Developments of Wide Field Millimeter/Submillimeter Instruments

SEKIMOTO, Y., NOGUCHI, T., KARATSU, K., NITTA, T.*, MATSUO, H., DOMINJON, A.
OKADA, N., MITSUI, K., TSUZUKI, T.
(NAOJ)

SEKINE, M., SEKIGUCHI, S., OKADA, T., SHU, S.
(University of Tokyo/NAOJ)

NARUSE, M.
(Saitama University)

MKID (Microwave Kinetic Inductance Detector) group of Advanced Technology Center is developing superconductive camera in millimeter and submillimeter wavelengthes for Antarctica terahertz telescope which observes distant galaxies with a wide field of view and for LiteBIRD which detects CMB B-mode polarization in collaboration with University of Tsukuba, Saitama University, KEK, and Riken. We reported four papers with a theme of wide field of view millimter/submillimeter instruments in 2014 fiscal year.

1. Wide Field 0.1 K Cryosytem [1]

MKID camera which is a new technology (P. Day et al. 2003) is a Cooper pair breaking detector. Superconducting resonators in MKID sense surface impedance variations owing to quasi-particles generate by incoming photons. It is necessary to cool MKID to1/7 of the superconducting critical temperature (T_c). We have developed a compact 0.1 K cryosystem (Fig. 1) with a dilution refrigerator by Taiyo Nissan Co. As a result, an MKID detector of T_c = 700 mK can be operated in this cryostat, which can detect photons of higher frequencies than 50 GHz. The key to the wide field of view is a large diameter silicon lens and its anti-reflection coating. Moreover, nested reflective baffles reduce stray lights.

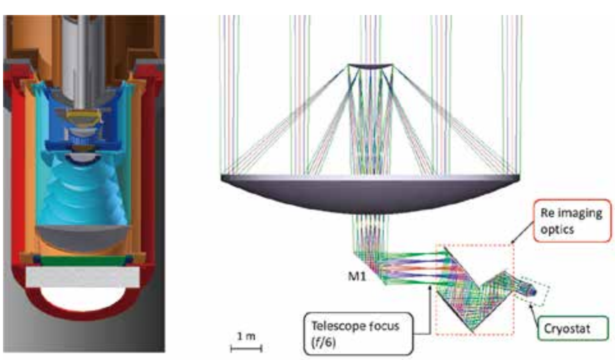

Figure 1: Compact 0.1 K cryosystem [1] and wide FoV (1.0 degree) terahertz optics [2].

2. Wide Field Terahertz Optics [2]

A wide field of view (FoV) optics with a main observation frequency 0.85 THz of Antarctica 10 m terahertz telescope has been designed (Figure 1). It relays from a F #6 Nasmyth focus to a F #1 detector focus with four reflective mirrors and one cooling refractive. The free-forming surface is used for the mirrors to expand the FoV. The cooling lens is an alumina lens of 60 cm in the diameter. Wide FoV survey at terahertz is realized by combining 20000 pixels MKID camera.

3. 700 pixels Si Lens Array [3]

To detect submillimeter-waves efficiently, the camera combined a lens array with superconducting planar antenna. A 700 pixels silicon lens array was machined with a high-speed spindle (Figure 2). Moreover, a mixed epoxy anti-reflection coating [5] was applied with the same way. The thickness of the ARC is controlled with 1 % accuracy. With these technologies, superconducting cameras with high efficiency became possible.

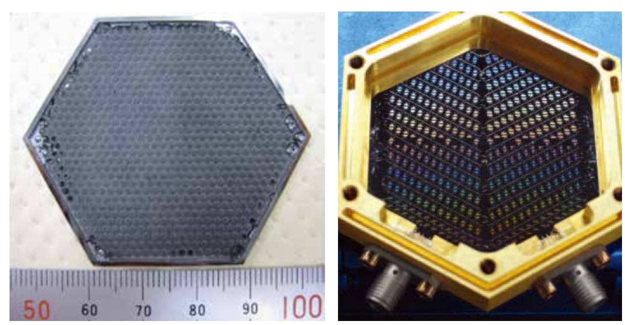

Figure 2: 700 pixels Si lens array and 220 GHz MKID camera.

4. CMB B-mode Polarization [4]

Observations of B-mode polarization of cosmic microwave background radiation (CMB) sense the inflation theory (K. Sato 1981). This paper reports MKID developments in collaboration with NAOJ, KEK, Riken. It demonstrates noise of the detector, the beam measurement, and the readout circuit. The polarization sensitivity is higher than that of BICEP2.

At ATC, we are developing broad band devices with MKIDs as well as wide FoV instruments.

References

[1] Sekiguchi, S., et al.: 2015, *IEEE TST*, **5**, 49.
[2] Tsuzuki, T., et al.: 2015, *JATIS*, **1**, 025002.
[3] Mitsui, K., et al.: 2015, *JATIS*, **1**, 025001.
[4] Karatsu, K., et al.: 2015, *IEICE 98-C*, 207.
[5] Nitta, T., et. al.: 2014, *JLTP*, **176**, 677.

* JSPS PD fellow, from 1-Apr-2015, Univ. of Tsukuba