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A high-performance all-silicon photodetector enabling telecom-wavelength detection at room temperature

Photonic integrated circuits (PICs) offer major advantages in speed, bandwidth, and energy efficiency for optical communication. A key challenge remains the integration of efficient photodetectors operating near 1550 nm—within the telecom C band—due to silicon's low absorption in this wavelength range. Conventional approaches rely on materials like germanium, which complicate fabrication and integration.
We demonstrate a high-performance, all-silicon photodetector that operates at room temperature and is fully compatible with standard silicon photonics platforms. By introducing deep-level impurities near silicon's solubility limit, we enable strong sub-bandgap absorption while preserving favorable electronic properties. The waveguide-coupled detector achieves a responsivity of 0.56 A/W, quantum efficiency of 44.8%, 2 GHz bandwidth, and a noise-equivalent power of 4.2×10-10 W/Hz1/2 at 1550 nm. These metrics meet the demands of telecom applications without requiring heterogeneous integration. This work presents a scalable and CMOS-compatible solution for monolithic photodetection in the telecom band, paving the way for compact and cost-effective silicon-based PICs.

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