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Development of "Thick" gas Electron Multipliers (TGEM)

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ABSTRACT

In this paper present the results of the development and testing a prototype TGEM with an sensitive area of 15×15 mm2. As a basis of GEM-like structure was selected the 1.6mm.plate from two-side Cu foil fiberglass. After a simple method of drilling and treatment this plate with holes was subjected to test for electric breakdown and leakage current in air. Then a device was placed in sealed body for testing in the gas mixture from 75% Ar+25%CO2 under alpha particles irradiation. The measurement data of electrical breakdown and leakage current in open air, the range of operating voltage in the avalanche multiplication of electrons in the gas mixture as well as the time and amplitude of the pulse signals show a good agreement with the similar data detectors of this type.

Introduction

The Gas Electron Multiplier (GEM) was invented by F.Sauli in CERN in 1996 year[1].Being the representative of a class the Micropattern Gas Detector (MPGD), that is wireless structure, GEM excluded influence of photons on formation of secondary avalanches, limited the application of gas detectors. Reproduction of electrons in devices of GEM-like type had to happen in stronger electric field in one hole. The main defect of all gas detectors which is occurred at a large gas gain was overcome thanks to such solution. This symbiosis from the best properties of wire gas detectors, the microstrip gas chambers and microchannel plates has to improve the high rate abilities and other properties of gas detectors significantly.

It is necessary to consider also that at simplicity of a design and a high reliability of this device. As a positive factor it is to point out the absence of freons and fire-dangerous additives in gas mixtures with agreement of ecology requirement.

The most extensive studies have been subjected to GEM –structures made from Kapton metalized foils [2].The diameter of the holes produced by etching varied from 50 to 70 microns. The gas gain in holes reached a value of 10^4 in single-step GEM and the size of 10^6 in the cascade of 3-4 steps of GEM. Further development of the GEM was performed as a standard technology of drilling of 1mm.holes in the fiberglass plates of 2 mm. thickness with double –side metal Cu cover [3-4].Made so "thick" GEM (TGEM) have low gas gain , but in combination with the respective emission convertors may widely used to detect the Cherenkov light, neutrons, X-ray, charge particles, etc. The possible application of TGEM proposed in paper [5], which deals the project of the development of cryogenic avalanche detector operating in the gas proportional mode at a low temperature in the experiment on the search of "dark" matter.

The main advantage of TGEM is defined by their simplicity of manufacturing, low commercial cost and high sensitivity to single events of alpha particles or radon in the process of monitoring of the open spaces with a many people: airports, railway stations, forest and etc.

Design of TGEM

Detailed description of the structural elements of GEM, TGEM and other detectors developed on this basis for a wide range of experiments in the different areas of researches is shown in paper [6-7].The following are the results of the basic information of the topic relating to the design of TGEM as most simple and accessible method of reproduction in the laboratory conditions of the wireless or hole type gas chambers.

The standard TGEM as well as GEM in our case is a two-side metal foil fiberglass plate having a lot of holes, (fig.1).The holes are in the shape of double cone and arranged in a hexagonal matrix with a pitch of 1.5 mm. Dimension of the hole shows separately as a close-up. High voltage is applied between the upper and lower metal parts of the plate. In this case a strong electrical field is formed with the strength of 10-40 kV/cm. enough to trigger a multiplication of electrons by means of avalanche process in gas.

Absence of photon feedback between holes and rapid retain of the positive ions provides great advantages in operation of TGEM over other types of gas detectors. Considering also a possibility of collection of the induced charge from the signal electrode divided by the induction gap from the area of electron amplification it should be recognized the high degree of protection of the device from breakdown. The transverse dimension of the induced signal is large enough to improve the spatial resolution in the reading method of finding the center of gravity of the induced charge.

Below are the main parameters of a TGEM according to the modeling and calculation of the electric fields and the geometry of the electrodes:

= 2 ÷ 10 ns
=0.4
=10

3. Results

Fig.3 shows the dependence of a leakage current between upper and lower electrodes of TGEM when applying a high voltage in air. Result of this test provides a preliminary assessment of the surface of the holes for the presence of burrs, sharp and other contaminations. Correcting after drilling is performed by means of making the cone in all holes on both side of fiberglass plate.

From the physics of the gas discharge is known that breakdown voltage between electrodes in the air with this configuration the amount 25.6 kV/cm. In our geometry with a thickness of a plate equal 1.6 mm. the breakdown voltage must not be less than 4.1 kV. From the shape of the curve it shows that this condition is almost satisfied.

Fig.4 presents the dependence of the pulse amplitude versus of voltage difference between TGEM electrodes. Test was performed with one-step TGEM in a gas mixture of 75%Ar +25%CO_2 by irradiation of alpha particles. It is seen that the avalanche multiplication starts at a voltage difference equal 2.1 kV and extends to value of the order of 3.0 kV. The amplitude of the pulse reaches 16 mV.

Conclusion

The measurement data of electrical breakdown and leakage current in open air, the range of operating voltage in the avalanche multiplication of electrons in the gas mixture as well as the time

and amplitude of the pulse signals show a god agreement with the similar data of detectors this type [8-9]. This device can find application in several fields, for example, as the dosimeter of alpha particles and trace of radon, or monitor of the medical beams, thanks to simplicity in mass production and safety in the operation.

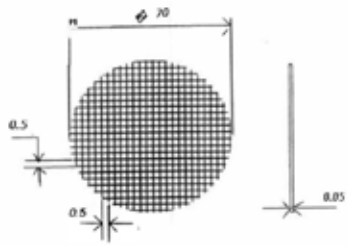
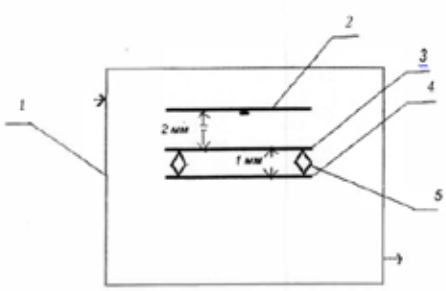


Fig2. The geometric dimensions of the metal greed



Fig3. The current-voltage characteristic of the detector type GEM in air



Figl. A schematic view of the open detector

1-body with inlet and outlet for the air or gas mixture

2-plate with alpha partic/es

3-greed-anode

4-greed-cathode

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