

High-performance graphene devices for light emission, detection, and modulation

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The unique electronic and optical properties of graphene make it an extremely promising material for optoelectronic applications. These include high electronic mobility; broadband light absorption; gate-tunable optical absorption; and tunable plasmon resonances. In addition, graphene's high strength and stability allows it to reach temperatures sufficient for thermal light emission at visible wavelengths¹. These properties have motivated extensive investigations of graphene optoelectronic devices. However, most such devices have utilized graphene on standard oxides, in which substrate-induced disorder and scattering substantially limits performance.

We have pioneered and perfected techniques for achieving ultrahigh performance in graphene using hexagonal boron nitride (hBN) as an insulating dielectric². Graphene devices encapsulated by hBN show intrinsic behavior at room temperature, including electronic mobility of 30,000-100,000 cm²/Vs. Using these devices, we have investigated a number of different properties and device architectures for optoelectronics: (1) ultrafast photodetectors integrated with waveguides³; (2) modulators consisting of double-layer graphene structures integrated with photonic crystals⁴; (3) sharp and tunable plasmonic resonances⁵. In addition, we have demonstrated that hBN-encapsulated graphene can sustain large currents to enable broadband visible light emission. These devices can be integrated on-chip and have operational lifetimes of many years. Therefore, we can now envision ultrafast photonic circuits with key active elements constructed entirely from graphene.

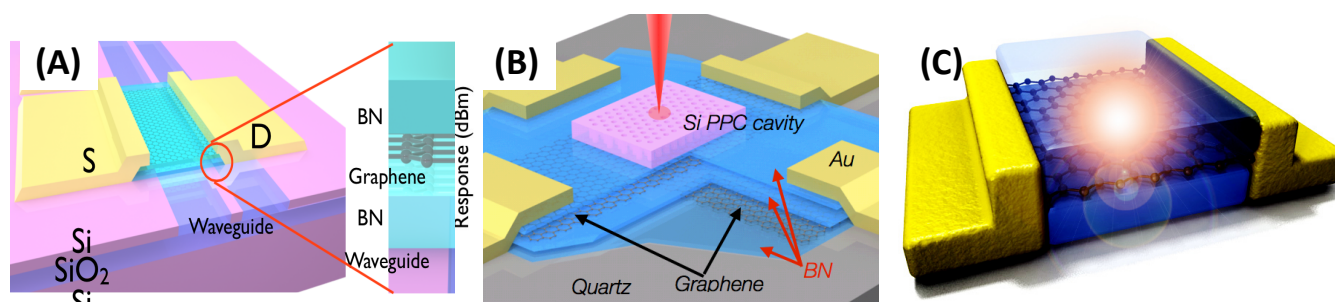


Fig. 1. Graphene / hBN optoelectronic devices. (A) Waveguide-integrated photodetector. (B) Double-layer graphene modulator integrated with photonic crystal cavity. (C) Incandescent light-emitter

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