Construction of a Three-Diode-Laser Terahertz Difference-Frequency Synthesizer and Its Application Toward Spectroscopy of Ammonia in the ν_2 State and Water in the Ground and ν_2 States

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An all-solid-state, high-resolution and frequency-calibrated THz spectrometer based on optical heterodyne in low-temperature-grown (LTG) GaAs been constructed. [Shuji Matsuura, Pin Chen, Geoffrey A. Blake, John C. Pearson and Herbert M. Pickett, IEEE MTT, in press]. This setup utilizes three distributed-Bragg-reflector (DBR) diode lasers to generate accurate and tunable difference-frequencies in the THz regime. Lasers #1 and #2 are locked to different longitudinal modes of an ultra-low-expansion Fabry-Perot etalon, and laser #3 is offset locked to laser #2, where the offset frequency (ν_{offset}) is set by a microwave sweeper. This three-laser, difference-frequency synthesizer is fully fiber coupled in rigid and compact optical rails. The primary outputs of lasers #1 and #3 pump the LTG GaAs photomixer to generate THz radiation (whose frequency equals to $n \times FSR + \nu_{offset}$, where FSR is the free spectral range of the etalon and n is an integer). The etalon's FSR, and thus the THz frequency, has been calibrated to 50 ppb by acquiring spectra of the 10 rotational lines of CO in the 0.23 to 1.6 THz region.

Using this spectrometer, we obtained measurements of 26 pure inversion and inversion-rotation transitions of ν_2-NH_3 at accuracy significantly higher than previously published values. In addition, 17 new measurements of H_2O transitions in the ground and ν_2 states have been acquired. In this paper, we discuss the design, frequency calibration, and the calibration stability of the spectrometer. Spectroscopic results (frequency measurements and fitted molecular parameters) will be presented as well.

Topic code : A, G

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