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Monitoring of Residual Ionization in Ambient Air by Thin Proportional Chamber.

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Abstract

This article presents the results of the research of determining the residual traces of the alpha and other types of ionizing radiation, using a thin multiwire proportional chamber operating in pulse mode in an exposed environment. The need for such detection arises in many spheres of human activity in both scientific and in social fields. Along with the development of the well known monitoring by integral and pulse ionization chamber, as well as the latest devices such as microstrip and hole electron multipliers is proposed here to consider an improved version of thin multiwire proportional chamber. This design provides a low noise threshold of traces of residual radiation at the level of 10 pA, thus preserving the signal-to-noise within a wide measuring range, starting with pulse mode ionization chamber up to Townsend avalanche multiplication gain of the order 10^4 without entering to corona discharge region. In this way can, for example, to register traces from the alpha particles with sensitivity at the level of 20 Bq/m^3 in duty of one hour measurement, which in several times better readings of industrial monitor under similar conditions.

Keywords:

Ionization Chamber, Multiwire Proportional Chamber, Electron Multiplication, MSGC, GEM, TGEM.

Introduction

The issues of detecting radioactive contaminations in the ambient air were always under the scrutiny of experimental physicists for accelerator halls and in applied researches. As the measuring devices are widely used ionization chambers working in current or pulse mode and multiwire proportional chambers with a gas multiplication [1.2]. In the last two decades has expanded rapidly microstrip gas chambers (MSGC) and hole gas electron multipliers (GEM, TGEM) for such researches .[3.4]. Their advantages respected to a number of indisputable features, for example, the lack of sagging and aging of the wires in long time, as well as the independence of the amplifying zones from the effect of positive ions during their drifting to the cathode electrodes.

At the same time we must recognize, that the possibilities of multiwire proportional chambers is far from exhausted. Especially attractive is their higher sensitivity to registration of tracks from minimum ionization particles with an energy threshold up to 0.3 MeV/nucleon compared to above mentioned MSGC and GEM or TGEM. [5].

The open gas detector, operating with gas multiplication.

The open or without walls detectors operating at air with electron multiplication have considerable advantages in comparison with the gas proportional counters or Geiger-Muller counters [6]. The open detector is the unique device for the account in one run of the low energy electrons or beta radiation, and alpha particles, x-ray and gamma radiations also. In the open detector electrons move as negative ions of oxygen towards positively charge anode. At the according potential difference between electrodes it is possible to reach such intensity of electrical field at which a separation of an electrons and its avalanche reproduction are occurred. In this case dead time of the detector will be defined by a sum of duration of ion drift time until a separation of an electron and time of time of interrupting of discharge by mean of electrical chain. The number of negative ions coming to area of electron avalanche multiplication is depending on number of impacts with air gas molecules. Therefore the velocity of the account of the charged particles registered by the detector is established in a wide interval from 1 to a maximum depending on a type of radiation and high voltage between electrodes. In this case the high speed ability of the detector of this type considerably surpasses value which is a characteristic for the ionization chambers discussed above. It should be note also that efficiency of registration, for example, alpha particles on air in the avalanche mode at the high level of coefficient of gas multiplication can reach a value of 100% independently from air humidity [7,8].

The main advantage of the gas detectors operating in the pulse mode at air is defined by their simplicity, low cost and high sensitivity to single events. One of possible applications this type of devices is the monitoring of the background from traces of alpha particles and other types of radiation. Owing to low cost of manufacturing and simplicity of using they can be served as sensors of radon both in the closed office rooms and in the open spaces where are many people: airports, railway stations, forest and etc.

This work has propose to continue research of possibility of operation of the thin gas proportional chamber with low level of noise for registration of the trace from ionizing particles with energy threshold order 0.3 MeV/nucleon.

The design of a thin proportional chamber.

The construction of a thin proportional chamber is shown in Fig.1.It was designed to achieve a minimum dark current level 10pA to register the traces of ionizing particles with minimum energy of about 0.3 MeV/nucleon. It is known that one of the main sources of noise in gas detector are the electrode surface leakage currents. For this reason proposed design provides for the observance of fundamental conditions, namely that the length of the path of flow of the surface currents of electrons and ions should be at least 30 mm. The surface resistance of the dielectric must be at the level of 10^{16} Ohm·cm.

