Transport properties of a quantum dot based optically gated field-effect transistor*

M. A. Rowe, M. Su, and R. P. Mirin
National Institute of Standards and Technology, M/S 815.04, 325 Broadway, Boulder, CO 80305
303-497-7879, 303-497-3387(FAX), mrowe@boulder.nist.gov

Abstract: We demonstrate an optically modulated field-effect transistor. Such a device has a possible application as a fast, flexible, and efficient single-photon detector.

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Photon detectors made with field-effect transistors (FETs) [1-5] that use an optically addressable floating gate consisting of a layer of quantum dots have the potential to be fast, flexible, and efficient single-photon detectors. With quantum dots one can control the absorption spectrum via material choices. In addition, resonant cavity designs, which raise the efficiency, are compatible with these structures.

Our devices are made with a GaAs/AlGaAs modulation-doped heterostructure. The two-dimensional electron gas (2DEG) formed at the GaAs interface is shaped into a long narrow channel. The conductance of this 2DEG channel is controlled by the charge stored in a layer of InAs quantum dots above the channel. When photons are absorbed in the device, the created holes recombine with electrons stored in the quantum dots, reducing the stored charge. Due to the corresponding reduction in screening of the channel, the conductance of the channel increases. Figure 1 shows our initial results with the FET at a temperature of 5 K. We use a laser source at 904 nm to excite the device, so the only absorption possible is at quantum dots and the wetting layer. The reset pulse fills the quantum dots with electrons, lowering the channel's conductance. Illumination with 904 nm photons causes the channel's conductance to rapidly increase. The final illumination in Figure 1 is only 20 fW (90,000 photons/s), and even this power saturates the detector. We expect that by further reducing the optical power we will get to the point where the devices are sensitive to single photons [2-5].

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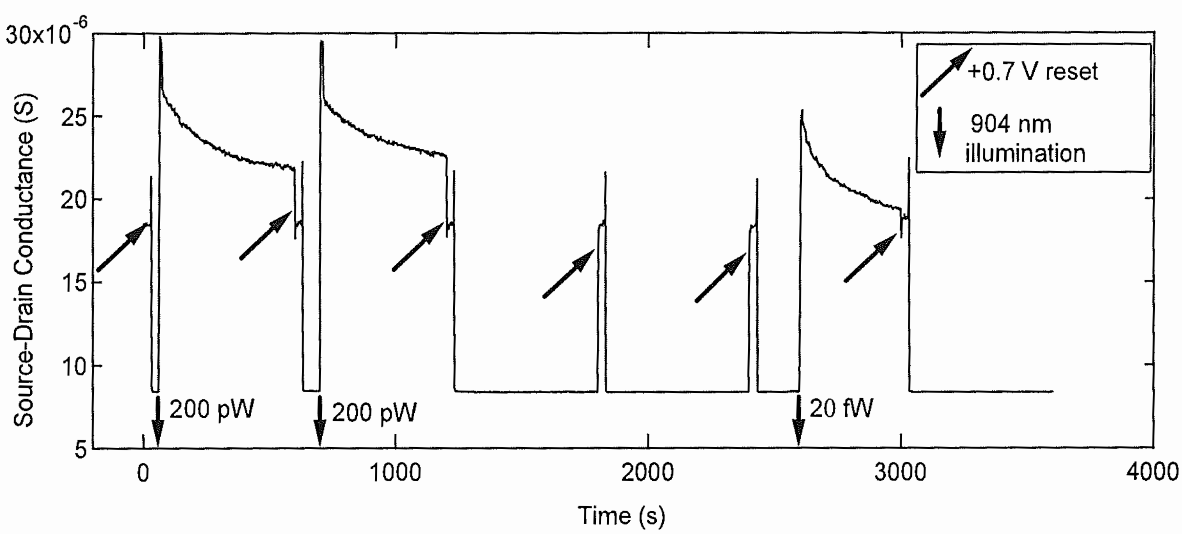

Fig. 1. Measured conductance of an optically sensitive FET.

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