High sensitivity silicon-based VIS/NIR photodetectors

James Carey and Eric Mazur
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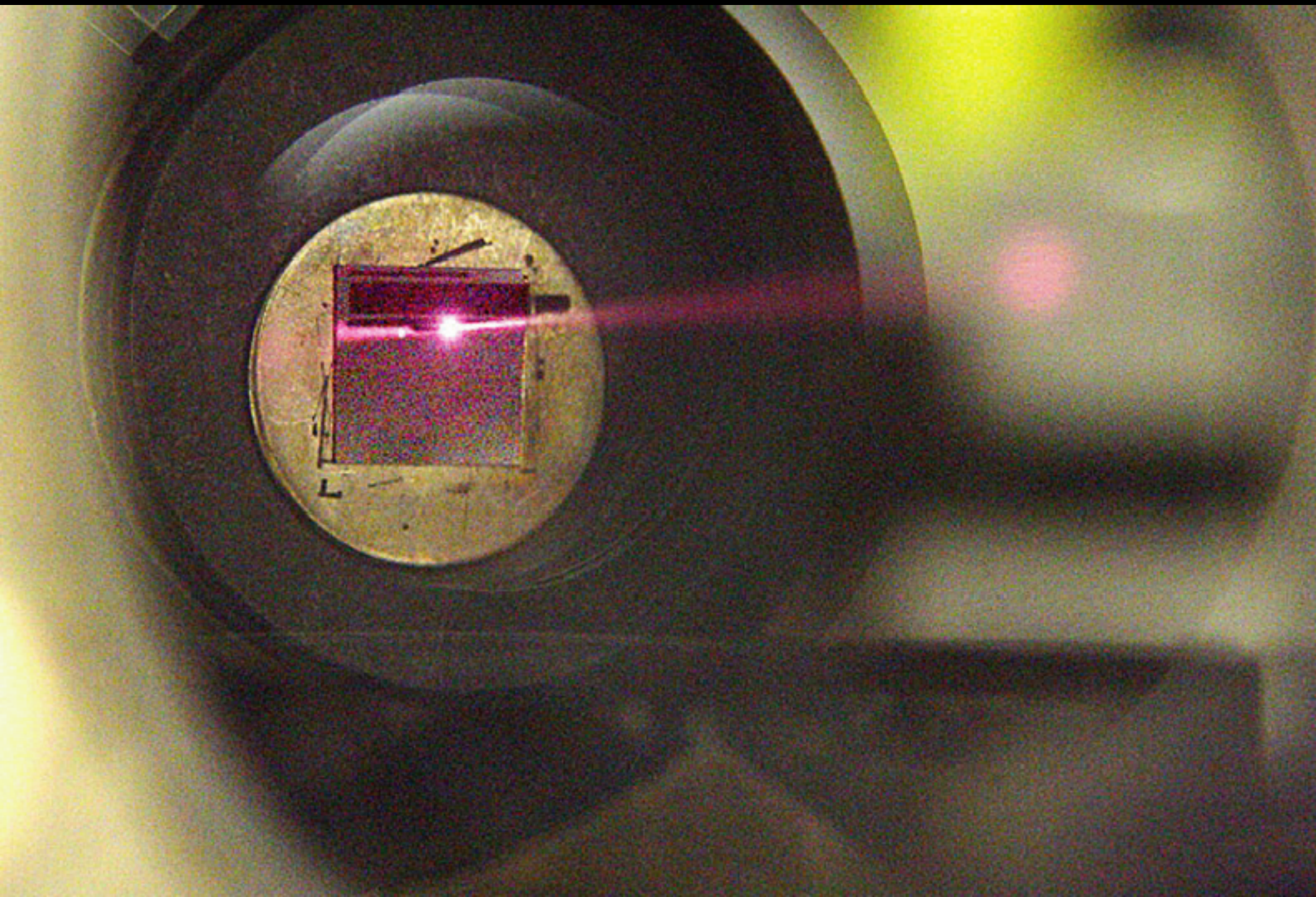
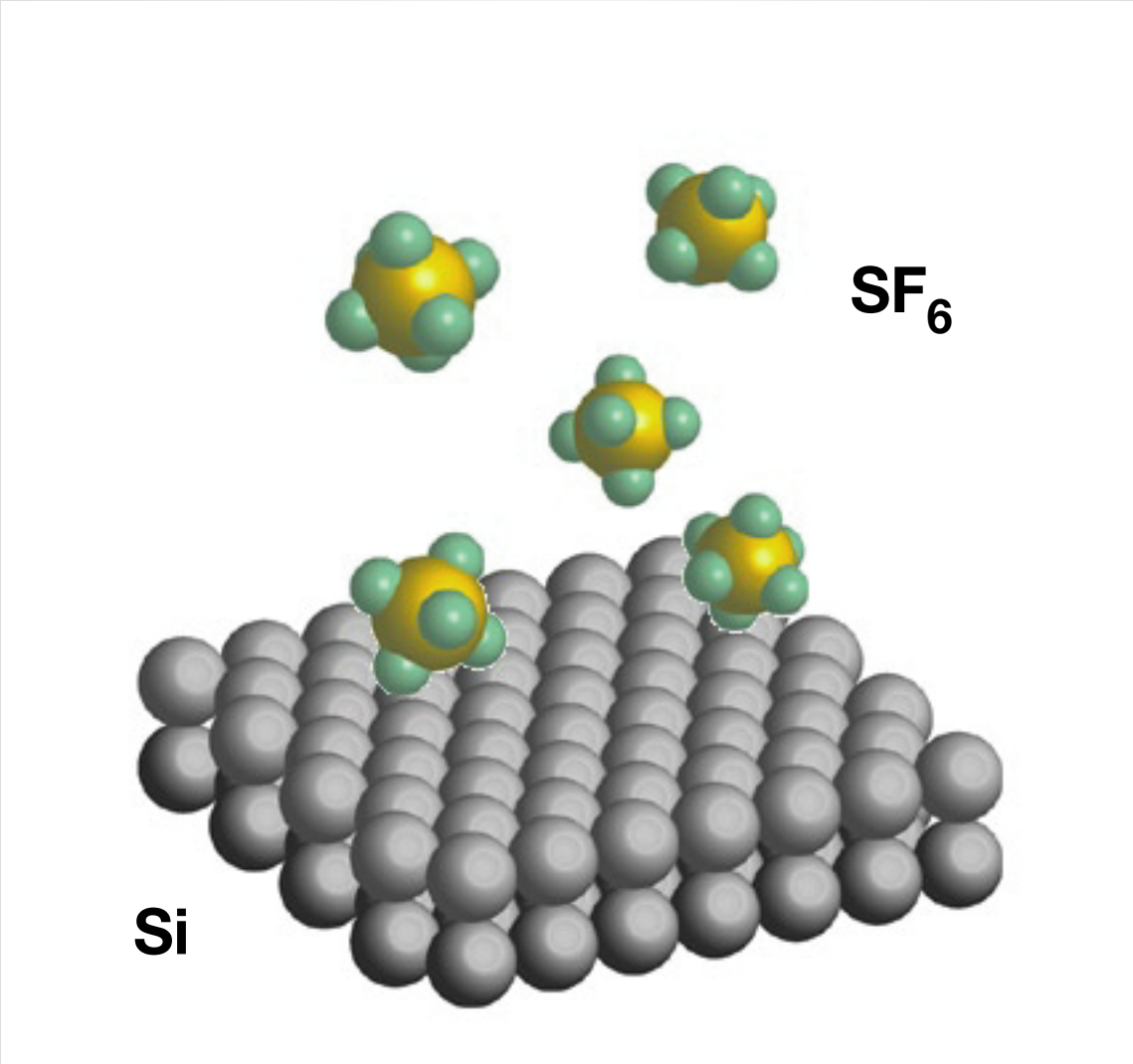
Introduction



