Fundamental experiments for development of hybrid detector using APD and MCP

*Hinako Kataoka[1], Seishiro Tanaka[1], Masafumi Hirahara[1], Satoshi Kasahara[2]

1. Tokai National Higher Education and Research System, 2. The University of Tokyo

Avalanche photodiode (APD) has an internal amplification gain and can detect electrons of several keV (≧ 5 keV) by enhancing the signal pulse height. For the exploration in geospace (ERG) mission, Kasahara et al. designed an electron sensor (MEP-e) composed of a cusp-type electrostatic analyzer (ESA) and APDs for the measurements of medium-energy (~7-87 keV) electrons in space. Since the pulse height of the signal of APD is almost proportional to the energy of incident particles in the medium energy range, the energy analysis of incident particles can be performed independently of the electrostatic energy analyzer. This also has the advantage of helping to reduce the background in observations in harsh radiation environments.

The microchannel plate (MCP) is a high gain amplifier for particles and photons. The gain of MCP depends on the operation voltage, and a high voltage (a few kV) is required to detect particles. MCP is sensitive to low-energy particles and is used to detect low-energy particles. Since MCP cannot identify incident particle species and detect energy, it is used in combination with an electrostatic analyzer to discriminate particle energies. However, if high-energy particles penetrate the analyzer structure and reach to MCP without energy analysis, MCP accidentally generates noise. Therefore, we are conducting fundamental experiments for the development of hybrid detector using MCP and APD in order to discriminate the penetrating high-energy particle energies and remove their noises based on the energy analysis results by APD.

We aim to detect a wide energy band (1 eV-100 keV) by combining a 1 or 2-layer MCP, APD, and low noise charge amplifier as the hybrid detector. The following advantages are expected for the hybrid detector: By detecting high-energy particles by APD separately from MCP, the noises caused by high-energy particles are discriminated and removed. The voltage required for the case of 1 or 2-layer MCP could be kept lower than common 3-layer MCP cases.

We first combined a 3-layer MCP and APD into a hybrid detector, and performed experiments to irradiate it with an electron beam. MCP is on the front side for incident particles and APD is attached behind it. We confirmed the characteristics that the total charge of the electron cloud increases as the operation voltage increases. Currently, we are conducting experiments by combining 1-layer MCP and APD, and we have been verifying electron clouds ejected from MCP and signals generated by particles that penetrate MCP and enter APD, independently.

