High Sensitive Ion Imaging System using Direct Combination of Stacked-type Solid-State Imager and Microchannel Plate

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Imaging system for ions and electrons of keV energy level is useful for instruments for surface analysis. Recently, a direct imaging system capable for charged particles has been proposed. This system is suitable for precise isotopic imaging for long accumulation time with slow readout. In this study, an ion imaging system operated in both high sensitive and high precision modes has been developed using a combination of stacked-type solid-state imager (SCAPS) and microchannel plate (MCP) .

The SCAPS is an integral-type 2D detector with 576 x 600 independent pixels that have several advantages including direct detection for charged particles, low dark current, wide dynamic rage, no insensitive period, and high fill factor. However, the readout noise is equivalent to about three incoming ions for a pixel. In order to detect single incoming ions, a MCP is settled in front of SCAPS device to amplify the incident ion signal. High speed readout electronic circuit of 10 image frames per sec has been also applied for the system. A noteworthy feature of new system is that the MCP devise is removable from the SCAPS and re-mountable onto the SCAPS in vacuum. This mechanism enables to switch the system from high sensitive, high speed mode to conventional high precision mode and vice versa.

The vacuum chamber of this system is composed of MCP movement unit, SCAPS cooling unit with liquid nitrogen, multipin-mini-electronic feedthrough specially ordered for the SCAPS package, electrical driving circuit for SCAPS at the atmospheric side.

New electronics is applied to operate both high and low speed readout modes. The electronic system is composed of voltage supply circuit, pulse generator, readout circuit. We use PXI-bus unit for this system. Timing of pulses and the voltages are programmable by LabVIEW (National Instrument). The Reconfigurable digital I/O using the LabVIEW FPGA module generates driving pulses for SCAPS by downloading pulse-timing program described by LabVIEW to FPGA. The AD module includes 18-bit A/D converter, amplifier and programmable 40kHz low pass filter. Using this electronic control system we expect that more flexible systemic change could be enabled and that optimization of analysis could be much easier than ever before.

Capabilities of single ion detection of this system were evaluated using a sector-type stigmatic secondary ion mass spectrometer (ims-1270, CAMECA). Negative ions of 18O- accelerated at 10 keV were used as the irradiated charged particles onto the detection system. The count rate of total secondary ions projected onto the imaging area was measured by an electron multiplier before and after the capture of SCAPS imaging. The secondary ion intensity during the experiment was adjusted to 100 ions per one image frame. This condition avoids multiple ion incidences into the same channel of MCP for an accumulation time of one SCAPS frame. The load voltages for input side electrode of MCP were changed to -1100V, -1050V, -1000V, -950V and -900V in order to control the MCP gain.

The detected ion counts become saturated over the voltages of about 1kV. The saturated level is about 60 ions per frame. This value is about 60% of incident ion numbers. Because the open area ratio of the MCP is 58%, the saturated level shows that this system accurately detected the single incident ions.