

Solid State Detection of Medium-energy Electrons for Space Plasma Missions

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The information on energy spectra of 1-100 keV electrons is expected to provide an important clue to understand heating and acceleration mechanisms of magnetospheric plasmas, because distribution functions of electrons vary over from the thermal one (several keV) to the non-thermal (100 keV) in this energy range. The reliable measurement of electrons in this energy range is important and connected directly with verifications of the scientific paradigm in the magnetospheric physics, such as the particle acceleration by magnetic reconnection and physics of the collisionless shocks, etc. Therefore, more detailed observations of non-thermal electrons in these regions are indispensable to clarifying the acceleration and heating mechanisms. However, electrons of several keV to several tens of keV are not properly verified by observations owing to the problems in the measurement techniques. This study aims to bridge this 'gap' by applying Avalanche Photodiodes (APDs) to the detection of electrons. The APD is a kind of p-n junction semiconductor with an internal gain due to the avalanche amplification. Electron-hole (e-h) pairs are created as a result of dissociations by injected electrons. These e-h pairs will be accelerated in the strong electric field inside the APD. If getting sufficient kinetic energy, electrons or holes create other e-h pairs in a 'avalanche' way. This gain enables high-resolution detection of low-energy electrons of several keV. In previous researches, we have tested several APDs (produced by Hamamatsu Photonics Co. Ltd.) with an electron beam up to 40 keV. The APD responded to 2-40 keV electrons with the fine peaks of the output pulse height distributions. The energy resolution is lower than 1 keV for 2-20 keV electrons and 5keV for 40keV [Ogasawara et al., 2006]. Additionally, the linearity of the response is also good. The lower limit of detectable energy is typically dominated by the depth of the surface 'dead' layer where created charges are not corrected. The highest energy limit is determined by the thickness of the active 'depletion' layer inside the APD. Then we developed an APD that has thicker active region (140 microns), and succeeded to detect 200 keV electrons with a good energy resolution [Ogasawara et al. in preparation]. However, the lowest detectable energy is limited to 10 keV. In this presentation, we talk about the latest result of a new APD having both a thin dead layer and a thick depletion layer. This would cover the whole of the medium-energy range in need. Some possible applications in view of future space plasma missions are also shown and discussed.