Si-compatible Infrared Photodetection via Thin Film TiO_2 Oxide Interlayers

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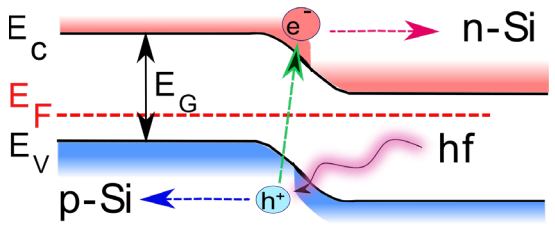
Targeted technology

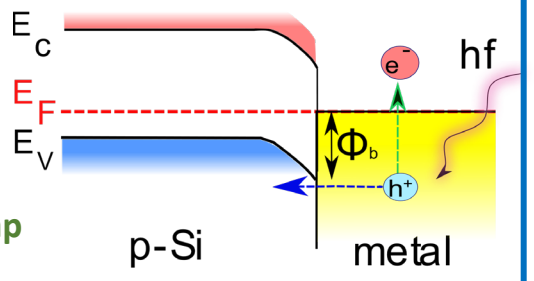
Si-compatible IR photodetection based on hot carrier Schottky junctions

Basic idea: Circumventing the bandgap limitation in semiconductors, especially Silicon by exciting carriers in a metal at a Schottky junction metal-semiconductor interface.



Classical p-n heterojunction: Carriers require at least the bandgap energy of the semiconductor

Schottky hot carrier junction: Merely the Schottky barrier potential is required



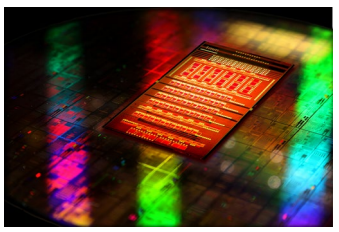
Applications

Strong points: Si-compatible, cheap, facile fabrication, bio-compatible (in contrast to e.g. InGaAs), self-powered, combination with refractory materials such as TiN, various materials and geometries can be exploited (see e.g. Cillian McPolin's poster)

Cheap and fast photo-detection diodes:

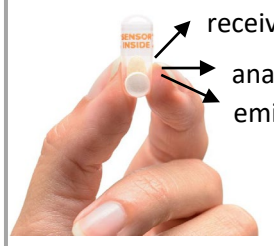
Schottky junctions Si-compatible are fast and cheap to fabricate. Hence offer great potential for the use of IR photodiodes

Si-chip compatible optical communication:



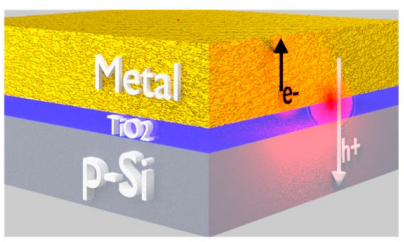
Si-chip compatible PDs are highly sought for, for next gen photonic computing. Here plasmonics allows for small footprints and Si integration.

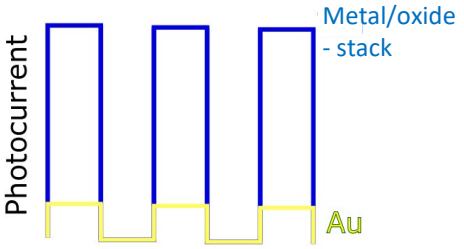
Ingestible sensors:

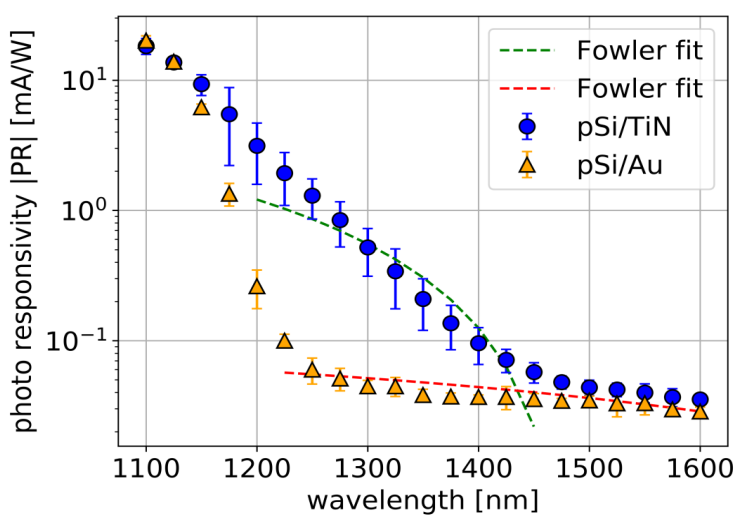


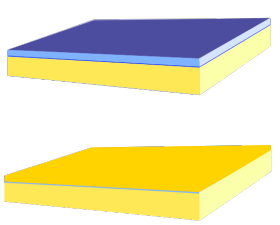
Human tissue has its transmission window in the IR. Also self-power technology circumvents the need of bulky battery elements

Results & Benchmarks









Stack	PR (mA/W)	Group, University	Year
n-Si/Ti/Au	3	Valentine, Vanderbilt	2014
n-Si/Pt	0.1	Munday, Maryland	2017
p^{++}-Si/Au	5	Halas, Rice	2018
n-Si/Au	8	Chen, Taiwan	2019
p-Si/TiN	**1.0**	**This work**	**2019**

Commercial InGaAs: ≈ 100 - 1000 mA/W

Conclusion:

The photo response of this simple flat layer stack is already in the competitive regime and can be further boosted by tuning the oxygen composition of the oxide interlayer as well as via combination with plasmonic resonance structures. Although the performance is still lower compared to commercial InGaAs and Ge-detectors, it offers important advantages such as simplicity, compatibility with silicon, and low-cost fabrication as well as self-powered operation.

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