Tunable THz plasmon resonances and photo-response in InGaAs/InP HEMT

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Abstract

Narrow-band voltage-tunable plasmon resonances in a InGaAs/InP high electron mobility transistor (HEMT) are reported at frequencies in the range 0.3-1.5 THz. The device was made using a commercial MBE-grown HEMT wafer with a InGaAs quantum well. The semi-transparent gate contact consisted of a 0.5 μm period metal grating formed by electron-beam lithography. Source and drain contacts were established by conventional photolithography with overlapping metallization to prevent IR transmission anywhere except through the gate. Transmission in the range 10 – 50 cm^{-1} was measured using a Fourier spectrometer equipped with Hg arc lamp, mylar pellicle beamsplitter, and 4 K Si bolometer. The device was mounted within the bolometer cryostat to maximize collection of the radiation transmitted through the sub-wavelength gate aperture. The resonance frequency shifts toward lower frequencies with applied negative gate bias as expected from theory with input parameters determined by device structure and electrical measurements. The actual observed resonance positions agree with calculated ones with a factor of ~2. The same theory predicts measureable resonant absorption up to 100 K device temperatures. The resonance absorption by two-dimensional plasmons in principle can affect the source-drain conductance of the device. Photo-response to the pulsed THz radiation from the UCSB free-electron laser was characterized. The device may have application in high-frame-rate THz array detectors for spectral imaging and threat detection with real-time chemical analysis.