Developments and performance evaluations of 0.48 THz band heterodyne receivers for the future Mars terahertz sensor missions with micro-satellites

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Mars is an important investigation target for understanding atmospheric environments, habitability, and resources of terrestrial planets. On Mars, methane has been detected, and research continues to study its origin and destruction processes by oxidation reaction networks in the atmosphere and on the surface. In order to understand the evolutionary processes of the Martian atmosphere, detailed and systematic observation of spatial and temporal variation of H_2O and oxidants such as HOx, altitude distribution of O_2 is still an important subject. Mars will also give us valuable information on the extent to which biomarkers O_2 and O_3 are formed abiotically in typical earth type planets with mainly CO_2 atmospheres.
Therefore, we are developing the Bread Board Model (BBM) of lightweight, low power consumption 0.48 THz band heterodyne remote sensing detectors for future Mars terahertz sensor missions with micro-satellites. THz/submillimeter-wave band heterodyne spectroscopy with high frequency resolution allows us to derive the altitude distribution of trace molecules of the planetary atmosphere, and this frequency band is less affected by the absorption and scattering by aerosol and dust because of its long wavelength. Also, regardless of the presence or absence of background light sources like the sun day- and night-side atmospheres are observable. In the BBM receiver system, subharmonic mixer (SHM) detectors with Schottky barrier diodes operating at room temperature were adopted and a circularly polarized wave separating device was united for the RF input port (manufactured by Virginia Diodes, USA), which enabled us to integrate two SHM detectors flatly and compactly. The equivalent noise temperature of the SHM mixers was 1400 - 1500 K (DSB) in the 1 - 6 GHz band. The power consumption and weight of the mixer receiver system are 11.2 W (1.66 A) and 0.6 kg. In the local oscillator system, 13 GHz band signals from the dielectric resonator oscillator with the phase locked to 99.9 MHz reference signal from an oven controlled crystal oscillator are multiplied and amplified with the integrated amplifier-multiplier chains (IAMC). For temperature fluctuations of about 3.5 degrees at room temperature, the frequency drift in the 0.48 THz band was about 100 kHz. Based on the performance of this front-end system, atmospheric radiative transfer simulation confirmed that atmospheric minor constituents such as O_3 and H_2O_2 as well as O_2 and H_2O can be sufficiently observed. In this presentation, we will report on these results.

Keywords: Mars, Planetary atmosphere, Heterodyne remote sensing, Terahertz, Mars lander with Micro-satellite

