

## TERAHERTZ PLASMA EXCITATIONS IN NANOTRANSISTORS

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In part A of the lectures We present physical basis of the THz excitation in nanometer semiconductor structures[1]. We show why nanometer size is necessary to reach THz frequency range. We show also that When the mobility is high enough, the dynamics of a short channel FET at THz frequencies is dominated by plasma waves. This may result on the one hand, in a dc current induced spontaneous generation of plasma waves and THz emission, and on the other hand, in a resonant photoresponse to incoming radiation. In other cases, when plasma oscillations are overdamped, the FET can operate as an efficient broadband THz detector.

In part B We present an overview of some important and recent results concerning the physics of nanometre scale field effect transistors showing that they can be used for the detection of terahertz radiation .The subjects were selected in a way to stress some new aspects/developments rather than purely technological/engineering improvements. The basic physics related problems like temperature dependence of the photoresponse [2], interferences of THz signals leading to helicity sensitive detection are presented [3]. Until now most of works on nanometer FETs detectors were considering only THz imaging applications. We show the progress in overcoming the loading problems and demonstrate first results on the application of nanometre FETs as detectors in wireless communication with signal modulated in GHz range[4]. Finally we present also results from THz detection by grapheme transistors[5]. A possible development of future THz detectors using grapheme structures is also addressed.

### References

- [1] W. Knap and M. I. Dyakonov, 'Field effect transistors for terahertz applications' in D. Saeedkia, *Handbook of terahertz technology for imaging, sensing and communications*, Cambridge, Woodhead Publishing, 121-155( 2013) and W. Knap, S. Rumyantsev, M. S. Vitiello, D. Coquillat, S. Blin, M. Shur, F. Teppe, A. Tredicucci and T. Nagatsuma *Nanometer size field effect transistors for terahertz detectors* Nanotechnology 24 (2013)
- [2] Klimentenko O A, Knap W, Iniguez B, Coquillat D, Mityagin Y A, Teppe F, Dyakonova N, Videliier H, But D, Lime F, Marczewski J, and Kucharski K *Temperature enhancement of terahertz responsivity of plasma field effect Transistors* J. Appl. Phys. **112**, 014506 (2012)
- [3] Drexler C, Dyakonova N, Olbrich P, Karch J, Schafberger M, Karpierz K, Mityagin Yu, Lifshits M B, Teppe F, Klimentenko O, Meziani Y M, Knap W and Ganichev S D 2012 Helicity sensitive terahertz radiation detection by field effect transistors *J. Appl. Phys.* **111** 124504 (2012)
- [4] Blin S, Teppe F, Tohme L, Hisatake S, Nouvel P, Coquillat D, Penarier A, Torres J, Knap W, Nagatsuma T *Plasma-Wave Detectors For Terahertz Wireless Communication* IEEE El. Dev. Lett. **33** 1354 (2012)
- [5] Vicarelli L, Vitiello M S, Coquillat D, Lombardo A, Ferrari A C, Knap W, Polini M, Pellegrini V and Tredicucci A. *Graphene field-effect transistors as room-temperature terahertz detectors*, Nature Materials **11** 865(2012)

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