Graphene Based Room-Temperature Terahertz Detector with Integrated Bow-Tie Antenna

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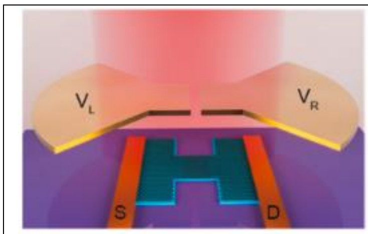
In electromagnetic spectrum, terahertz (THz) wave is between light and microwave. Its photon energy is much lower than normal infrared light and its frequency is higher than microwave. Therefore, it is hard to implement techniques of these two spectral ranges into THz spectrum, especially techniques in generation, modulation and detection. This has hindered the exploitation of THz spectrum although recent studies have showed its promising potentials in industries such as semiconductors, biotechnology, communications, imaging and so on. We have designed a bow-tie antenna and integrated it into a graphene photodetector. In this device geometry, the absorption enhancement region overlaps with photocarrier separation regions in graphene, which therefore greatly increases photocurrent generation. In addition to the antenna, we also design the channel. Firstly, we use BN-encapsulated graphene which has shown low residual doping (residual doping concentration of $1.3 \times 1011\ cm^{-2}$) and high mobility (μ up to 20000 $cm^{2} \cdot V^{-1} \cdot s^{-1}$ at room temperature) in the device. The high-quality graphene as channel guarantees a large seeback-coefficient difference at the pn junction and fast photoresponse. The corresponding noise equivalent power (NEP) is calculated as about 1 nW·Hz−1/2 if Johnson-Nyquist noise is assumed as the dominating noise. Moreover, the operating frequency is measured as larger than 5 kHz, which, together with the enhanced photoresponse, indicates that our design is a promising candidate for THz detection.



Picture

Pic.1 Schematic diagram of an antenna integrated graphene THz detector.

Bibliography

[1]. Jiawei Yang, Chunyag Zheng, Yahui Pang, Zhongyang Ji, Yurui Li, Jiayi Hu, Jiangrui Zhu, Qi Lu, Li Lin, Zhongfan Liu, **Qingmei Hu***, Baolu Guan*, Jianbo Yin*, **Acta Phys. -Chim. Sin. (**2023), 2307012.

[2].Mingjia Jiang, Denan Kong, Minghao Zhang, He Lan, **Qingmei Hu***, Yao Zhou, Jiadong Zhou*****, Advances in Two-Dimensional Materials for Infrared Photodetection: Synthesis, Heterostructures, and Device Innovations[J]. **Advanced Physics Research** (2025).