Development of ion monitor system with stacked CMOS active pixel sensor(SCAPS)

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Some primitive meteorites and interplanetary dust particles (IDPs) exhibit large excesses in deuterium and/or 15N relative to terrestrial values. However, there are a few reports about isotopic anomalies in meteorites by in situ measurements. The small sizes of the particles make it difficult to identify in the meteorites.

Hence isotope mapping is the most effective method to survey isotope anomalies about a large area in the meteorites.

The conventional two-dimensional detection system uses a micro channel plate/florescent screen which transforms the mass-resolved secondary ion signals into visible light images which are subsequently digitized using charge coupled device (CCD) camera.

Although SIMS in ion microprobe mode has been used to many isotopic analyses, ion microscopy has seen limited use in the quantitative image depth profiling of semiconductor materials. This is largely due to nonlinearity of response of the imaging detection system (Hunter et al., 1991). It is necessary for complicated correction procedures relating micro channel plate/CCD image intensities to secondary ion intensities.

An integral-type solid-state image sensor for charged particles, called the stacked active pixel sensor (APS), has been developed for charged particles (Matsumoto et al.,1993).

The operational principle of APS is based on detecting the change in the potential of a floating photodiode caused by the irradiation of charged particles. As the pixels, simultaneous two-dimensional detection for charged particles and for soft X-rays can be achieved. The capabilities of the APS have been demonstrated for ions, electrons (Yurimoto and Matsumoto, 1996), and soft X-rays (Takayanagi et al., 1995).

The APS has several advantages over conventional systems including two-dimensional detection, wide dynamic range, no insensitive time, direct detection of charged particles, constant ion sensitivities among nuclides, and a high degree of robustness.

Conventionally, the SCAPS detection system has been developed to raise the precision. We have developed the ion monitor system with SCAPS with a focus on speed. The signal charges decrease continuously with speed. So we used MCP in order to increase the charges.

The ion monitor system consists of SCAPS device, a driving pulse circuit, a readout circuit, and a host computer. A driving pulse circuit is connected to SCAPS through a readout circuit by a circuit generating a pulse to drive SCAPS. The SCAPS needs five kinds of voltages such as the power for the SCAPS, the reset bias, the drain voltage. A host computer displays the data which through an A/D converter to a monitor. The A/D converter has resolving power of 12 bits and drives it by readout frequency 4MHz. 27Al+ are irradiated which had energy of 4.5keV using secondary ion mass analysis spectrometry IMS-3f (Cameca instruments) on the SCAPS. 27Al+ converted into electrons by MCP irradiated to electrodes of SCAPS, and interacting with the electrode surface, electric charges will be accumulated by capacitor of SCAPS.

The electric charge that accumulated begins to be read through a readout circuit, and it is computerized after it was converted A/D into, and it is displayed by a monitor.

When the electron is irradiated in SCAPS, a secondary electron occurs from SCAPS electrode. This secondary electrons give big influence to quality of a provided image, but was able to control it by modulating applied voltages into MCP. The voltage values to be most suitable for ion monitoring are input side -880V and output side +20V.

As for the readout speed, An ion image with scanning frequency 4MHz per a 1 pixel was acquired stably. Because SCAPS can drive with 20MHz, and a maximum sampling rate of the A/D converter is 5MHz, the rate-limiting factor is processing ability of a computer drawing an ion image.

It is expected to increase frame rate by performance improvement of a computer in future.