In noble gas detectors of Dark Matter particles (WIMPs) of current generation, detection of scintillation and electroluminescence is performed by photomultipliers (PMTs). In future Dark Matter experiments, with increasing sizes and masses of detectors and reduction of radioactive background of experimental setups down to the ultralow values of 1 event/100 kg/year a question will arise on replacement of the PMTs, which are currently the most radiosensitive elements to less radioactive photodetectors. Several experimental groups, which develop detectors for the Dark Matter experiments, are investigating new semiconductor devices — micro-pixel avalanche Geiger photodiodes, MRS APD (the widely used names are: SiPM, MPDC, MPPG). These photo detectors operate at a single photon counting mode and may replace PMTs in future because they are expected to contribute the negligibly low radioactive background in comparison to the PMTs. Moreover, they are very thin. MRS APD can be assembled in a matrix with a ratio of active to total area of about 70-80% due to spacing between elements, package borders and places for contacts bonding. The cost of the matrix of the MRS APD is currently nearly approaching the cost of the PMTs with the equivalent area.

The main obstacles now for replacement of the PMTs by them are the lack of sensitivity in the VUV region of luminosity of noble gases and the high intrinsic thermionic noise level (in comparison with the noise level of the same area PMT). These obstacles do not allow one to build a large-area photosensitive plane for detection of the scintillation signal. However, these photodetectors, apparently, could be used for detection of the electroluminescent signal from the very low-energy events. Elegant system comprised of MRS APD together with a wavelength shifter (WLS) and a thick gas electron multiplier (THGEM) could be used for Dark Matter experiment.

Additional amplification of the change in the THGEM holds the large light signal of electroluminescence detected with an array of MRS APD. This realist system provides the min accuracy for the very low-energy events, that is important for reliable separation of the rare physical events from the background ones caused by spontaneous emission of the electrons from the liquid noble gas surface.

MRS APD

The very first Metal-Resistor-Semiconductor APD (MRS APD) SIMP was inserted in USBB in 1989. The idea was born as a result of the observation of the effect of avalanche multiplication on a common silicon substrate caused by supply voltage above the value corresponding to the initiation of a breakdown to reach high voltage. During discharge the subsequent voltage drop across the individual contacts (resistor layer) leads to the avalanche growing and to localization of the discharge in the dead ionization microroles, while the rest of the photosensitive structure remains in the working state.

Since the Geiger discharge grows much faster than electron transit time from the substrate, for a given discharge, the current is different for different substrates. The current sensitivity of the THGEM is defined by the minority carrier lifetime in the laser wavelength range (green). For THGEM, the lifetime was measured in the wave length range from 180 to 350 nm. The peak corresponding to the S0 => S2 transition has shifted from 308 nm to 306 nm. Since absorption and fluorescence spectra of molecular crystals are usually slightly different from those of molecular solutions, we have studied absorption of a data (50%) polyethylene(polyethylene) layer vacuum deposited on a fused silica optical window. The absorption spectra have 2 main components, one at the wavelength 308 nm=209 nm=266 nm=5=1 cm1=2 and the other one at the wavelength 308 nm=209 nm=266 nm=7=1 cm1=2 due to multiphoton processes.

Wavelength shifter

A pair of 0.4-0.6 mm/thickness have been chosen as a wavelength shifter. Absorption spectrum of a molecular solution of terphenyl in heptane has two maxima: at 256 nm, with an extinction coefficient of 1.5 x 104 cm1 mol1 and at 260 nm, with an extinction coefficient of 1.0 x 104 cm1 mol1. These maxima correspond to the singlet transition (S1 => S0) and the triplet (T1 => S0) at 273 nm=260 nm=7=1 cm1=2 respectively, the pumping process is sufficiently long. On the other hand, the long pumping is required to decrease the decay time of the excited state. The pumping process is sufficiently long. On the other hand, the long pumping is required to decrease the decay time of the excited state.

Data analysis and results

Data analysis included event by event calculation of the areas of the recorded signals from the MRS APD to the analysis of the data and the area distribution. A ROOT code was used for the analysis. Typical waveform of signals from both the PMT and from the MRS APD are shown in the figure (a). The data analysis included event by event calculation of the areas of the recorded signals from the MRS APD. The correction was made with a formula: Ncell=0.53A0.2fcell for cell management.

Components of the detector

The recently developed gas-electron multiplier (GEM) consists of a film polyethylene foil, coated on one side, and subjected to a high voltage of 10-30 kV. With a potential gradient applied, it is a powerful preamplifier for electrons released by ionizing radiation in a gas. The advanced form of GEMs, called hexapoles, are high resolution in excellent spatial resolution; good imaging capability, operation in magnetic fields, large sensitive area, flexible geometry and low cost. Anode geometry of a GEM, as compared to other micro-pixel detectors, is relatively simple to operate in cascade.

Results

Double GEM

The typical current-voltage characteristic of MRS APD is shown in figure 1. The first two prime factors are shown in figure 2. The third factor is shown in figure 3. The avalanche gain for MRS APD is shown in figure 4. The avalanche gain is shown in figure 5.