Development of 1.9-THz-band Waveguide-type Hot-electron Bolometer Mixer Employing Superconducting NbTiN Microbridge

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Many spectral lines for rotational, rotation-vibration, and fine-structure transitions of gas species in the interstellar medium and planetary atmospheres lie in the millimeter to terahertz waveband. In this frequency band, heterodyne spectroscopy with high frequency resolution is a powerful tool for understanding of the basic physical and chemical properties of planetary atmospheres and interstellar media. Despite its scientific and observational importance, 1–10-THz-band radio astronomy and remote sensing have long been unexplored because of the lack of good observing sites and the unavailability of sensitive heterodyne detectors in this frequency range.
We are currently developing a 1.9 THz band waveguide/diagonal-horn type HEB mixer employing a superconducting NbTiN micro-bridge fabricated using *in situ* sputtering techniques. The crucial observational targets for this frequency band are OH radicals, H_2O, and [OI], which are important oxidants in the chemical-reaction network in the atmosphere of Earth and other planets; [OI] and [CII] lines, which are the basic coolants of the interstellar medium; and other complex and high-*J* molecules.
The optical system and waveguide probe of the HEB mixer receiver that couple the input signal were newly designed with 3D electromagnetic-field simulators, GRASP and HFSS(TM). The fabrication of the waveguide chip slot of which the dimensions are 50 μm width and 40 μm depth were successfully realized by recent high- precision micromachining techniques. The performances of the diagonal horn such as beam pattern (axial symmetry and side-lobe levels) were newly optimized re-designing the length and truncated structures of the horn. The cold head of the 4 K mechanical refrigerator for the HEB mixer receiver has the temperature fluctuation of 0.2 K. By inserting the new optics as a buffer material between the cold head and the mixer we succeeded to reduce the fluctuation at the position of the HEB mixer to 1.6 mK, which is much smaller than the transition width of temperature between superconducting state and resistive state of the NbTiN microbridge. Therefore the reduced temperature fluctuation does not affect the performance of the HEB mixer.
In this conference, we will present the current developmental status of the newly fabricated 1.9-THz-band waveguide/horn-type HEB mixer detectors.

Keywords: Terahertz, heterodyne remote sensing, Superconducting detector

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