THz emission from silicon metal-oxide-semiconductor field-effect transistors

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Current-driven instability in the channel of a field-effect transistor (FET) leads to emission of electromagnetic radiation. This phenomenon was observed in high electron mobility FETs based on GaInAs and GaN quantum wells and heterostructures. Theory predicts that to get a radiation in the THz range, one has to investigate FETs with the gate lenght of a fraction of a micrometer. In this work, we report on two new experimental facts. First, the emission observed is generated in a Si metal-oxide-semiconductor FETs (Si-MOSFETs) which was not observed before. Second, a THz emission was observed in spite of the fact that the gate length of investigated transistors was as long as 5 μm.

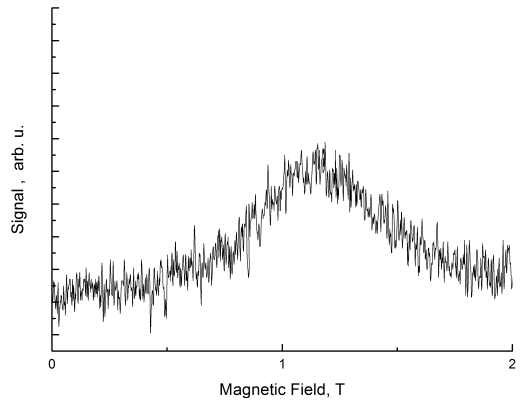

Figure 1: An example of the emission spectrum of a Si-MOSFET registered with a magnetically tunable InSb detector. The maximum of the signal corresponds the emitted frequency of 2.4 THz.

The measurements were carried out in a system in which the emitter (a Si-MOSFET) and a detector were closed in a brass tube in a distance of about 20 cm. The tube was placed in a liquid helium cryostat at 1.9 K in such a way that the detector was positioned in the center of a superconducting coil. The emitter was outside the coil and the influence of the magnetic field on the emitter was negligible. The emitter was biased with voltage pulses. A photocurrent induced in the detector by emitted radiation was measured by a lock-in technique as a function of the detector magnetic field. A typical emission spectrum is shown in Figure 1.

The principle of operation of the detector is related to cyclotron resonance transitions in the conduction band of InSb bulk crystal. Due to a very small electron effective mass in InSb, the cyclotron resonanse energy moves with the magnetic field with a slope of 2 THz/T which makes InSb a sensitive detector for a THz frequency band.

In conclusion, THz emission from Si-MOSFETs was observed for the first time. The experiments require a new thoretical approach to explain a THz emission from transistors with micrometer-long gates.

This work was supported by a National Science Center project 2011/03/B/ST7/03062.