Investigation of Thermal and Plasmonic Emission from Grating-Gated GaN/AlGaN High Electron Mobility Transistors

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High frequency and high power electronics applications require material parameters, which are difficult to achieve with silicon technology. Gallium nitride (GaN) is one of the most promising materials, which would allow the fabrication of such devices. Preferable material parameters encouraged rapid development of GaN-based devices during recent years. A two dimensional electron gas (2DEG) formed at GaN/AlGaN heterojunction interface have been proposed to use for the development of field effect transistors (FETs) and antenna coupled terahertz (THz) detectors [1]. Moreover, the density and mobility of 2DEG can reach sufficiently high values at room temperature required for the development of an efficient THz emitter of the plasmonic GaN/AlGaN FET [2]. Radiative plasmonic oscillations at THz frequency originate in the transistor channel and couple out to free space via the grating electrodes which biasing can modulate the emission frequency via modulation of carrier density in the channel.

The aim of this work was to investigate THz emission spectra from the grating-gated AlGaN/GaN transistor structures at room and liquid nitrogen temperatures. The THz emitters with different geometry gratings were fabricated of the AlGaN/GaN structures grown on Al_2O_3 substrate [3].

The radiation power from dc-biased THz emitters was investigated at room environment using the two parabolic mirrors telescope and the pyroelectric THz detector and measuring the opto-mechanically modulated THz radiation with Lock-In technique. It was so called DC regime. In addition a supplied current was electrically modulated to realize an AC regime. A linear dependence between an electrical supplied power and an optical THz power was found. The THz emission power was slightly reduced upon sample cooling up to 80 K temperature. The decrease of the THz emission was attributed to the reduction of effective temperature of the 2DEG which was found depended on the supplied AC power.

In the next step, the radiation spectra of the sample in DC and AC regime were recorded using vacuumed Fourier spectrometer. Shape of the emission spectra in the DC regime was ascribed by thermal black body model without notable signatures of plasmonic radiation. Intensity of the thermal radiation in AC regime was reduced via an increase of ac-bias modulation frequency but without signature of emphasized plasmonic emission. It was found that thermal radiation from grating-gated GaN/AlGaN transistor dominated the spectrum. And the power of plausible plasmonic emission was at least ten times smaller than the thermal radiation power. Plasmonic THz power detection would require more sensitive He-cooled THz detectors with the response time faster than provided by used pyroelectic detectors. Recently it was demonstrated that the THz emitters would require more sophisticated electrical contacts [4] and better developed GaN/AlGaN heterojunction with electrons drift velocity higher by up to two orders of magnitude [5].

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