Introduction

irradiate with 100-fs, 8 kJ/m^2 pulses



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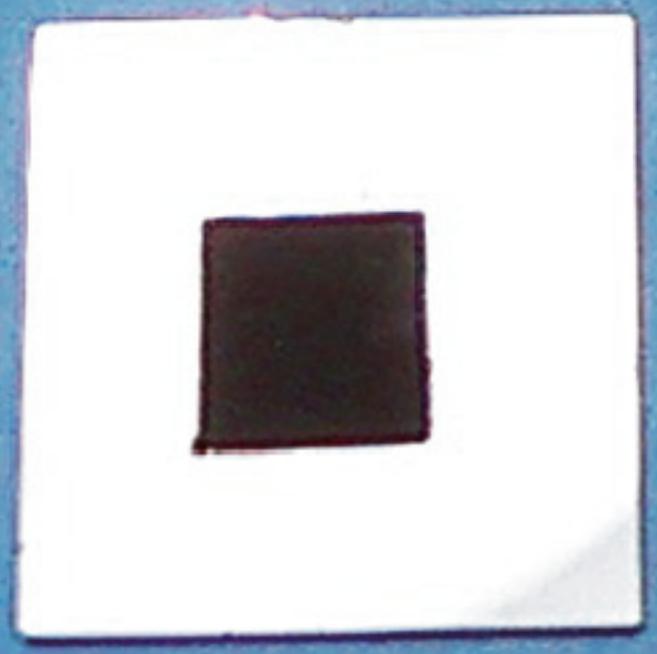
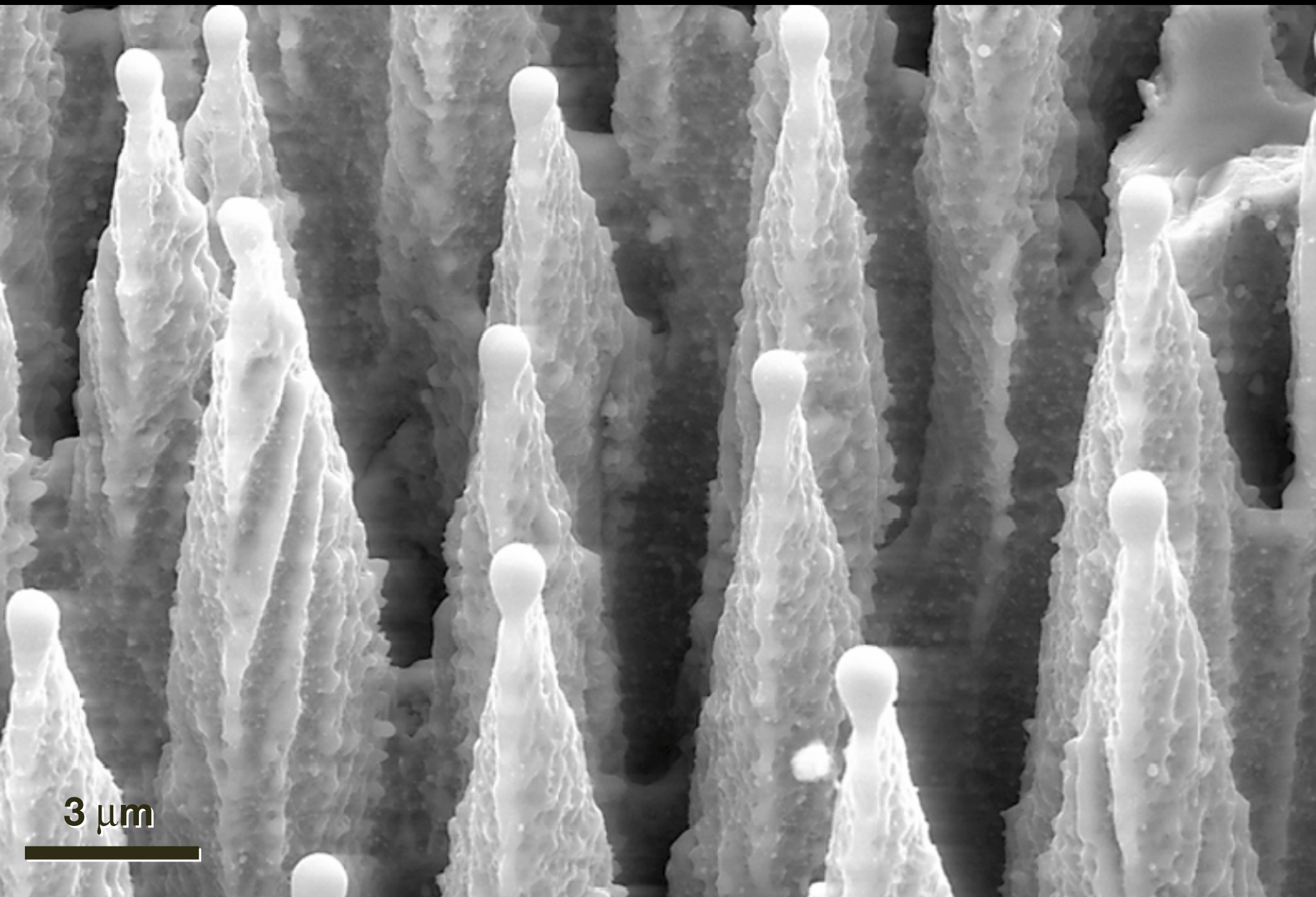


