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Terahertz spectroscopy of two-dimensional plasmons in grating-gated AlGaN/GaN heterostructures

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High electron mobility and temperature stability of III-nitride heterostructures serve as a base for the development of tunable frequency THz emitters. Some THz emission results of the 2D plasmons in nitride high electron mobility transistor (HEMT) structures have been previously reported, but they are still far from commercially viable devices. It is worth noting that the graphene-based plasmonic metamaterial for THz laser transistors was proposed recently. Nevertheless, the III-nitride heterostructures as promising plasmonic material were confirmed too by demonstrating possibility of the 2D plasmon excitation up to room temperatures. In this work, we report on the emission and transmission spectra of the 2D plasmons excited in THz range in grating-gated AlGaN/GaN HEMT structures at the 80 K temperature. The plasmonic samples were fabricated by positioning the periodic metal stripes on top surface of heterostructures over an area of about 2 × 2 mm2. Three gate-gratings were prepared in the same process on the 10x10 mm2 sample to minimize fabrication uncertainties and ensure the uniformity of material parameters over the different gratings. The periods of the gratings with filling factor of 50 % were selected to be 600 nm, 800 nm, and 1000 nm enabling the excitation of fundamental plasmon modes in the frequency range of 1 3 THz in wide temperature range. In this work the symmetric 800 nm period gratings were investigated in order to find optimal conditions for excitation of 2D plasmons under electrical excitation. The ohmic source, S, and drain, D, contacts to the conductive 2DEG channel were developed outside of the grating, the wave vector of which was oriented perpendicularly to the contacts as described elsewhere. The resonance position and intensity were found to be related to the grating period and the bias voltage applied to the transistor terminals. Moreover, the Rabi splitting of 2D plasmon resonance was observed in the emission spectra demonstrating the splitting values to be up to 400 GHz which was considerably larger than previously reported for the plasmonic samples developed of similar III-nitride heterostructures.

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