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Single-THz-Photon Detection in New Schemes

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A single photon detection in a far-infrared (FIR) range (λ=220-170μm) has been experimentally observed by measuring transport through quantum dots (QD) in high magnetic fields [1]. Although, studied detectors are of a few orders more sensitive than existed before, further improvement of some parameters is highly desirable for application. For instance, it is important to extend the wavelength range and to avoid the high magnetic fields. To realize that, we have invented and fabricated a device schematically shown on Fig.1. Metal gates are deposited on the top of GaAs/AlGaAs heterostructure crystal with a two-dimensional electron gas (2DEG) of a sheet carrier density and a mobility n_s=2.6×10^{15} m^{-2} and μ = 85 m^2/V·sec, respectively, at 4.2 K. As the gates are negatively biased, two capacitively coupled QDs are formed. By measuring transport through a QD1 at low temperatures (current is schematically shown as white arrows), one can detect change of electron number in a QD2. The tunneling rate as well as barrier heights of the QD2 can be varied by biasing its gates. If we illuminate the QD2 by FIR-radiation with photon energies higher than barrier heights, photons can be absorbed by electrons in the dot, which, in turn, can escape from the dot over barriers (because they have an excess energies). Then, these hot electrons rapidly release the excess energies in the bulk 2DEG and have no chance to come back over the barriers. To couple the long wavelength FIR radiation to the 2DEG of the QD2 with 0.5μm size, the gates are extended to more than 100μm, forming nearly bow-tie antenna. An influence of electron escaping on the transport through the QD can be observed without FIR excitation. Fig. 2 demonstrates an experimentally measured gray-scale plot of conductance oscillations through the QD1 as a function of control-gate and antenna-gate voltages. Dark areas correspond to high conductance when resonant tunneling through the QD1 takes place, while white ones to the coulomb blockade regime. When a potential of the antenna-gate increases (by sweeping the voltage in negative direction), electrons are pushed out one by one from the QD2. This results in step-like drop of the QD1 potential and shift of the resonant conductance peaks down in the control-gate voltages, which can be seen as brakes in conductance peak traces on Fig. 2.

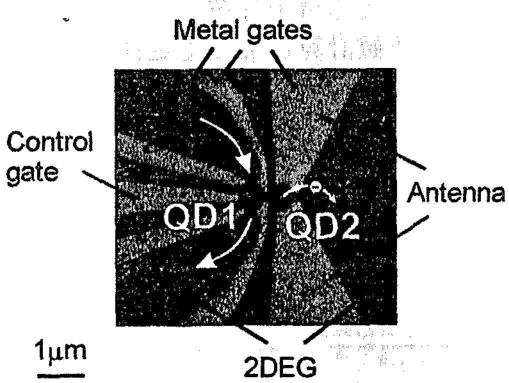

Fig. 1. Schematic view of the double QD-device.

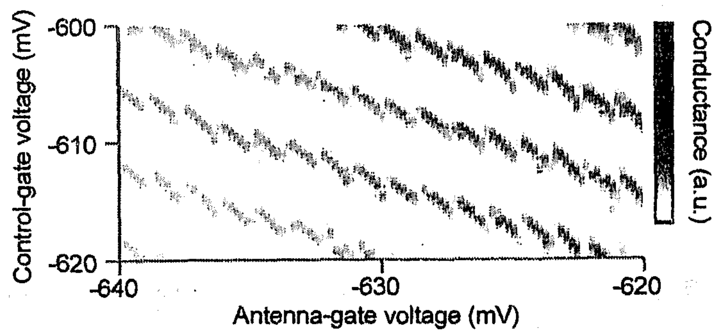

Fig. 2. Two-dimensional plot of conductance oscillations.

1. S. Komiyama, O. Astafiev, V. Antonov, T. Kutsuwa, and H.Hirai, Nature **403**, 405 (2000).