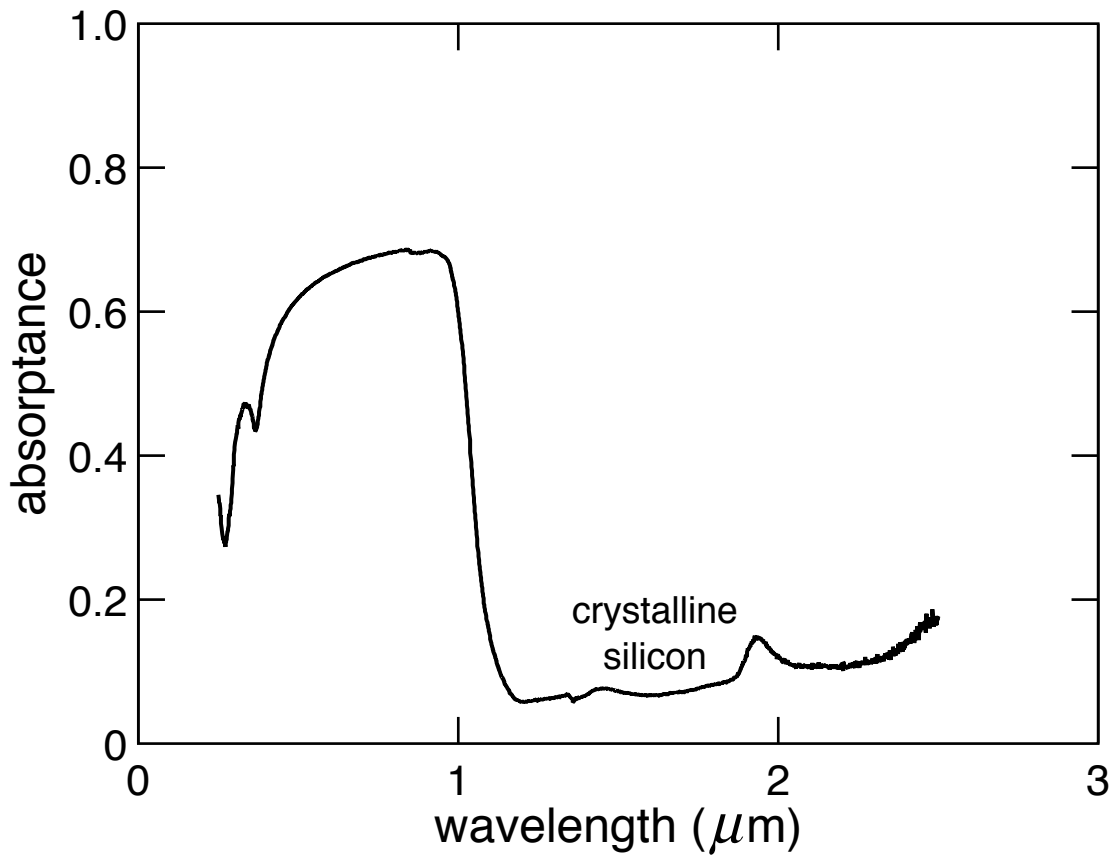
"black silicon"

Introduction



Introduction

absorptance (1 – *R* – *T*)



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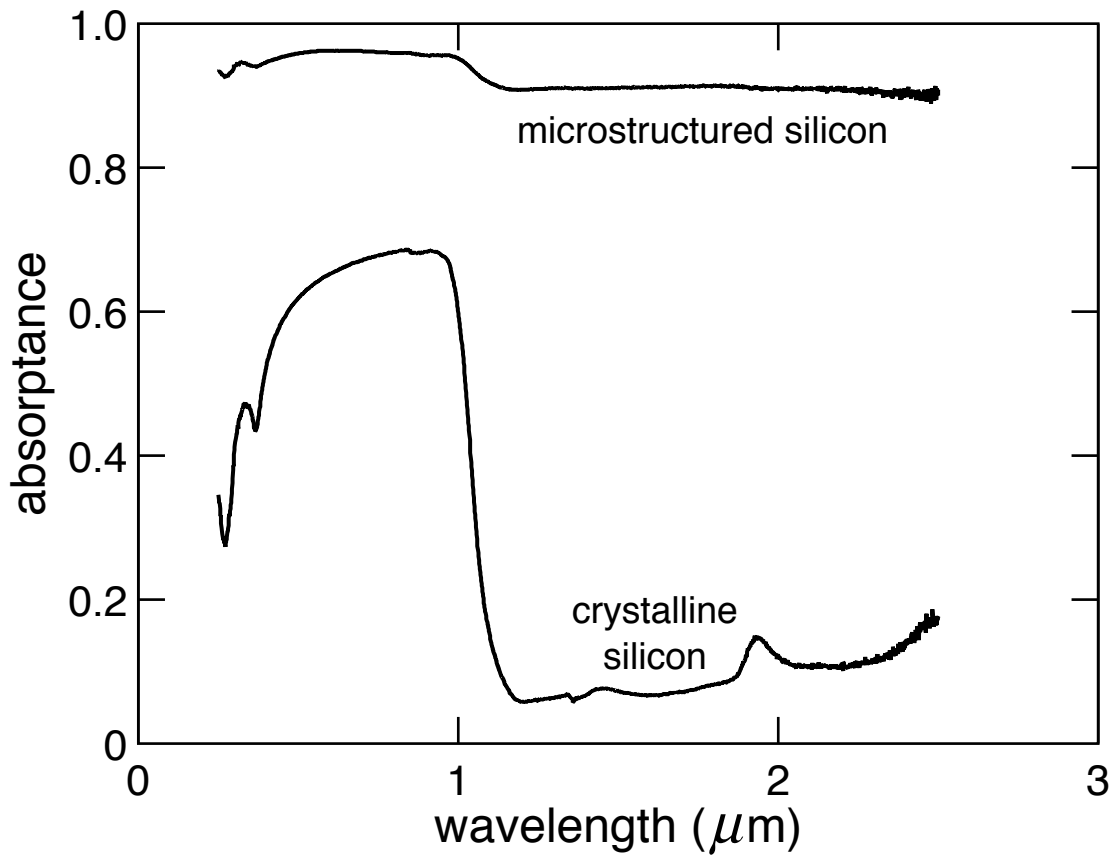
absorptance (1 – *R* – *T*)



