AlGaN/GaN field effect transistor with lateral Schottky barrier gate as sub-millimeter detector

P. Sai[1], D. B. But[1], P. Prystawko[1], I. Yahniuk[1], K. Nowakowski-Szkudlarek[1], J. Przybytek[1], S. L. Rumyantsev[2], W. Knap[1], G. Cywiński[1]

[1] *Institute of High Pressure Physics PAS, ul. Sokolowska 29/37, 01-142 Warsaw, Poland*
[2] *National Research University of Information Technologies, St. Petersburg, 197101, Russia*

We report on a study of a new type of AlGaN/GaN heterostructure field effect transistors (FETs) with gates based on lateral Schottky contacts [1]. Lateral Schottky contacts gives a possibility to control channel width which is interesting for plasma related terahertz (THz) resonant detection and emission application using FETs [2]. This is because it can eliminate so called "oblique plasma modes" which propagate in the transistors with the channel width of the order or larger than the channel length. These modes lead to important broadening of plasma resonances which is the most important obstacle in high quality resonance plasma detection and emission.

The AlGaN/GaN heterostructure used in current work was grown by metalorganic vapour phase epitaxy on a sapphire. More detailed information about sample preparation can been found in Ref. 1. Using this heterostructure, we made two types of transistors. A first one is FET with the fin-shaped channel (FinFET) where the gate covers whole channel and a second one – a new design, where unlike common two-dimensional transistors, two gates were deposited only to the edges of the two-dimensional electron gas (2DEG) channel. We propose EdgeFET as the short name for this device. In this case, a lateral gate based on side Schottky contact between the gate metal and 2DEG. The typical length and width of the FinFET and EdgeFET channels were 4 µm and 2 µm, respectively. Their transport characteristics are shown in Fig.1a.

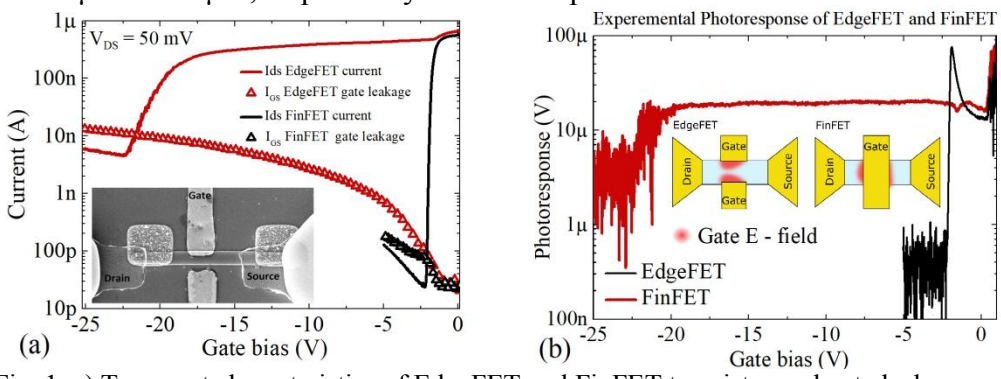

Fig. 1. a) Transport characteristics of EdgeFET and FinFET transistor and gate leakage current characteristic. The inset shows the microscopy images of the lateral Schottky barrier diode gate (upper one) of EdgeFET with a partial covering of the channel b) Photoresponses as a function of gate voltage of the same devices at 140 GHz. The inset shows the schematic draws of a FinFET and EdgeFET.

In this work we present first room temperature experiments on non-resonant detection in sub-THz (sub-millimeter) wave range on EdgeFETs and compare them with detection by FinFETs (see Fig.1b). The FinFET demonstrated a response that can be explained in the frame of existing theories. The EdgeFETs signal versus gate voltage characteristics were very different and we show that a new theoretical approach is necessary to explain their THz detection. Finally, we discuss possibilities of the cryogenic temperatures resonant plasma detection by these new EdgeFETs transistors – avoiding the oblique plasma modes broadenings.

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