ELECTROMAGNETIC DETECTION IN 2D MATERIALS VIA DESIGN OF CONTACT GEOMETRIES

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Intrinsically high mobility and moderate light absorption per layer in 2d materials set the basis for operation of fast and sensitive electromagnetic detectors. Still, emergence of zero-bias photocurrent in any detector generally requires the introduction of p-n junctions. The latter operation requires chemical doping which is not yet developed for 2d materials. Even if developed, doping would result in mobility degradation and, hence, lower speed of 2d photodetectors.

Here, we report the approach for dopingless 2d photodetectors which we dub as 'geometric design of contacts' [1]. It is based on the two physical principles (1) a lateral contact between 2d material and metal necessarily involves a built-in Schottky junction, where an internal photovoltaic effect takes place (2) the "metal-2d material" junctions at the source and drain can be made geometrically inequivalent, which makes their partial photocurrents non-compensating.

We discuss in detail the two detector architectures designed using this principle. The first one represents a rectangular 2d flake with metal contacts to the orthogonal sides. Illumination of the structure with linearly polarized light results in enhanced local intensity at one side via the polarization-dependent lightning rod effect [2]. Therefore, the device demonstrates a zero-bias photocurrent with direction specified by the angle of linear polarization. The second class of devices represents a 2d layer with two contacts, one patterned to a sawtooth shape, and the other completely flat [3]. Here, the local light intensity at the patterned contact exceeds the intensity at the flat contact, independently of the polarization state of light. Bringing the two contacts in close proximity to each other (~200 nm) results in extreme light concentration at the edges, strong light-induced heating of 2d electrons, and large photothermoelectric voltage.

[1] V. A. Semkin *et al.*, "Zero-Bias Photodetection in 2D Materials via Geometric Design of Contacts," *Nano Lett.*, vol. 23, no. 11, pp. 5250–5256 (2023)
[2] V. Semkin, D. Mylnikov, E. Titova, S. Zhukov, and D. Svintsov, "Gate-controlled polarization-resolving mid-infrared detection at metal–graphene junctions," *Appl. Phys. Lett.*, vol. 120, no. 19, p. 191107 (2022)
[3] A. Yu. Bocharov *et.al.* "Detector of electromagnetic radiation", patent for the invention RU 2 816 104 C1 (2024)