References

1 Giomataris I, De Oliveira R, Andriamonje S et al. Nuclear Instruments and Methods in Physics Research A, 2006, **560**: 405–408

2 Giomataris Y, Rebourgeard P, Robert J P et al. Nuclear Instruments and Methods in Physics Research A, 1996, **376**: 29–35

3 Bouchez J, Burke D R, Cavata C et al. Nuclear Instruments and Methods in Physics Research A, 2007, **574**: 425–432