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Plasmonic response of partially gated field effect transistors

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Electron density oscillations in the transistor channels - plasma waves in the two-dimensional electron gas - determine the high frequency device response. Plasmonic field effect transistors have emerged as very sensitive, tunable, and extremely fast detectors of THz radiation. They have been implemented using silicon (CMOS), AlGaAs/InGaAs HEMTs, and AlGaAs/InGaAs HEMTs, with the HEMTs shown to operate more efficiently at higher THz frequencies. These HEMTs have both gated and ungated sections of the device channel between the source and drain, and the photovoltaic regime of operation requires an asymmetric gate placement in the device channel. The interactions of the plasma waves in the gated and ungated channel regions strongly affect the overall response and have been investigated in numerous publications. This work addresses a new aspect of such interaction - the effect of the relative position of the gated and ungated section. We show this previously unexplored effect plays a dominant role in determining the response. The results of the numerical simulation based on the solution of the complete system of the hydrodynamic equations describing the electron fluid in the device channel show that the inverse response frequency could be approximated by the sum of the gated plasmon transit time in the gated section of the device, the ungated plasmon transit time in the ungated section of the device between the gate and the drain, and the RC gate-to-source constant. Here, R and C are the resistance and capacitance of the gate to source section. Hence, the highest speed is achieved when the gate is as close to the source as possible. This suggests a novel plasmonic detector design, where the gate and source electrode overlap, which is shown to have a superior frequency response for the same distance between the source and the drain.

Biography

G Rupper received his BS and MS degrees in Electrical Engineering and Computer Engineering from Brigham Young University in 1999. He worked for seven years with Qualcomm Inc. working on CDMA Cellular Telephone Technology. In 2010, he received his PhD in Optical Science from the University of Arizona. His dissertation was based on theoretical work on laser cooling of semiconductors. He also did some experimental work on strong coupling between a quantum dot and a photonic crystal. He joined ARL as a Post-doc in 2010 and is currently working on multi-scale modeling of semiconductor devices.

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