Field Effect Transistors Based Terahertz Detectors History, State of the Art and Future Directions

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In the beginning of 90-ties Dyakonov and Shur proposed field effect transistors (FETs) as potential candidates for THz detectors and emitters. In their pioneering works the operation principle has been explained using physical models of plasma-waves propagating (or overdamped) in the channel of the transistors- for review see references [1,2]. Later some specific cases (room temperature overdamped plasma oscillations) has also been described as a distributed self-mixing resistive mixer [3,4] and by a lumped element approach [5]. A complete analytical expression valid in all regions of operation of the FET, including sub-threshold, linear and saturation as well as the loading effect has been proposed in references [6,7]. The theoretical predictions have been confirmed by many experimental results and the matrixes of FETs detectors were reported-for review see reference [8]. The real interest in FET based THz detection and imaging was triggered by a breakthrough discovery that standard Si-MOSFET transistors, in spite their low carrier mobility, can be very efficient detectors [9,10]. Later it has been shown that wide band – up to 4THz single pixel and focal plane arrays operating at sub-THz atmospheric windows can be achieved in Si -Technology [11,12]. Wireless communication applications with Si-CMOS based THz receivers operating at sub-THz bands have been also demonstrated [13].

We present an overview of results concerning THz detection related to plasma nonlinearities in nanometer field effect transistor. The subjects were selected in a way to show physics related limitations and advantages rather than purely technological or engineering improvements of FETs Terahertz detectors. We address the basic physics related problems like temperature dependence of the response [14], helicity sensitive detection [15] and nonlinear/saturation response at high incident power [16]. We present also the first results on new THz detectors based on GaN/AlGaN edge gate transistors and Si junction-less FETs [17,18] showing that the signal-versus gate voltage has unusual behavior and the results cannot be interpreted using standard models. A new theoretical approach is presented. All the recent results will be discussed in view of the physical and technical limitations of FET THz detectors and their application for quality control and postal security and nondestructive quality control linear scanners [19].

Finally, we will discuss possible future direction for FET-THz detectors improvements and applications.

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