Title of the Talk: FET-based detection of THz Radiation: Measurements, Mechanisms, Modeling

J. Marczewski[1], D. Tomaszewski[1], M. Zaborowski[1], P. Bajurko[2]

[1] Łukasiewicz Research Network – Institute of Microelectronics and Photonics, Warsaw, Poland (Ł-IMiF)

[2] Warsaw University of Technology, Warsaw, Poland (WUT)

Abstract: Silicon MOS field-effect transistors (MOSFETs, SOI MOSFETs) detect THz radiation even at frequencies above a few THz, i.e., far beyond cut-off and maximum frequencies of MOSFETs. The THz detection is observed also for other types of FETs, e.g., in HEMTs. This has made mature sub-micrometer FET technologies excellent platforms for development of electronic systems for communication, safety and research areas, to name a few.

Though electro-physical models of the FET operation are well developed and broadly used, the THz radiation detection in FETs cannot be explained by classic laws of electron transport. A number of models of this effect have been proposed by the research teams, including plasmon-based and resistive mixing-based ones. In those models, different mechanisms have been taken into account. To validate these models, measurement techniques have been developed. Existing views on the THz detection mechanism and measurement techniques will be briefly presented in the talk.

In the main part of the talk, works on measurements of THz detection in FETs and modeling of this effect, conducted jointly by Ł-IMiF and WUT will be presented. In the study a so-called junctionless field-effect transistor (JLFET) was used. The device architecture made it an efficient tool for investigating a possible THz detection mechanism. In particular, deeper insight into this effect was provided by a case study in which the low concentration of electrons in the gate-controlled region excluded plasmonic effects contribution. Considering the experimental results, a critical discussion of the plasmon-based theory of THz detection by JLFETs will be presented. Taking into account the revealed inconsistencies and based on numerical simulation results, a simple, one-dimensional model of the JLFET photo response was proposed. It is based on local electron heating in the channel between the gate and the source, where the high frequency current flows. The model was verified in a simulation-assisted experiment showing that the energy of hot electrons generates a sufficient photoelectric voltage, typical for silicon FETs integrated with antennas illuminated by THz radiation. The proposed model as well as prospects of its extension to a wider gate bias range will be presented. The talk will be concluded by a short discussion whether the proposed approach developed for the JLFET is valid for analysis of operation of other FETs as the THz detectors.