Investigation of the energy resolution with a RETGEM detector*

LIU Da(刘达)[1,2;1)] LU Chen-Gui(鲁辰桂)[1,2] DUAN Li-Min(段利敏)[1;2)] YANG He-Run(杨贺润)[4]
LU Yan-Xia(鲁彦霞)[1,3] HU Rong-Jiang(胡荣江)[1] LI Zu-Yu(李祖玉)[1] ZHANG Jin-Xia(张金霞)[1]
HU Zheng-Guo(胡正国)[1] SUN You-Mei(孙友梅)[1] XU Zhi-Guo(徐志国)[1] MA Peng(马朋)[1,2]
GENG Peng(耿朋)[1,2] TANG Shu-Wen(唐述文)[1,2] WANG Wen-Xin(王文昕)[4]
ZHOU Jian-Rong(周建荣)[4]

[1] Institute of Modern Physics, Chinese Academy of Sciences, Lanzhou 730000, China
[2] Graduate University of Chinese Academy of Sciences, Beijing 100049, China
[3] School of Nuclear Science and Technology, University of South China, Hengyang 421001, China
[4] School of Nuclear Science and Technology, Lanzhou University, Lanzhou 730000, China

Abstract A novel Micro-pattern gaseous detector (MPGD), thick GEM with electrodes made of a resistive material (RETGEM) is presented. In this paper we mainly investigate the energy resolution of a RETGEM in Ar+CO_2 with different gas mixtures. The results indicate that an energy resolution 30% in single and double mode can be obtained. The existence of an optimum energy resolution is discussed.

Key words RETGEM detector, energy resolution, Ar+CO_2, single mode, double mode

PACS 29.40.Cs

1 Introduction

The gas electron multiplier (GEM) detector developed at CERN by Fabio Sauli [1], can operate at relatively high gains in pure noble gases. However, the GEM is still a rather fragile detector. It can be easily damaged by sparks, which are almost unavoidable when operating at high gain. A team at the Weizman Institute of Science developed a new version of detector called Thick GEM (TGEM) but this problem persisted [2]. Recently, a new, more spark-resistant version of the GEM was developed at CERN and INFN, in which the metallic electrode layers were replaced with electrodes of resistive material [3]. This kind of Thick GEM with Resistive Electrodes was normally called RETGEM. It is reported that RETGEM can effectively avoid the occurrence of sparks [3].

Since 2007 we have built a prototype of RETGEM from a standard PCB 1 mm thick and a hole diameter of 0.8 mm, a pitch of 1.2 mm, with 30 μm resistive layer, whose active area is 30 mm×30 mm. In this paper, we mainly investigate the energy resolution of RETGEM in different Ar+CO_2 gas mixtures.

2 Experimental set up

The experimental set up for the testing of the RETGEM detectors is shown in Fig. 1. It consists of a gas chamber in which one or two RETGEMs in cascade mode were installed and a gas system allowing the flushing through the chamber of various gases. The drift distance between the drift pad and the top of the RETGEM is 8 mm. In double mode the gap between the RETGEMs is 4 mm.

Received 30 April 2009

* Supported by Knowledge Innovation Project of Chinese Academy of Sciences (KJCX1-YW-004, YFKJCX3.SYW.N5) and Major State Basic Research Developing Program (2008CB817702)

