TECHNISCHE UNIVERSITÄT WIEN

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EINLADUNG zum IFP-SEMINAR

Development of novel detectors and modulators for the terahertz range

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Host: Andrei Pimenov

Termin: Mittwoch, 14. Februar 2024, 16:00 Uhr

Ort: TU Wien, Freihausgebäude

Wiedner Hauptstraße 8-10, 1040 Wien

Seminarraum DC rot 07 (roter Bereich, 7. OG)

Vor dem Vortrag gibt es ab 15:30 Kaffee und Kekse

Abstract:

In this talk, I will present my team's recent results on the development of novel terahertz (THz) detectors and modulators.

In the area of terahertz (THz) detection, we have recently discovered a new quantum phenomenon [1] in a gated 2D electron gas (2DEG). In this effect, which we called the "in-plane photoelectric effect", electrons absorb THz photons and jump on an artificially created, electrically tuneable potential step within the plane of a degenerate 2DEG. This effect enables efficient THz detection and can be realised in a device structure with two antenna-shaped gates on top of a semiconductor heterostructure, electrically similar to a type of dual-gated field-effect transistor. The devices exhibit a strong direct THz photoresponse at zero source-drain bias. The observed photoresponse could not be explained by previously known mechanisms, e.g., the measured response is an order of magnitude larger than expected from classical plasmonic mixing. Our theory of the phenomenon predicts that this mechanism is ideally suited for radiation detection across the entire THz gap. This in-plane photoelectric effect paves the way to the realisation of novel photoelectric tuneable-step (PETS) detectors on its basis. I will also present our recent results on the optimisation of PETS THz detectors.

In the area of THz modulation, we have demonstrated a novel graphene-metal metamaterial terahertz modulator, which we call a tuneable capacitance modulator [2]. It exploits graphene for capacitive tuning of a metamaterial, instead of the common approach of resistive shunting of the antenna gaps. We demonstrate a modulation depth in excess of 40 dB and a speed that is several orders of magnitude faster than seen in previous modulators with a high modulation depth. Our device exhibits the highest experimentally demonstrated modulation depth for a non-integrated graphene-based metamaterial, and our approach is compatible with GHz-speed modulation.

[1] W. Michailow et al., "An in-plane photoelectric effect in two-dimensional electron systems for terahertz detection", Science Advances 8, eabi8398 (2022).
[2] R. Xia, W. Michailow et al., "Achieving 100% amplitude modulation depth in a graphene-based tuneable capacitance metamaterial", arXiv:2312.16330 (2023).