Geometrically confined magnetoplasmons in a 2DEG

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We report on the investigation of magnetoplasmons excited with a THz radiation in a two-dimensional electron gas (2DEG) of finite dimensions. Since the work of Dyakonov and Shur [1], the research on THz detectors based on field-effect transistors (FETs) has led to development of commercially available multipixel cameras [2]. These devices use a non-resonant signal generated in FETs. However, THz detectors with tunable resonant frequency are required. This has brought us to examine plasma resonances at low temperatures and at magnetic fields. Our previous research has shown that magnetoplasmons are excited resonantly with a wave vector related to a sample width [3]. In the case of samples with a thin gate metallization (15 nm), the wave vector of an n-th magnetoplasmon is given by $k_n = (4n-1)\pi/W$, where W is the width of a sample.

Basing on this result, we have fabricated new samples of different channel widths (8 μm, 14 μm and 20 μm) covered with a 15 nm-thick Au/Ti gate. The length of all samples was 400 μm. We have used electron beam lithography with a wet etching method. Experiments were performed with an electronic monochromatic THz source in the frequency range of 630–660 GHz and at the temperature of 4 K. We have measured a photovoltage generated by the incoming radiation between source and drain contacts of samples as a function of the magnetic field. Results show a maximum which appears at magnetic fields corresponding to theoretically predicted positions. Observed positions depend on the samples' widths and confirms our previous conclusion that the first magnetoplasmon mode wave vector is $k_1 = 3\pi/W$.

We also managed to reduce an amplitude of higher order modes ($n > 1$) by etching 100 μm-wide trenches at sides of samples. On the other hand, we also observed a large amplitude non-resonant signal, which we attribute to interferences of the incoming THz radiation. Such interferences make the non-resonant signal strongly dependent on small geometrical distortions of the THz beam geometry. The non-resonant signal is challenging when considering our devices as resonant THz detectors, because in some situations its amplitude might be comparable to the amplitude of the actual resonant signal, which could limit the usability of our devices.

In summary, presented results provide a yet unexplored resonant THz detector based on a 2DEG strip of a finite width and covered with a thin gate. The plasma resonant frequency is determined by the width of the 2DEG strip. By etching wide trenches around a strip an amplitude of high order plasmon modes can be limited. However, suppressing a non-resonant signal remains a challenge for the proposed resonant detector. This work was partially supported by a Polish National Science Centre Grant No. DEC-2011/03/B/ST7/03062.

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