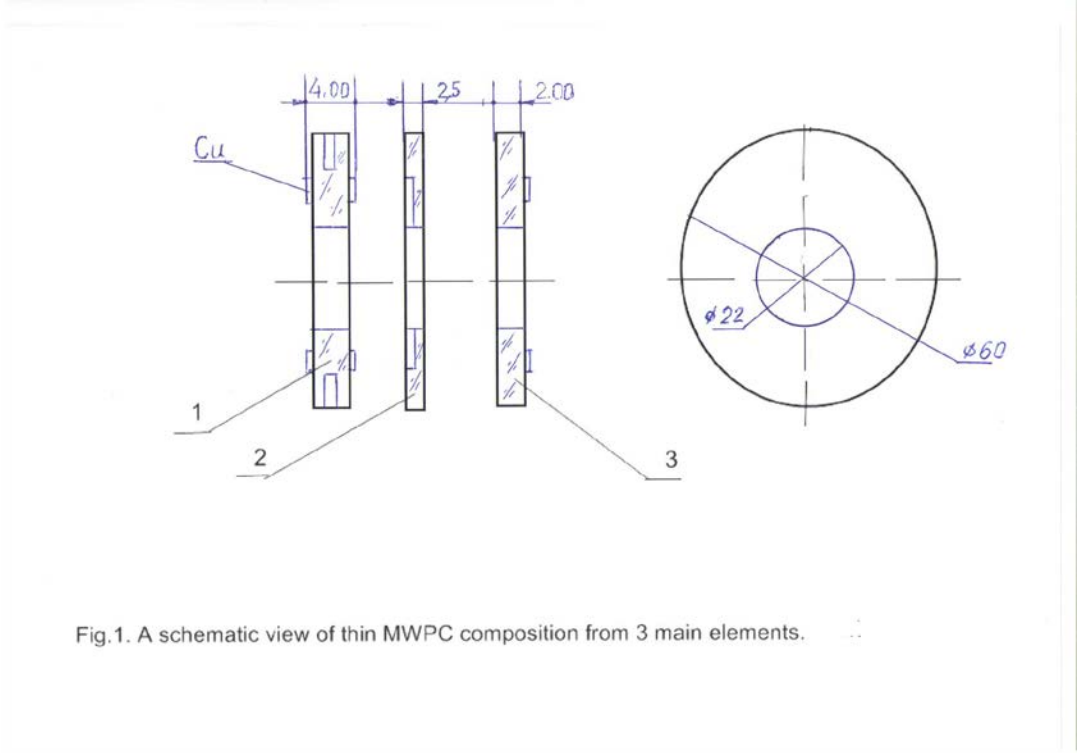
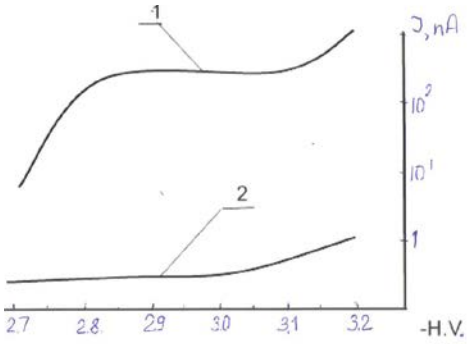


Fig.1. A schematic view of thin MWPC composition from 3 main elements.

Element 1 of this design is the one of the base electrodes in which one side is soldered the cathode wires of beryllium bronze with a diameter of 50 micron and pitch of 1 mm. Anode wires from gold-plated tungsten with diameter of 20 micron are wound on the other side with a pitch of 2mm.

Element 2 is a dielectric spacer between the anode plane and the second cathode plane which is marked as item 3. Winding the wires on it made orthogonal to the direction of anode wires on the element 1.All the elements are pulled together by means of 4 pins. After assembling in the package the gap between cathode and anode electrodes must be equal to 4±0.02 mm.



d leakage current of thin MWPC in gas mixture Ar+20% CO2
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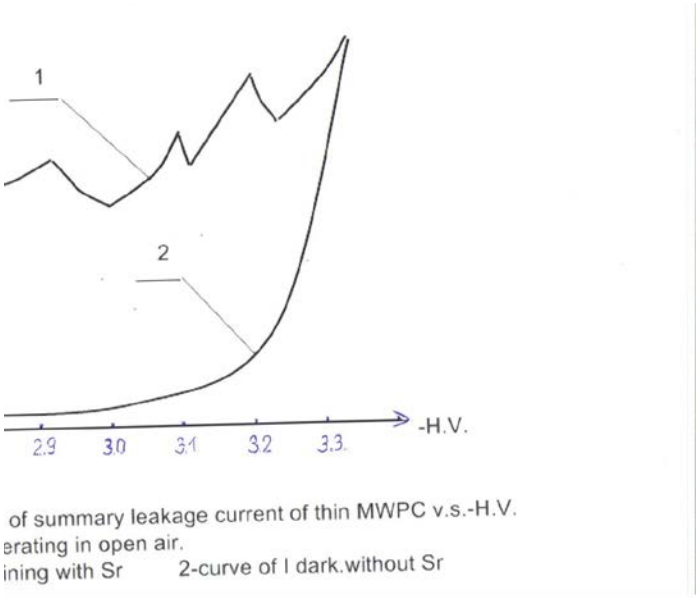
In Fig.2 shows the current-voltage characteristics of this device measured in ambient air. Curve 1 refers to results obtained within a time step by step increasing of negative high voltage on cathodes. The detector was irradiated by beta radiation from Sr^{90} .The view of curve is

explained by process of wire training in the regime of a negative corona [7].Curve 2 obtained after end of training without beta source.



of summary leakage current of thin MWPC v.s.-H.V.
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In Fig.3 shows the curve of the efficiency of registration with beta source of Sr^{90} in the gas mixture Ar+20% CO_2 for confirming of the good state of the detector. We can see that plateau of efficiency reaches the value of about 250 volts indicating a well -chosen design of the detector to compare with previously samples. The curve 2 shows the value of the dark current when detector operates without a source of radiation.

Discussion.

This article describes the results of a study of the characteristics of a thin gas wire detector, operating in proportional amplification mode in the environment air. Taking into account , that a range of alpha particles in air space of approximately 4 cm, it has developed a detector design that enables a scanning of the surface with residual radiation to a level not higher than 60 KeV. This requirement is met by using a device with the sensitivity current threshold of not more than 10 pA. Given results in this work reveal that this requirement was satisfy by use of the method of train with help of corona discharge in electronegative gas [8].

In addition this method allows a calculation of the voltage limit, which corresponds to a given geometry of the electrodes to prevent a spark breakdown.

It should also be noted that due to the high sensitivity and the simplicity with a low cost of manufacturing such devices may find wide application for the detection of traces of alpha particles, high energy electrons, photons and X-rays.

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