# Waveguide Integrated $MoS_2$-based Photodetectors in the Shortwave IR

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Abstract

Photodetectors with a broad spectral response, operating at room temperature in the visible and infrared wavelengths, are of major significance in spectroscopy, imaging, and communication [1,2]. Although the traditional crystalline silicon (c-Si) and amorphous silicon (a-Si) technologies have amazingly developed over the years, they have a severe limitation on spectral sensitivity (VIS-to-NIR) and operating wavelength (0.3–1.1µm) [3]. Germanium on-Silicon (Ge-on-Si) and other traditional materials, including compound semiconductors HgCdTe, InGaAs, InSb, and type-II superlattices, can cover spectral bands in the infrared but, their technologies are complicated, and they typically face high-cost manufacturing and are not compatible with the standard scalable silicon fabrication facilities [4]. 2D materials integration with SiPh opens an unprecedented opportunity to reach the goal of monolithically integrated broadband photodetectors on-chip.
Here we report the design, fabrication, and characterization of a single-layer $MoS_2$ (1L-$MoS_2$)-based photodetector integrated with silicon-on-insulator (SOI) waveguide, operating at telecom wavelengths (1.5-1.6µm). 1L-$MoS_2$ is a two-dimensional semiconductor with an energy bandgap in the visible wavelengths (1.9eV), therefore it cannot absorb IR radiation directly by the band-to-band absorption [5]. In our design, a metal contact is placed on top of the silicon waveguide and the 1L-$MoS_2$, therefore the light absorption takes place at the metal contacts and not in the 2D material itself. Our photodetector operates at zero bias with no dark current. The responsivity of our device can be described by the combined mechanisms of the photo-thermoelectric effect produced by temperature gradient and internal photoemission of the photoexcited electrons at the metal/$MoS_2$ interface. Our device shows responsivity of 5-10V/W with maximum values of ~100V/W. Our results pave the way for developing broadband-integrated $MoS_2$-based photodetectors from visible to IR.

References

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Figures

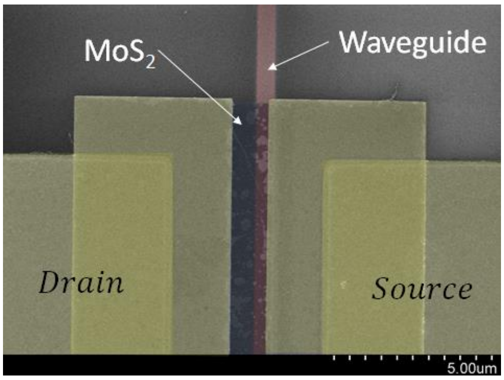


**Figure 1:** Scanning electron micrograph (false-color) of 1L-$MoS_2$ photodetector integrated with an SOI waveguide.

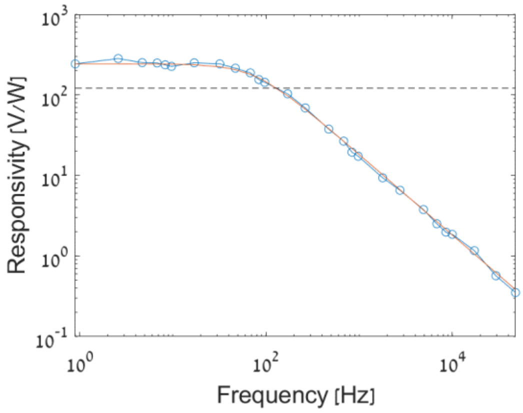


**Figure 2:** Frequency response of the photodetector.