

# High-Responsivity Monolithic Graphene/Germanium Junction Field-Effect Phototransistor for Short-Wave Infrared

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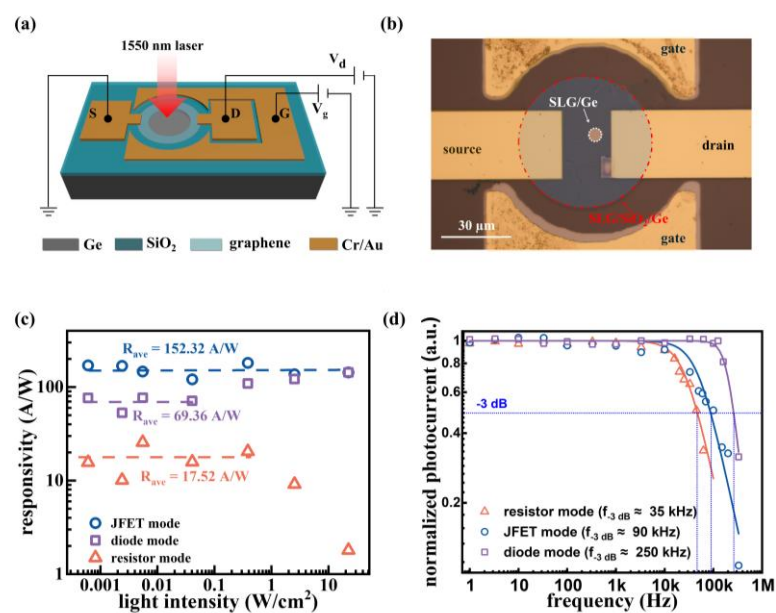
Abstract.

Monolithically integrating 2D graphene with conventional 3D semiconductors offers a promising strategy for realizing high-responsivity, ultrafast on-chip photodetectors by leveraging graphene's fast carrier transport and the strong light absorption of bulk semiconducting substrates [1-3]. In this work, we introduce the design, fabrication, and experimental characterization of high-performance single-layer graphene/germanium (SLG/Ge) junction field-effect transistor (JFET)-based photodetectors (PDs), fabricated using a standard CMOS-compatible process flow and an advanced semi-dry SLG transfer. The realized devices can operate in different photodetection modes, including resistor, photodiode, and phototransistor, using diverse electrical biasing. Due to the advanced device configuration, the JFET mode exhibits a significantly higher responsivity, enabling enhanced photogenerated carrier injection at the SLG/Ge interface using active electrical modulation from the gate and bringing carrier multiplication in the SLG channel. This yields a peak photo-responsivity of  $\sim 150$  A/W at 1550 nm, with a microsecond response time. This work demonstrates a promising approach to developing broadband 2D/Ge hybrid PDs with high responsivity and favourable integration with photonic integrated circuits.

References

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2. Kovalchuk, O., Gong, S., Moon, H. et al. *npj Nanophoton.* 2, 31 (2025).
3. Zha, J., Luo, M., Tan, C. et al. *Adv. Funct. Mater* 32, 2111970 (2022).

Figures



**Figure 1:** (a) The schematic SLG/Ge JFET photodetector configuration; (b) The optical microscope image of the fabricated SLG/Ge JFET detector; (c) The device power-dependent responsivity and (d) measured frequency response.