中間エネルギーイオン計測に向けた半導体素子の性能評価

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Performance evaluation of a single-sided strip SSD for medium energy ion measurements

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In the past decades, space plasmas have been extensively investigated by satellite-borne in-situ measurements. They revealed that charged particles have a broad energy range from less than 1 eV up to more than 10 MeV and they form a number of plasma structures in the earth's magnetosphere. However, processes of acceleration, transports, and losses in the magnetosphere are not fully understood. For instance, the earth's ring current ions are characterised by energies of ˜10-˜200 keV, while typical energies of ions in the ionosphere and solar wind are considerably lower (less than 1 eV and ˜1 keV/nuc, respectively), though they are considered to be the source particles. Thus build-up processes of the ring current are the subjects of intensive research. For investigations of the transport processes and energisation mechanisms of ions, important quantities are energy (E), mass (m), and charge state (q) of each ion. Mass and charge state of each ion provide information on their origins (solar wind or the terrestrial ionosphere). Furthermore, measurements of their three-dimensional distribution functions are significant, since non-gyrotropy and temperature anisotropy of ions are thought to be relevant to the acceleration and the wave generation. However, despite such importance, measurement techniques of medium energy (10-200 keV) ions are not well established due to technical difficulties. In order to obtain above information at future magnetospheric missions (such as ""ERG"" and ""SCOPE"" missions), we have been developing a new energy-mass analyser; we think of the combination of a cusp-type electrostatic analyser (ESA), a time-of-flight mass spectrometer (TOF), and solid-state detectors (SSDs). They can simultaneously and independently measure energy-per-charge (E/q), velocity (v), and energy (E) of incoming ions, respectively; E, m, and q can be deduced from the above values. Incoming directions are decided from detected positions. The ESA has sufficient sensitivity to acquire ion 3D distribution in less than one minute during magnetic disturbances. The TOF unit has been designed to be suitable for the electrostatic analyser. It detects start and stop electrons by a single unit of MCPs, which enables a simple, light, and small sensor system. Our SSD is a single-sided strip type; the p-side (backside) of a silicon chip is divided into 32 strips and signals are detected independently. This kind of SSDs can lower background noises, since the levels of some kind of noises are proportional to the area of surfaces. We have checked the performance of test model SSD through laboratory experiments; the response to some ion species has been experimented, and the dead layer thickness has been estimated as ˜200 nm.