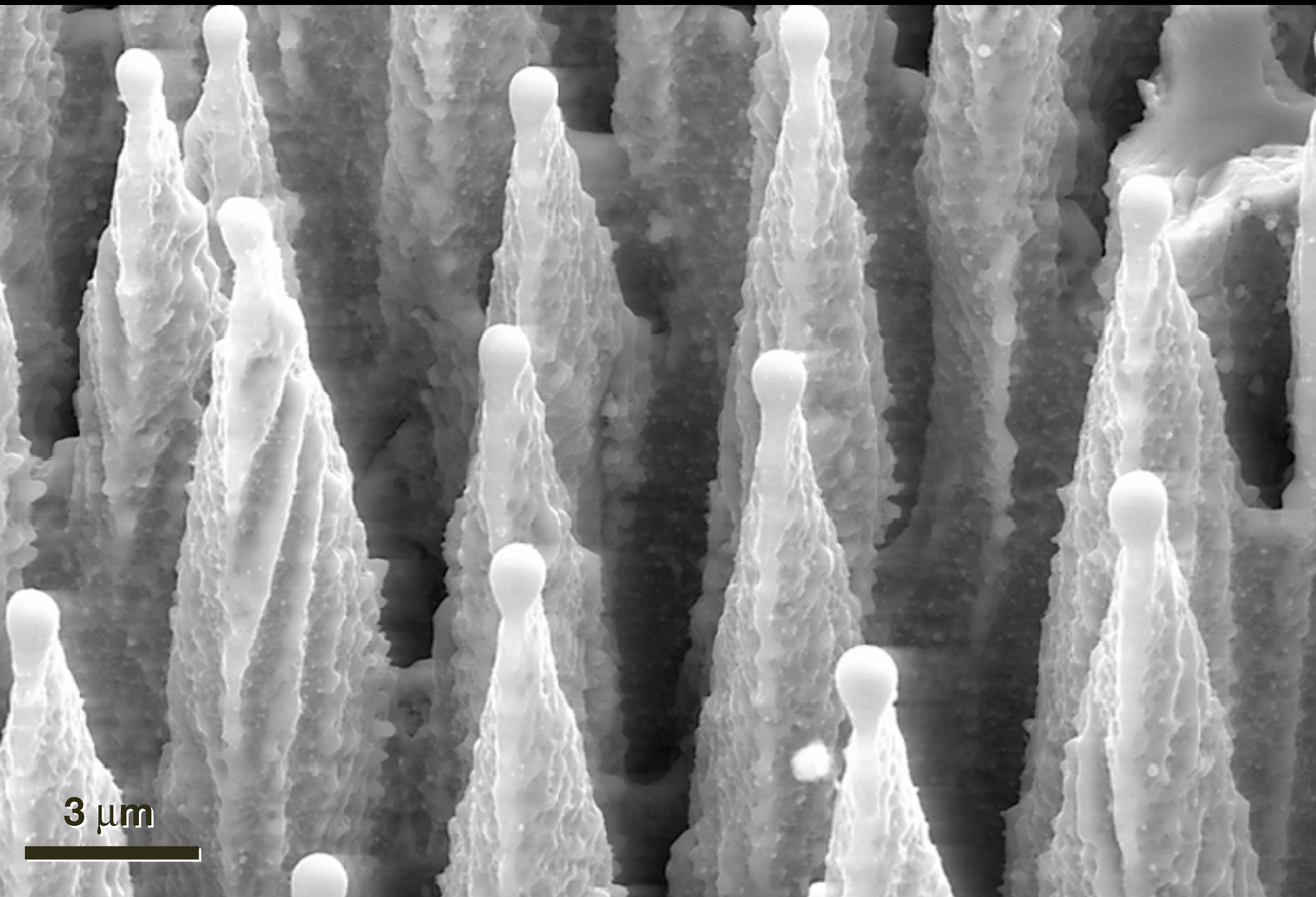
Introduction

- enhanced visible absorption
- near-unity absorption in near-IR
- easily integrated with microelectronics

