reactive plasmonics

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Tuneable Cavity-enhanced Bandgap-free Photodetectors

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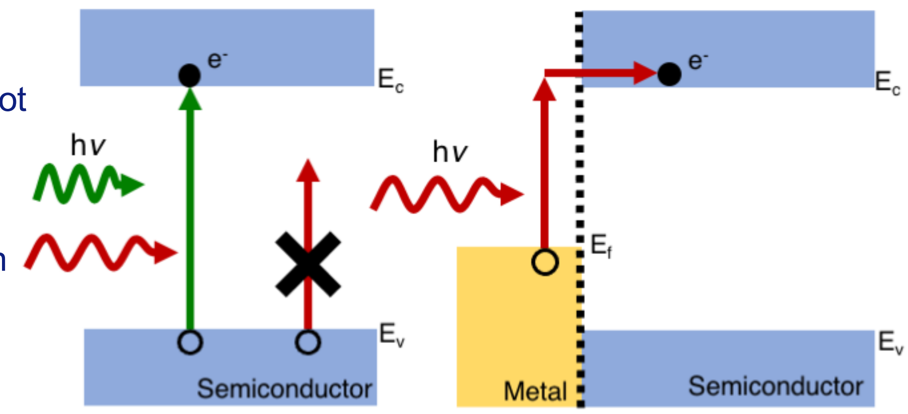
Semiconductor photodetectors – require light with energy matching or exceeding the bandgap, curtailing their spectral range.

Silicon-based visible light detectors (low cost, CMOS compatible) cannot operate far in the infrared (1.1 μm bandgap) - costly materials (e.g. InGaAs) employed instead.

Solution: expand silicon detectors into the infrared using a metal-silicon interface - absorption occurs in the metal and hot carriers are subsequently injected into the semiconductor.

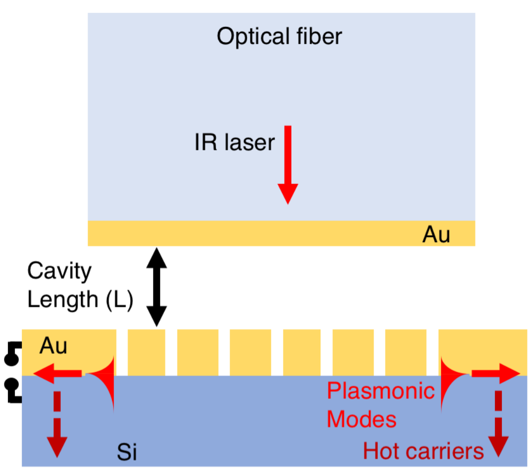
Here, we demonstrate a compact means of enhancing this process via plasmonic and optical cavity modes, yielding larger photocurrents, and also tuning the detection wavelength, allowing for a wide range of wavelength-selective applications.



Conventional, bandgap-limited absorption

Metal-enabled, bandgap-free absorption

Design



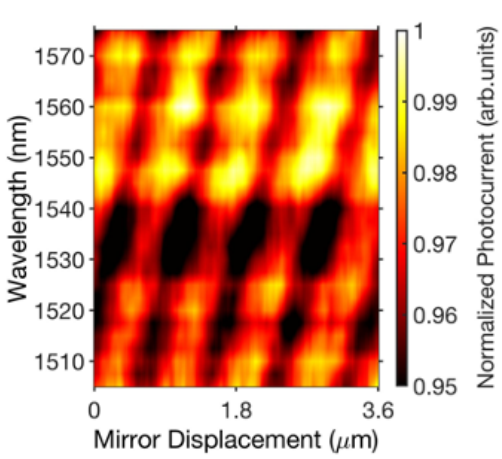
Performance of this metal-enabled bandgap-free approach can be significantly enhanced by using plasmonic and optical cavity modes.

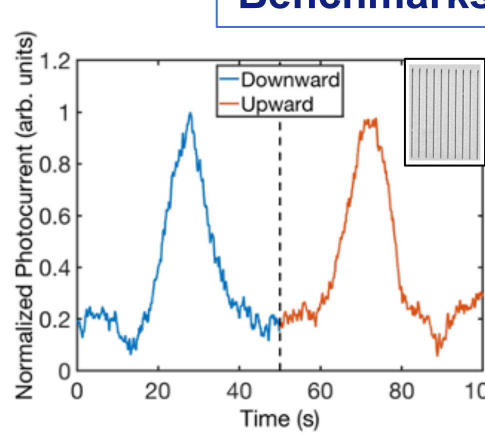
General Design: Compact optical cavity incorporating a grating on silicon.

Cavity modes lead to enhanced plasmonic generation and thus **significantly increased metal absorption at the silicon-gold interface**, leading to greater photocurrents.

Cavity can be **actively controlled (e.g. electromechanically, all-optically) to tune the detection wavelength.**

Benchmarks





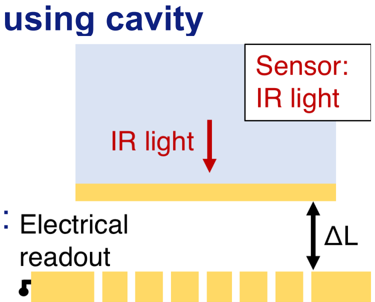
- **Spectrally tuneable detection**
- Stable, narrowband photoresponse
- **Enhanced photocurrent (x5)**
- **Compact design amenable to on-chip integration**, small footprint (15 x 12 microns)
- Compatible with many photodetector architectures

Universal approach to enhancing plasmonic bandgap-free photodetectors – towards commercial performance

Applications

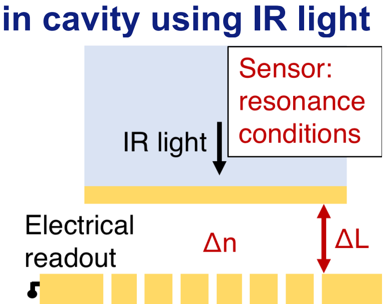
Sensing IR light using cavity

- On-chip photodetectors: optical communications (1.3 -1.6 μm).
- IR imaging beyond 1.1 μm: e.g. biological, LIDAR



Sensing changes in cavity using IR light

- Pressure: change in film separation (ΔL)
- Biosensing: change in refractive index between films (Δn)



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McPolin et al., Reconfigurable Cavity-based Plasmonic Platform for Resonantly Enhanced Sub-bandgap Photodetection, J. Appl. Phys. (2020) doi: 10.1063/5.0027865