1) E-mail: liuda@impcas.ac.cn

2) Corresponding author. E-mail: lmduan@impcas.ac.cn

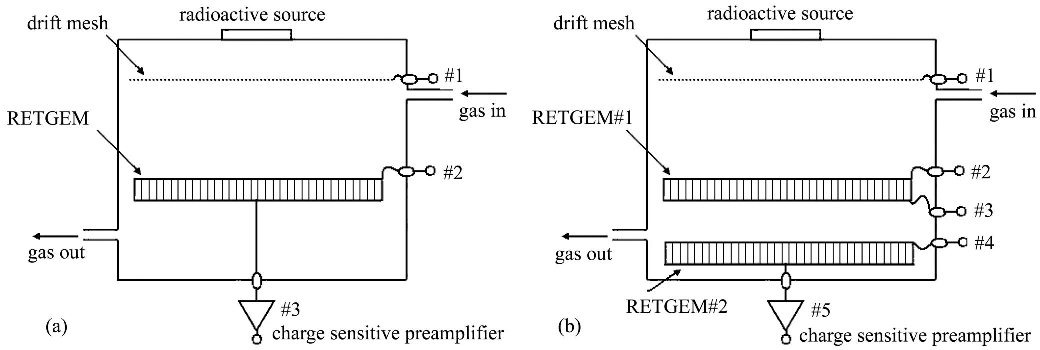

Fig. 1. A schematic drawing of the experimental set up, single mode (a) and double mode (b).

The tests were performed in different Ar+CO_2 mixtures at a total pressure of 1 atm. Measurements were performed using a ^{55}Fe source collimated by a ϕ1 hole. Signals from the detectors were recorded by charge sensitive preamplifiers Ortec 142AH.

3 Results

Figure 2 shows the energy spectrum measured in Ar+2%CO_2 with 5.9 keV X-rays with a 1540 V high voltage applied across the RETGEM. It demonstrates that the full energy peak and the escape peak of Ar can be separated clearly with an energy resolution of 28%.

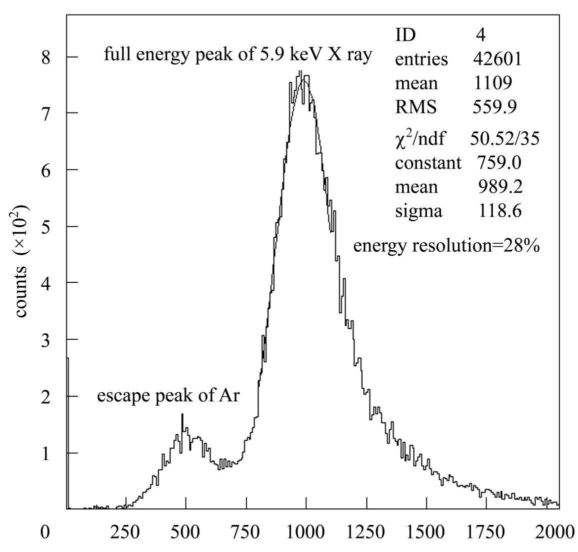

Fig. 2. The energy spectrum of a single RETGEM in Ar+2%CO_2 at a gain of 1100.

During these measurements, the voltage applied to the feedthrough #1(in Fig. 1) was −1200 V and −400 V applied to the top electrode of the RETGEM through feedthrough #2.

In order to comprehend the curve of energy resolution in detail, we show the discharge probability and the energy resolution curve at the same time in Fig. 3 and Fig. 4.

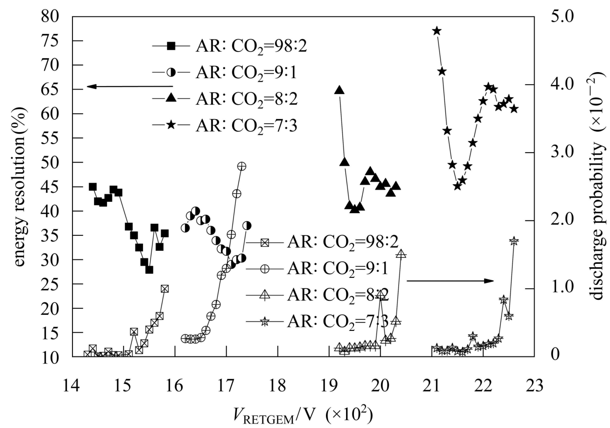

Fig. 3. The energy resolution and discharge probability for a single mode in different Ar+CO_2 gas mixtures.