Introduction

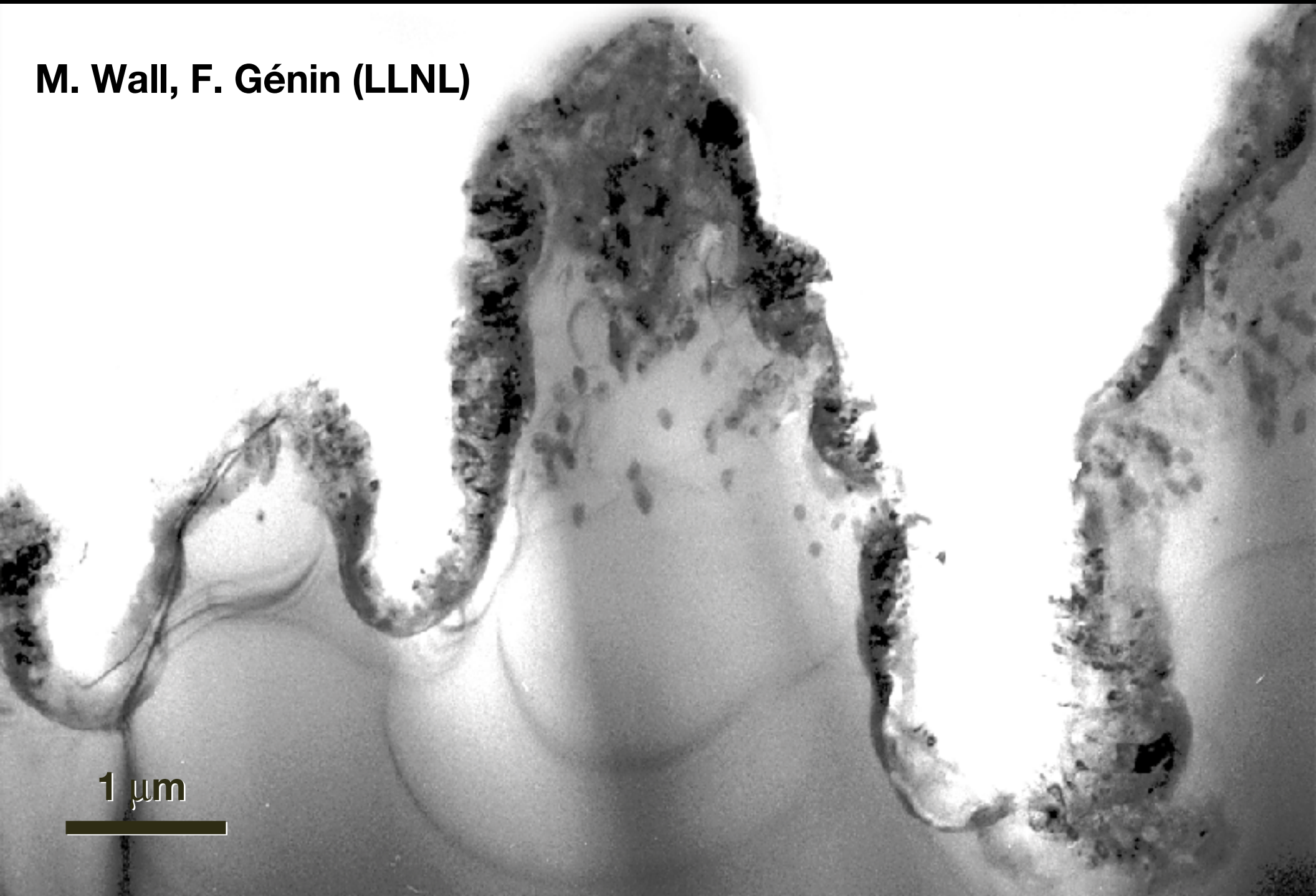
can we take advantage of high absorption?

