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Development of a Measurement Technique for Medium-Energy Electrons

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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 reconection 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 dissosiations 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. We have tested an APD (Type spl 3989, 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 hight distributions. The energy resolution is lower than 1 keV for 2-20 keV electrons and 5keV for 40keV. 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. According to a Monte Carlo simulation of particle transport inside the APD, electrons up to about 60 keV are expected to be well detectable.