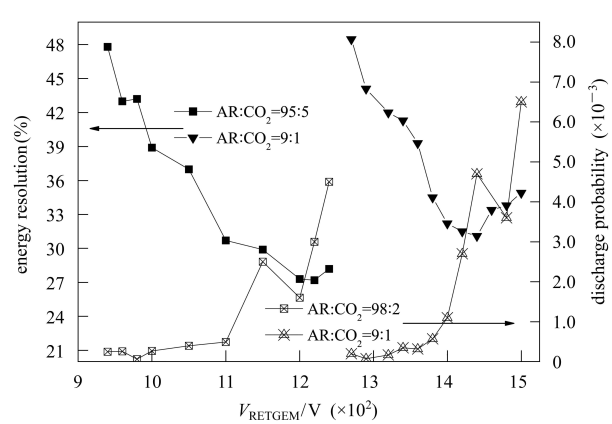

Fig. 4. Energy resolution and discharge probability vs. voltage, while operating in double mode.

Figure 3 shows the energy resolution vs. voltage applied across the single RETGEM measured in different Ar+CO_2 gas mixtures, and the corresponding gas gain is around 10^3.

One can see that the energy resolution improves with decreasing CO_2 content, and we can achieve an energy resolution of about 30%. However, we find the energy resolution changes sharply for high voltages applied across the RETGEM.

In order to get a higher gain, we need to test RETGEM in double mode. Fig. 4 shows the energy resolution vs. the voltage applied across the RETGEM#2, measured in double mode.

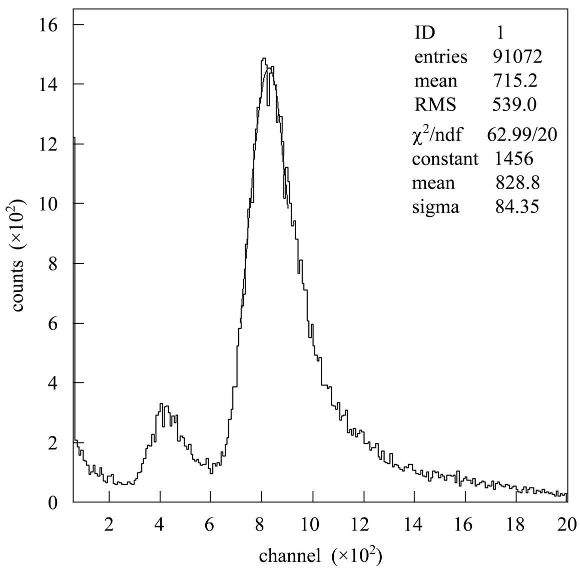

Fig. 5. The energy spectrum of double RETGEMs in Ar+5%CO_2 at a gain of 1033.

We can see that the energy resolution improves if the discharge probability is under 1%. With Ar+5%CO_2 the recorded energy resolutions can even fall below 30%. One of the energy spectrum measured in Ar+5%CO_2 is shown in Fig. 5, an energy resolution of 27% FWHM is recorded with 5.9 keV X rays.

4 Conclusion and discussion

Preliminary experimental results presented in this paper have proved that RETGEM made with industrial PCB can reach rather good energy resolutions.

Figure 3 and Fig. 4 show that the energy resolution can be improved by the reduction of CO_2 in the gas mixture and a value of about 30% can be obtained; however, the energy resolution changes rapidly. The reason for this may be as follows: At first, we can't separate the escape peak of Ar and the full energy peak of the 5.9 keV X rays because of the low voltage applied across the RETGEM detector. Then the energy resolution is above 40%; with the increase of the voltage applied across the RETGEM detector, the two peaks will be slowly separated and improve the energy resolution. A further increase of the voltage will lead to more frequent discharges and worsen the energy resolution. Therefore there should be an optimum point in the curve of the energy resolution.

In double mode the energy resolution curve has a much better behavior, especially for Ar+5%CO_2, one can achieve energy resolution below 30%.

In conclusion, we would like to note that the achieved energy resolution of around 30% is sufficient for the RETGEM. Thus we believe that the RETGEM has a good potential for many applications, for example in the time projection chamber (TPC). Certainly, more tests would be needed to apprehend the performance of the RETGEM in detail.

References

1 Sauli F. Nucl. Instrum. Methods A, 1997, **386**: 531
2 Chechik R, Breskin A, Shalem C et al. Nucl. Instrum. Methods A, 2004, **535**: 303
3 Oliveira R, Peskova V, Pietropaolo F et al. Nucl. Instrum. Methods A, 2007, **576**: 362