Toward Realization of Submillimeter-wave Camera

HIBI, Y., MATSUO, H. (NAOJ)
WATANABE, D. (Toho University)
SEKIGUCHI, S. (University of Tokyo)
IKEDA, H. (ISAS/JAXA)
FUJIWARA, M. (NICT)

In Advanced Technology Center of NAOJ, we aim to develop submillimeter-wave imaging array with more than 10,000 detector pixels. We have developed GaAs-JFET cryogenic integrated circuits to readout large number of submillimeter-wave SIS photon detectors. Experimental demonstration of cryogenic readout module as well as combination test of charge integrating amplifiers with SIS photon detectors are reported.

The GaAs-JFET electronics can operate under cryogenic temperature with low power dissipation. In 2010 we have reported development of GaAs-JFET cryogenic integrated circuits for charge integrating amplifiers and multiplexers. In 2013 we have successfully developed and demonstrated operation of 32-channel cryogenic readout modules using the cryogenic circuits. The size of the module is 40 mm × 30 mm × 2 mm with input and output connectors. The module can multiplex 32-channel detector signals and output two voltage signal. Room temperature electronics applied source and control voltages to conduct evaluation of the 32-channel cryogenic module [1,2]. Figure 1 shows the picture of the module and an example of measured output signal.

The submillimeter-wave SIS photon detectors are superconducting tunnel junction detectors whose operation is based on photon assisted tunneling of quasi-particle current. SIS photon detectors made of niobium junctions were cooled down to less than 1 K and DC magnetic field was applied to suppress Josephson current. We combined the SIS photon detectors and cryogenic charge integrating amplifiers to readout detector current signal. In this experiment there were no radiation input to detectors but DC magnetic fields were applied to change detector current. The detector currents were successfully measured by the change of the slope of output signal as shown in figure 2, from which we estimated noise equivalent power of 4×10^{-15} [W/Hz$^{0.5}$] [1].

We have successfully developed multi-channel read-out system for submillimeter-wave camera and demostrated detector signal readout using charge integrating amplifiers, and now ready to fabricate submillimeter-wave imaging arrays for astronomical observations.

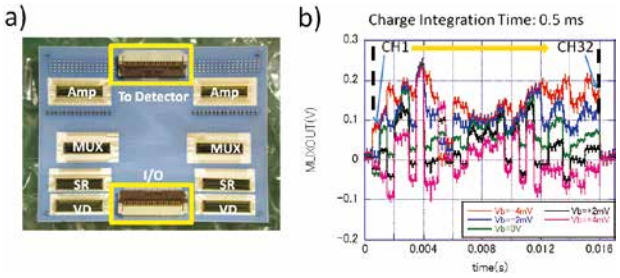

Figure 1: a) The 32-channel cryogenic readout module. 'Amp' are 16-channel charge integrating circuits, 'MUX' are 32-channel multiplexers with sample-and-holds, 'SR' are shift resistors and 'VD' are voltage distributors. b) Output signals for 1 MΩ resistors in place of detectors for bias voltages from +4 mV to −4 mV. Operation temperature of the module was 4 K and their power dissipation was 350 μW.

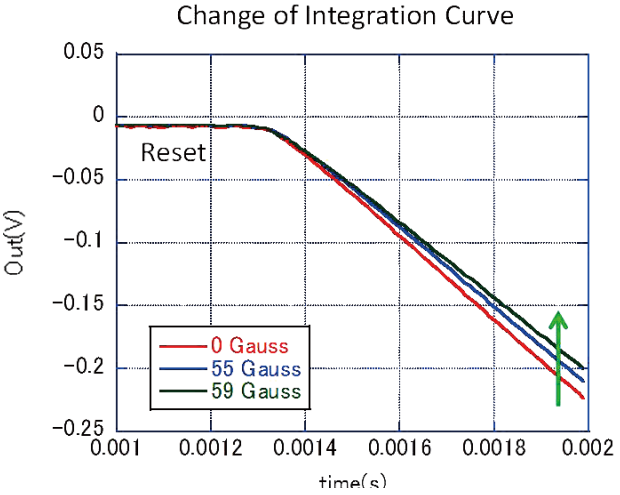

Figure 2: Output signal of charge integrating amplifiers for different DC magnetic fields applied to detectors; 0, 55 and 59 Gauss for red, blue and green lines, respectively.

References

[1] Hibi, Y., et al.: 2013, *IEEE THz Sci. Tech.*, **3**, 422.
[2] Watanabe, D.: 2014, Master thesis, Toho University.