Integration of black phosphorus photoconductors with lithium niobate on insulator photonics

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Photodetectors formed with layered two-dimensional (2D) materials have shown significant potential for integration with photonic circuits, offering fast, high responsivity and low noise detection over a broad range of optical wavelengths. However, only preliminary trials of this concept have been performed on the emerging photonics platform - lithium niobate on insulator (LNOI).

In this study, we demonstrate a novel architecture consisting of ~15 nm thick layered black phosphorus (bP) photoconductors draped over LNOI waveguides, as shown in Fig. 1. The performance of these detectors is studied across the telecom bands at room temperature, and a high extrinsic responsivity of 148 mA W^{-1} is measured at λ = 1550 nm under low bias conditions (V_{DS} = 0.3 V). This is among the highest responsivity results reported for waveguide integrated 2D materials detectors under low power conditions. The spectral response of the detectors is broad allowing the response of other photonic components to be characterized in-situ, without need to out-couple the light. Finally, the speed of the bP detectors is found to be beyond our instrumentation, setting 100 ns as an upper-limit rise/fall time, with the actual speed of the bP detector likely to be much faster.

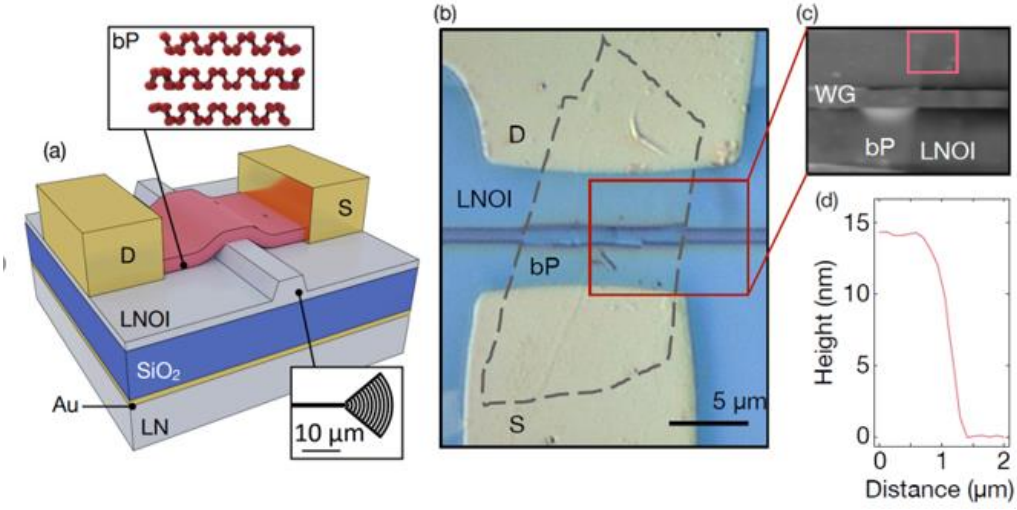

Figure 1. (a) Conceptual schematic of the device consisting of a ridge LN waveguide and a bP photoconductor. Black phosphorus' layered crystal structure is shown in the top inset. (b) Optical microscope image of a representative device showing the bP, source (S) and drain (D) and the LN waveguide (WG). (c) AFM image of the region approximately indicated by the red box in (b). (d) Step height measurement of ~15 nm corresponding to the red box in (c).