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Voltage-tunable detectors for Terahertz radiation operating above 100k with ns rise times

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Collective vibrations of proteins, rotations of small molecules, excitations of high-temperature superconductors, and electronic transitions in semiconductor nanostructures occur with characteristic frequencies between 1 and 10 THz [1]. Applications to medicine, communications, security and other fields are emerging. However, mapping the coldest parts of the universe has been the largest driver for developing THz detectors [2]. The result is a family of exquisitely-sensitive detectors requiring sub-4K temperatures. For earthbound THz science and technology, sensitivity remains important but many applications require high speed and operating temperatures. Room-temperature Schottky diodes enable some of these applications [3]. Here we demonstrate a new type of detector in which THz radiation collected by a microscopic antenna excites a collective intersubband oscillation of ~25,000 electrons between two gates in a microscopic four terminal GaAs/AlGaAs transistor. The energy dissipates into other modes of the electron gas, warming it and changing the source-drain resistance. The detector shows amplifier-limited rise times near 1 ns and has detected THz laser radiation at temperatures up to 120K. Theory predicts that rise times should be ^{2}10 ps, enabling operation as a mixer with >10 GHz IF bandwidth [4]. The frequency of the collective oscillation tunes with small gate voltages. The first-generation tunable antenna-coupled intersubband Terahertz (TACIT) detectors tune between 1.5 and 2 THz with voltages <2V. Supported by NASA and the NSF. Work performed in collaboration with M. F. Doty, P. Focardi, A. C. Gossard, M. Hanson, W. R. McGrath and M. S. Sherwin. Please address communication to M. S. Sherwin, Physics Dept., UCSB. [1] Sherwin, M. S., Schmuttenmaer, C. and Bucksbaum, P. , editors, "Opportunities in THz Science," http://www.sc.doe.gov/bes/reports/abstracts.html#THz [2] de Bernardis, P. et al. A flat Universe from high-resolution maps of the cosmic microwave background radiation. Nature 404, 955-959 (2000). [3] Siegel, P. H. Terahertz technology [Review]. IEEE Transactions on Microwave Theory & Techniques 50, 910-928 (2002). [4] Sherwin, M. S. et al. Tunable antenna-coupled intersubband terahertz (TACIT) mixers: the quantum limit without the quantum liquid., in Proceedings of Far-IR, Sub-mm and mm Detector Technology Workshop (Monterey, CA, 2002). http://www.sofia.usra.edu/det_workshop/papers/ manuscript_session6.html.