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Development of THz band superconducting hot-electron bolometer mixer for atmospheric and astronomical observations

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We are aiming at THz band heterodyne spectroscopy of interstellar matter and minor constituents in the earth's atmosphere. OH is one of the most important radicals in atmospheric chemistry because it is a strong oxidant linked to the destructive processes of various atmospheric molecules. However, remote measuring methods of the OH radical have not been fully established, due to its short life time and low abundance, resulting in an insufficient understanding of HOx chemistry. OH has the transition lines at 2.5 and 1.8 THz bands. In interstellar medium the atomic fine-structure transition of ionized carbon (CII) has also forbidden line at 1.9 THz band. The emission of this CII line plays a vital role in the cooling mechanism of interstellar cloud. High-spatial and high frequency resolved CII observation will provide us with an important information about the dynamics and evolution of interstellar clouds in galaxies. The THz region is an unexplored frequency band in heterodyne sensing technology fields because a conventional niobium-based SIS mixer cannot function due to superconducting Cooper pair breakdown by photon absorption in the THz band. To overcome this obstacle, we are developing an alternative THz-band heterodyne device known as a hot electron bolometer mixer (HEBM), in collaboration with University of Tokyo. Recently we have improved the fabrication processes of a superconducting thin NbTiN nano-bridge through an inductively-coupled plasma etching method. The bridge is formed on non-doped high-resistivity Si wafer integrated with quasi-optical feeding system composed of a twin-slot antenna and a Si hyper-hemisphere lens. The frequency response of our HEBM is currently optimized for 1.8 -2 THz band.

We have promoted a plan to build a terahertz band telescope at Dome Fuji in the antarctica with the collaboration of a consortium composed of several Japanese astronomical groups. By carrying our HEBM receiver in the telescope we will develop the terahertz heterodyne sensing in astronomy and atmospheric research mentioned above.

In this meeting we will present the preliminary results of the development of 1.8-2 THz band HEBM.