

Development of SCAPS-II ion imager

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Ions have been used for mass spectrometry systems. A solid-state ion imager called SCAPS (Stacked CMOS type Active Pixel Sensor) was proposed to measure the spatial distribution of the ion density quantitatively. The SCAPS has 600x576 pixels array and each pixel has stacked electrode to detect ions independently. The pixel electrodes take charge resulted of the interaction between incident ions and the surface of electrode. The degree of charging is proportional to the number of incident ions. The charge is integrated in the pixel capacitance. Quantity of integrated charge changes the electric potential of a gate on the readout transistor in inverse proportion to the pixel capacitance and floating capacitance induced by the pixel electrode and wires. The SCAPS device output the amplified current signal depending on the gate potential as a voltage by current-voltage conversion circuit in the device. The larger output caused of the fluctuation of an electron on the capacitance called conversion gain, the bigger the signal-to-noise ratio. The pixel capacitance of the current SCAPS is about 14 fF and estimated conversion gain is about 9 microvolts per electron. We are developing SCAPS-II ion imager, which have new pixel structure with low pixel capacitance less than 4 fF to improve the conversion gain.

The SCAPS-II has 504x504pixels array with each pixel size is 7 square-micrometers. This device has several advantages in readout manner including signal integration circuit and amplitude suppression circuit. The signal integration circuit reduces the readout noise by the integration of multiple signal sampling. The amplitude suppression circuit automatically discharges the pixels approaching saturation by accumulated signals and counts up the number of discharging operation times. This function has potential to increase the dynamic range. This device output the signal with 2 lines in order to fast readout. The vacuum chamber assembly consists of 121 pin hermetic seal, mounting unit for the device specified in ultra high vacuum, cooling unit with LN2 dewar and cold finger to decrease the thermal noise. The electronics are modular packaged in a PXI industrial open standard chassis.

The signal integration function can reduce the noise statistically. The conversion gain of SCAPS-II was measured to be about 29 microvolts per electron using thermally generated electrons in the pixel capacitance, which is three times larger than current SCAPS device.