A promising detector of terahertz (THz) radiation is a field effect transistor (FET) with high mobility two-dimensional electron gas (2DEG) channel. Estimates for the real parameters of FET show that the frequencies of plasma excitations of charge carriers (plasmons) in the 2DEG transistor channel are in the THz frequency range [1]. Existing THz FET detectors operate in a wide range of THz frequencies, at ambient temperature and show a good balance between sensitivity and speed at non-resonant regime of detection [2], where plasmons are overdamped and the FET response is a smooth function of frequency as well as of the gate voltage. The main advantage of resonant regime of detection is narrow band signal with maxima at the plasma oscillation frequency and tunable by the gate voltage, which is not fully realized so far. For instance, control of resonant frequency can be used to obtain color images in THz range from a single array of detectors that are key elements in navigation systems, substance identification systems, industrial and anti-terrorism safety systems, terahertz tomography, astrophysics and other fields of science and technology.

The gated two-dimensional plasma excitations have a linear dispersion $\omega_p = sk$, where ω_p is the plasmon frequency, k is the wave vector, s is the velocity of two-dimensional plasma waves. In turn, the velocity of plasmons is proportional to the square root of electron density in a 2DEG layer. Therefore, a transistor structure based on a material system with a high electron density in a layer of a 2DEG will be characterized by a high adjustable frequency in the THz range. Therefore, the AlGaN/GaN nanoheterostructure looks promising for applications in THz detectors, where the 2DEG density reaches 10^{13} cm^{-2}. Thus, the resonant plasmon frequency can be tuned over a wide range due to changing the concentration of electrons by applying a voltage to the gate.

Among existing problems of high quality resonant plasmonic detectors in THz frequency range it is worth to mention the weak coupling of the transistor structure with THz radiation [3] and existing of the oblique plasma modes that propagate at different angles between source and drain terminals and make resonance broader and weaker as it was demonstrated in the first experiments of resonant and voltage-tunable THz detection in nanometer transistors [4].

This project is a basic research project, where the scientific objective is to investigate the plasmonic resonance phenomena in the AlGaN/GaN structures with the grating-gate and fin-shaped channel. The ***main goal*** of this project is to study the effects that are responsible for effective coupling between the short-wave gated plasmon oscillations and the relatively long-wavelength THz radiation and suppression the oblique modes excitation of plasma waves in AlGaN/GaN grating-gate and fin-shaped transistor structures.

Timeliness and novelty of the proposed research comes from recently developed progress of the epitaxial growth of AlGaN/GaN structures and innovative design of grating-gate structures of large (1.5×1.5 mm^2) area and fin-shaped structures with two lateral Schottky barrier gates. Where the first approach has following advantages: i) diffraction of incident electromagnetic radiation, which modulates radiation in the near field, enabling the excitation of plasmon, as result increasing of coupling efficiency between incoming THz radiation and plasma waves in 2DEG layer; ii) determination of wave vectors of excited plasmons due to periodic gate structure; iii) suppression of oblique plasma modes due to grating-gate action as an effective THz polarizer. Second our approach is fin-shaped structure, where channel length is much greater than channel width. In this geometry the oblique plasma modes are suppressed due to ability of propagation only in one direction between source and drain. Previously we have proposed the simple realization of wire channel transistor geometry by using two lateral Schottky barrier gates [5]. In this case lateral Schottky barrier gates are deposited directly to the edges of fin-shaped AlGaN/GaN channel, that makes possible to change channel width by gate voltage bias. Our preliminary studies of DC characteristics and non-resonant response in the sub-THz frequency confirm the validity of the approach [6].

Therefore, we expect that the project will have very ***high impact on the research field and discipline*** because it will answer the main question: are the high quality plasma resonances in the grating-gate and fin-shaped AlGaN/GaN structures possible and in which physical conditions (geometry, material properties, etc.) they can reach high quality factors. Understanding of the mechanism of broadening should also allow us to define FET structures useful for THz spectroscopy and imaging in security, quality control or medical applications. We expect also important outcome from the point of view of future applications thanks to new efficient THz detectors. Therefore, research proposed in the project may have ***important economic and societal impact***.

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