Background



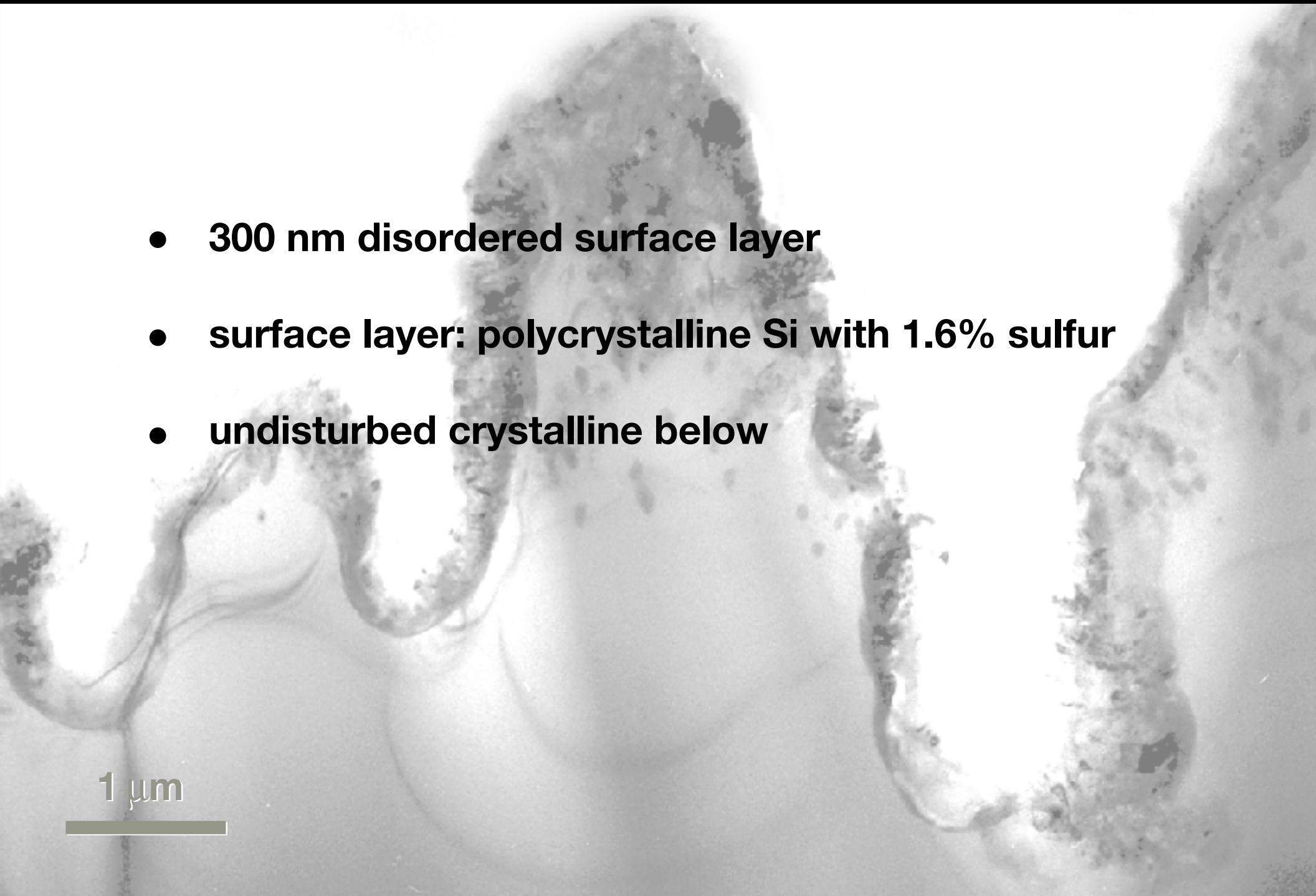
Background

M. Wall, F. Génin (LLNL)



Background

- 300 nm disordered surface layer
- surface layer: polycrystalline Si with 1.6% sulfur
- undisturbed crystalline below



