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In this reporting period, we have extended this work by creating vertical transport structures to allow for resonant injection into the higher levels of a parabolic quantum well to improve the efficiency and intensity of Terahertz emission. Measurements showed the clear presence of coherence and resonant tunneling behavior for wells as wide as 1000 A. Then, vertically injected Terahertz emission devices were made with multiple cascaded PQWs (30 to 10 wells) sandwiched between n+ contact layers. The initial results from these devices has shown a factor of 4 improvement in emission power over the in-plane excitation devices described above. The current power level of 30 nW for these devices is comparable to the state of the art for other techniques of Terahertz generation at these frequencies.

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Fabrication and Properties of High-Peformance Graded Quantum Structures

July 30, 1997

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I. Academic progress

The student supported under this grant, Mr. Kevin Maranowski, did not take any classes in this reporting period.

II. Technical Training

In the previous reporting period, we had started work on new far infrared (FIR) emission sources, which are based on the excitation of electrons in parabolic quantum well (PQW) resonators by passage of an electrical current parallel to a modulation-doped well.[1] The modulation-doped parabolic well samples were processed with electrical contacts and with grating couplers to allow emission of radiation from the surface of the samples. We have observed FIR emission from the PQWs using an n-InSb photoconductive detector. Since the Terahertz radiation has been observed, this device has the attractive additional possibility that, with simple modifications, it could provide a source for easily tunable emission of radiation. Such a tunable source would be unique in this portion of the electromagnetic spectrum and could have useful applications in spectroscopy, communications, and environmental monitoring.

In this reporting period, we have extended this work by creating vertical transport structures to allow for resonant injection into the higher levels of a parabolic quantum well to improve the efficiency and intensity of Terahertz emission. Initially, simple resonant tunneling diodes with a parabolic well were examined with current-voltage measurements to determine the feasibility of resonant injection in wide wells for far-infrared emission. These measurements showed the clear presence of coherence and resonant tunneling behavior for wells as wide as 1000 Å. Then, vertically injected Terahertz emission devices were made with multiple cascaded PQWs (3 to 10 wells) sandwiched between n+ contact layers. The initial results from these devices has shown a factor of 4 improvement in emission power over the in-plane excitation devices described above. The current power level of 30 nW for these devices is comparable to the state of the art for other techniques of Terahertz generation at these frequencies. Further band gap engineering of these cascaded structures is possible to improve efficiencies and output power even more.

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1) "Far infrared emission from parabolically graded quantum wells", K.D. Maranowski, A.C. Gossard, K. Unterrainer, and E. Gornik, **Applied Physics Letters**, December 2,1996, V69, N23:3522-3524.