Frequency conversion with a photomixer for high-resolution broadband spectroscopy

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Optical heterodyne conversion with two near-infrared lasers and a biased photomixer has been used to generate broadband tunable THz-waves with high spectral performances. Device design relies on a low-temperature-grown GaAs photoconductor with sub-picosecond electron recombination time, high mobility and large breakdown field that is coupled with interdigitated electrodes to a planar antenna. Electrical transport mechanisms lead to a nonlinear current-voltage response of the device that is exploited here for broadband frequency conversion. The device is electrically addressed with a bias-t and THz-waves are focused to the antenna with a silicon lens. Rectification in the THz regime allows direct detection with the photomixer. Spectral components of a THz-wave pulse-modulated at a radiofrequency rate are detected by phase-coherent frequency conversion to dc by coupling radiofrequency to the photomixer. Alternatively, heterodyne detection of a THz field is performed by using the optical beat between the lasers as local oscillator. Spectral components of a THz-wave pulse-modulated at a radiofrequency rate are detected individually by down-conversion to the microwave domain with the heterodyne detection scheme. Thermal noise of the photomixer operated at room temperature limits the detection sensitivity at $\sim$0.3 nW/Hz$^{1/2}$ for a device with 1.2 ps electron lifetime and 20 mW laser power. Precision spectroscopy is an important application of this approach where a THz-wave with a great number of coherent modes addresses molecular energy levels. Detection with the photomixer allows spectral resolution, identification and measurement of the amplitude or probing the relative phase of the modes. A Doppler-limited spectroscopy setup is presented as an example with scanning over $\sim$150 MHz at video rate and a spectral resolution of $\sim$1 MHz determined by optical beat linewidth.