Detection of 1.6 and 2 THz radiation with a Tunable Antenna-Coupled Intersubband Terahertz (TACIT) detector.

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We have realized a new kind detector for Terahertz frequencies based on Intersubband Transitions in semiconductor quantum wells. Intersubband transitions in our case occur between carefully engineered quantum confined electron states in the conduction band of coupled GaAs quantum wells. The optically excited electrons thermalize rapidly, increasing the electron temperature and hence the resistance of a heterojunction channel. The resistance is measured between source and drain ohmic contacts using a current amplifier. Two 25 micron squared Schottky gates define the channel, and are used to tune the absorption resonance via the Stark effect and by varying the electron density. The intersubband transition linewidth of 100 GHz defines the detection bandwidth, and the center frequency can be tuned between 1 and 2.5 THz by applying gate voltages of order 1 Volt.

The detector was fabricated using flip chip microprocessing to integrate the quantum well absorbing region at the focus of a twin-slot dipole antenna. The antenna, RF filters and 5micron by 5 micron mesa were all patterned on a GaAs wafer, which was subsequently thinned to 0.7 microns in order to couple the quantum well most efficiently to the antenna leads and Schottky gates. The device was mounted on a silicon lens to couple light more efficiently to the antenna radiation pattern.

In order to test the device, we used highly attenuated, 5 microsecond pulsed plane waves from UCSB's Free Electron Laser (Figure 1). We scanned the gate voltages to tune the TACIT detector in and out of resonance with the laser tuned to either 1.6 or 2 THz. The data (Figure 2) shows that for a particular frequency, the device tunes into resonance for two stark fields, of equal magnitude but opposite sign, as it should for symmetrical biasing. The data also agree very well with theoretical calculations based on solving Schrodinger's equation. So far, working with non-optimized, first generation samples, we have achieved responsivities of order 1Volt/Watt at temperatures of 77K, and are working towards our theoretical prediction of 1kV/W. The detector is at least as fast as the 5 microsecond laser pulse length and this response time is currently limited by the amplifier electronics. Theory[1] predicts operation as a heterodyne mixer could achieve nearly quantum noise limited performance with IF frequencies exceeding 10GHz at temperatures above 77K. This work was supported by NASA under contract NAG10299.

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[1] M. S. Sherwin *Proceedings of Far-IR Sub-mm and mm Detector Technology Workshop* (April 2002)

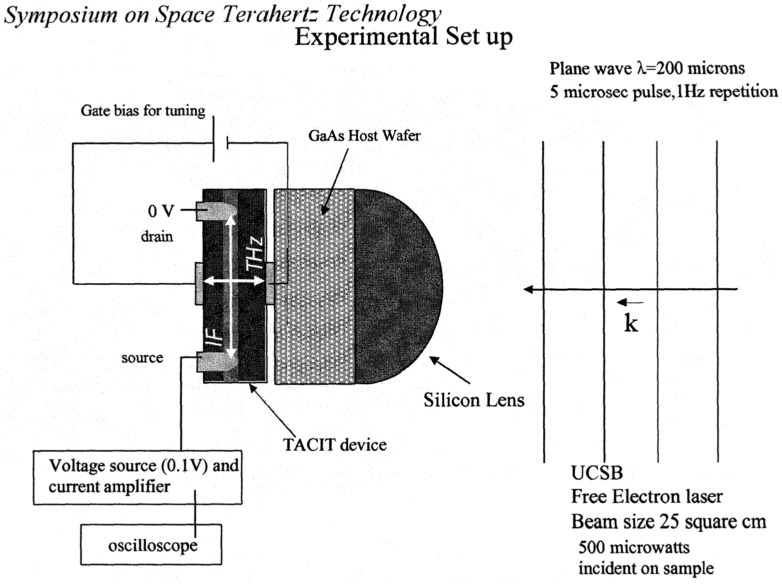

Figure 1

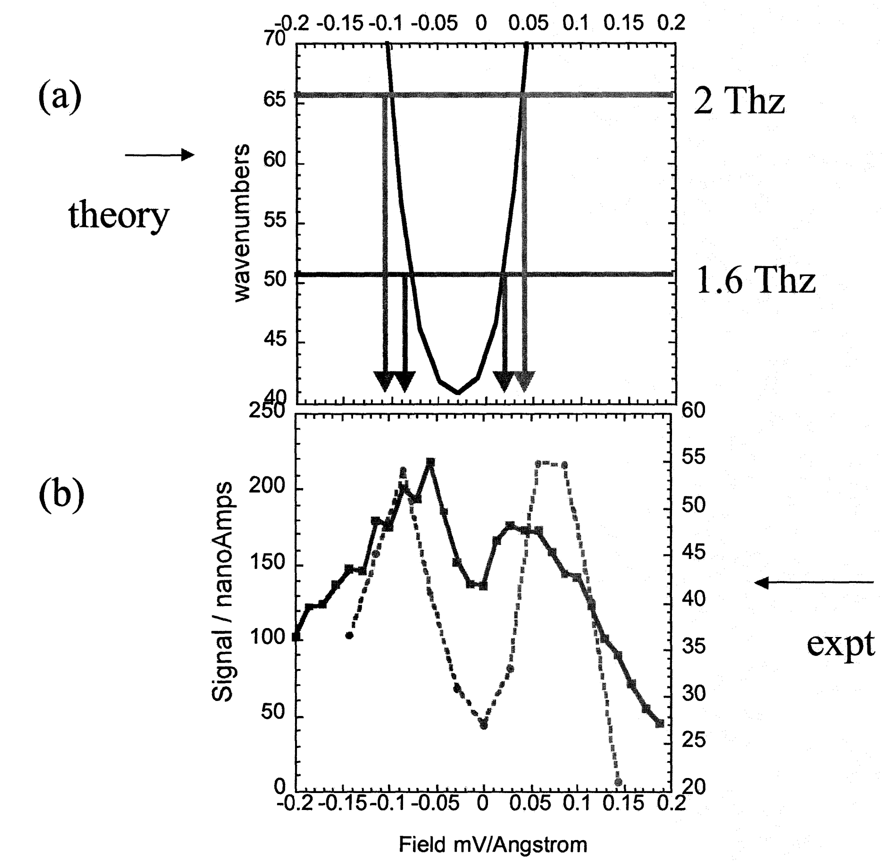

Figure 2 (a): Theoretical calculation for the frequency response as a function of applied DC field, based on solving Schrodinger's equation. **(b)** Signal as a function of gate voltage (DC stark field) for two different incident Terahertz fields at 2 THz (dotted curve) and 1.6 THz (solid curve). The double resonance occurs because DC fields of equal magnitude but opposite sign result in the same Stark shift.