Geometric Design of Contacts to 2D Materials for Efficient Unbiased Photodetection

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A necessary condition for photodetection is the presence of nonlinearities for radiation rectification and their asymmetry to obtain an uncompensated overall photoresponse. We propose a configurable and technologically easiest approach to reach it — geometric contact engineering. This technique eliminates the need for bias current or chemical doping or multiple lithography-metallization cycles for dissimilar metallization. In our approach, metal/2d material junctions are used as nonlinear rectifying elements. In conjunction with strong polarization-sensitive scattering of electromagnetic waves at the edges of thin metal contacts [1], this can satisfy the necessary condition if the electrodes are properly designed. To demonstrate this, we fabricated a detector based on a 2d material with 90˚-rotated contacts [Fig. 1a], providing geometric asymmetry [2]. Under linearly polarized illumination oriented perpendicular to one of the contact edges, the electric field is enhanced near the corresponding junction. While the opposite junction remains relatively passive due to the absence of comparable field enhancement. Thus, the total photocurrent is determined mainly by the first junction. When the light polarization is rotated by 90 degrees, the roles of the junctions change and the photocurrent sign flip [Fig. 1b]. This is just the first demonstration of the principle that we are currently developing and we will soon be ready to present new results. To conclude, geometric contact engineering for 2d materials holds great promise for photodetection purposes and has already been appreciated by the scientific community [3].

References

[1] V. Semkin et al., Appl. Phys. Lett., 120 (2022), 191107
[2] V.A. Semkin et al., Nano Lett., 23 (2023), 5250-5256
[3] L. Shi, Nat. Nanotechnol., 18 (2023), 702–702

Figures

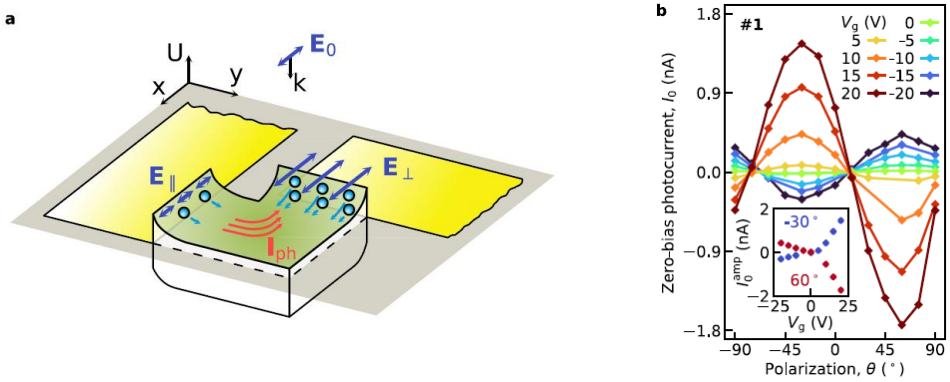

Figure 1: a, Illustration of the operating principle for the corner-type detector: incident linearly polarized field is enhanced by the metal contact orthogonal to the E-field and suppressed by another contact. The Schottky junction at the 'active' contact generates large photocurrent, which cannot be compensated by a small current at the 'passive' junction. **b**, Series of zero-bias photocurrents I_0 for corner-type device vs polarization angle θ at different gate voltages V_g. [2]