Sub-THz detection by lateral high electron mobility devices based on AlGaN/GaN heterostructures

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We studied the AlGaN/GaN high electron mobility devices with a lateral Schottky barrier contact. The Schottky metallization was deposited directly to the sides of AlGaN/GaN mesa heterostructure. In case of field effect transistor (FET) two lateral gates were formed on the edges of two dimensional electron gas channel (see insert of Fig. 1a). EdgeFET abbreviation was proposed for this transistor [1]. Similar geometry of lateral Schottky barrier diode (LBSD) is shown in the insert of Fig. 1b.

For the first time the idea of using a FET for THz radiation detection was proposed by Dyakonov and Shur in ref. [2], where the key principles and different regimes of THz detection were described. It was predicted, that in some cases the dynamics of a short FET channel at THz frequencies is dominated by the plasma waves and the resonant response should be observed. One of the possible problems of obtaining high quality factor resonant response from FET detector is the existence of the oblique plasma modes in the FET channel. We propose to create the wire channel transistor by applying a negative voltage to the side gates. If the diameter of this wire channel is smaller than the channel length, the oblique modes should be eliminated, and plasma waves propagate only in the source-drain direction.

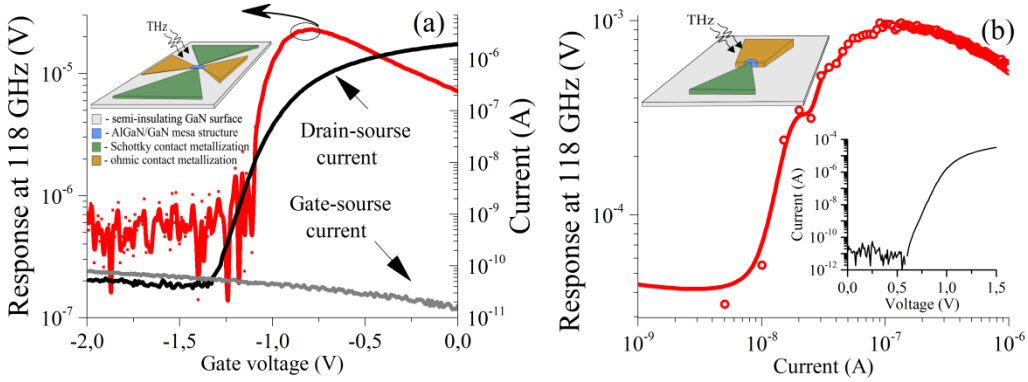

Fig. 1 Response measurements and I-V characteristics of EdgeFET (a) and LSBD (b).

When we consider the Schottky barrier diode (SBD), there are some important differences compared to THz detection by FET. In both devices, the detection process is based on rectification of the incident THz field by a nonlinear element, but in case of SBD nonlinearity is due to the nonlinear I-V characteristic of the potential barrier between the metal and the semiconductor. Lateral Schottky barrier diode has an advantage of the extremely small area and corresponding capacitance, which is beneficial for terahertz detection. The design of the ohmic contact assumes contacts on five sides of the mesa, i.e., on top and on every 4 sides of AlGaN/GaN mesa, thus reducing the contact resistance. These lead to the reduction of the *RC* product and increase of the cut-off frequency.

Room temperature response measurements of the detection on EdgeFET (Fig. 1a) and LSBD (Fig. 1b) demonstrate the ability of functionalization at the sub-THz range.

[1] G. Cywiński, *et al.*, *Appl. Phys. Let.*, **112**, 133502, (2018).
[2] M. Dyakonov and M. Shur, *IEEE transactions on electron devices*, **43**, 380, (1996).