Development of the 1.3-1.5 THz Band Superconducting HEB Mixer Receivers for ASTE 10 m Telescope

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Abstract In the THz region, there exist many spectral lines of various fundamental atoms, ions and molecules, which give us novel information on chemical and physical state of interstellar clouds including star and planet forming regions. Although observations of these lines have successfully been started with Herschel HIFI, further observations with higher angular resolution from the ground based telescope are still important by utilizing some THz atmospheric windows. With this in mind, we have been developing superconducting HEB (Hot Electron Bolometer) mixers for the THz heterodyne sensing at The University of Tokyo. By use of these mixers, we are preparing a cartridge-type THz heterodyne receiver for the 0.8-0.9 THz and 1.3-1.5 THz bands. This receiver will be installed on ASTE 10 m telescope (Atacama Chili) for molecular line observations in the above regions.

The receiver is the ALMA cartridge type with a single beam. It can observe dual bands (0.9 THz and 1.3-1.5 THz) simultaneously in the DSB mode by using the wire grid. We employ the in-house waveguide HEB mixers for the both bands. Although SIS mixers now show a better performance than HEB mixers at 0.9 THz, we use the HEB mixer to demonstrate observation capability of our HEB mixer. The LO signal is coupled with the RF signal by wire grids placed on the 4 K stage. As for the LO signal source, we use frequency-multiplier chains driven by the microwave synthesizer. We use NbTiN and NbN superconducting films fabricated on a quartz substrate for the HEB mixers. The NbN film formed directly on a quartz substrate does not show high T_c. Hence, we use the AlN buffer layer between the quartz substrate and the NbN film (Shiino et al. 2010). The thickness of superconducting microbridges is set to be 10.8 nm for NbTiN and 6 nm for NbN. The receiver performance has been measured in the test apparatus. The minimum receiver noise temperatures achieved so far are 450 K for the 0.8 THz NbTiN and NbN mixers, 1050 K for the 1.5 THz NbN mixers, and 570 K for the 1.5 THz NbTiN mixers. The noise performance of the 1.5 THz NbTiN mixer is excellent. The noise temperatures show significant dependence on microbridge size (0.5~3.0 μm width and 0.1~0.4 μm length). We will be able to achieve better noise performance by optimizing the microbridge dimensions carefully.