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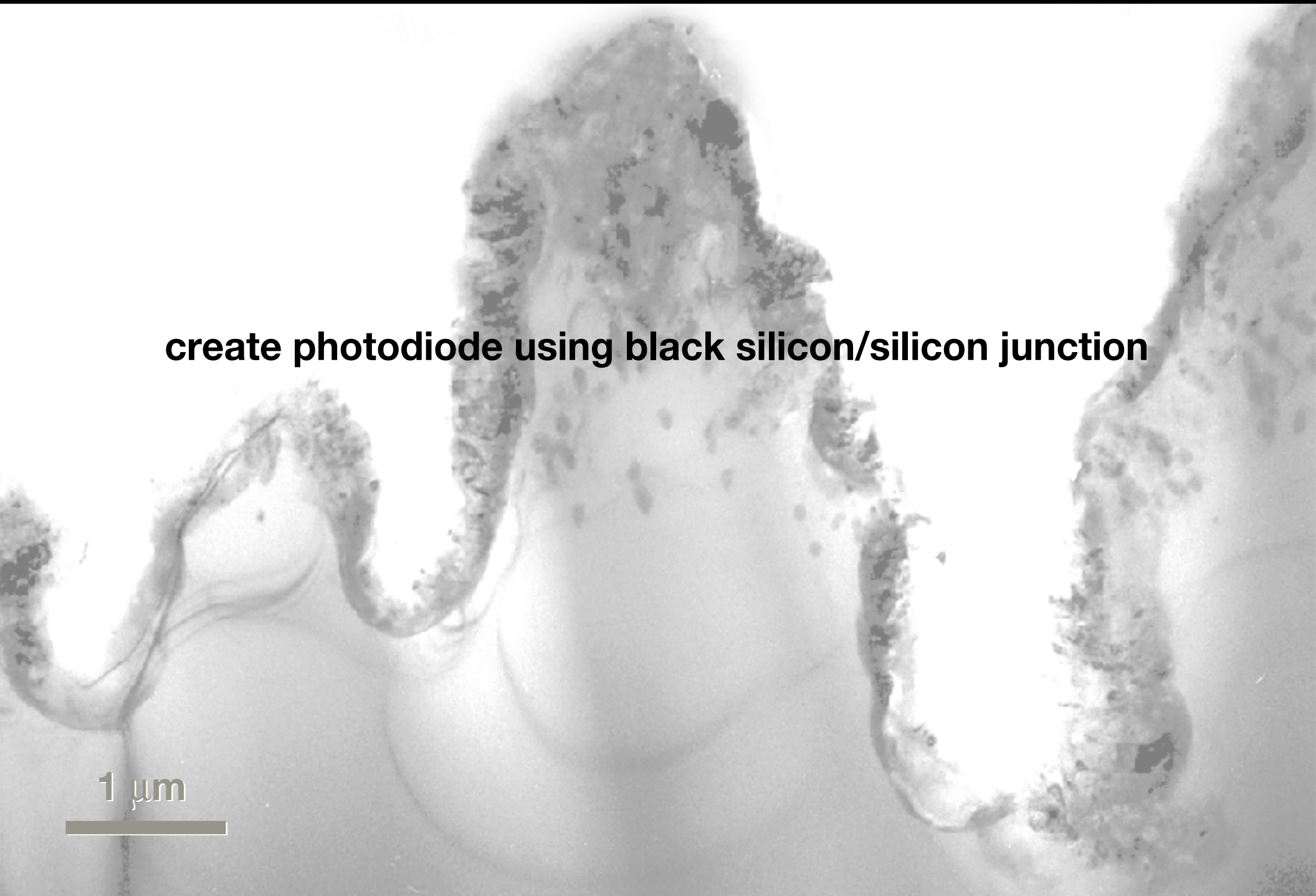
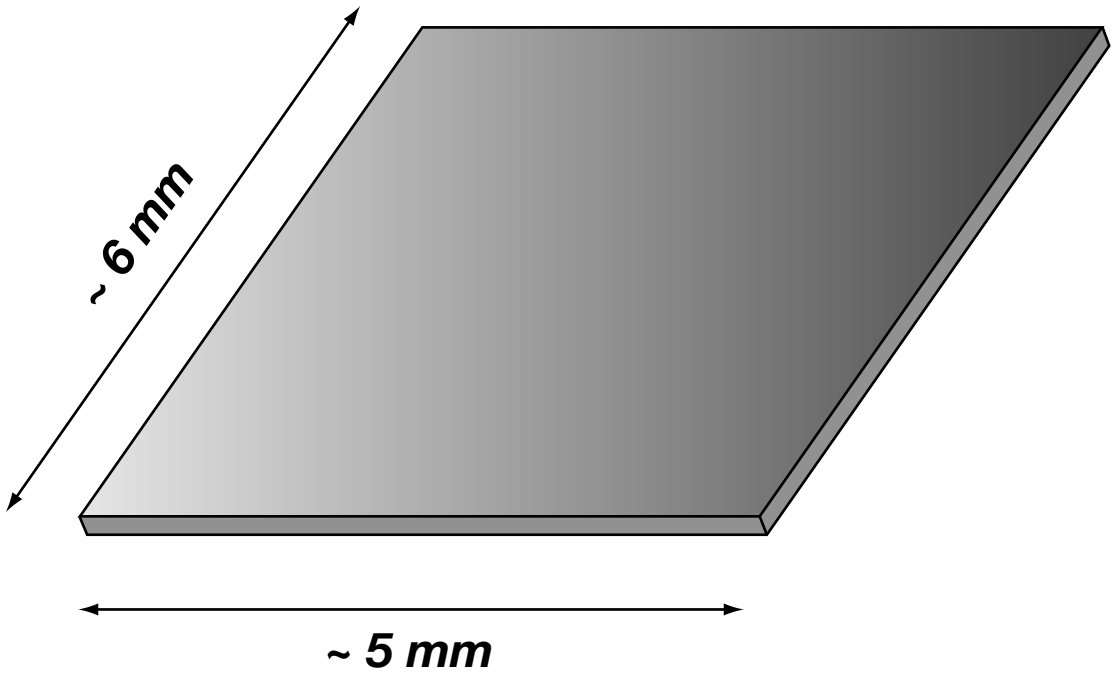


create photodiode using black silicon/silicon junction

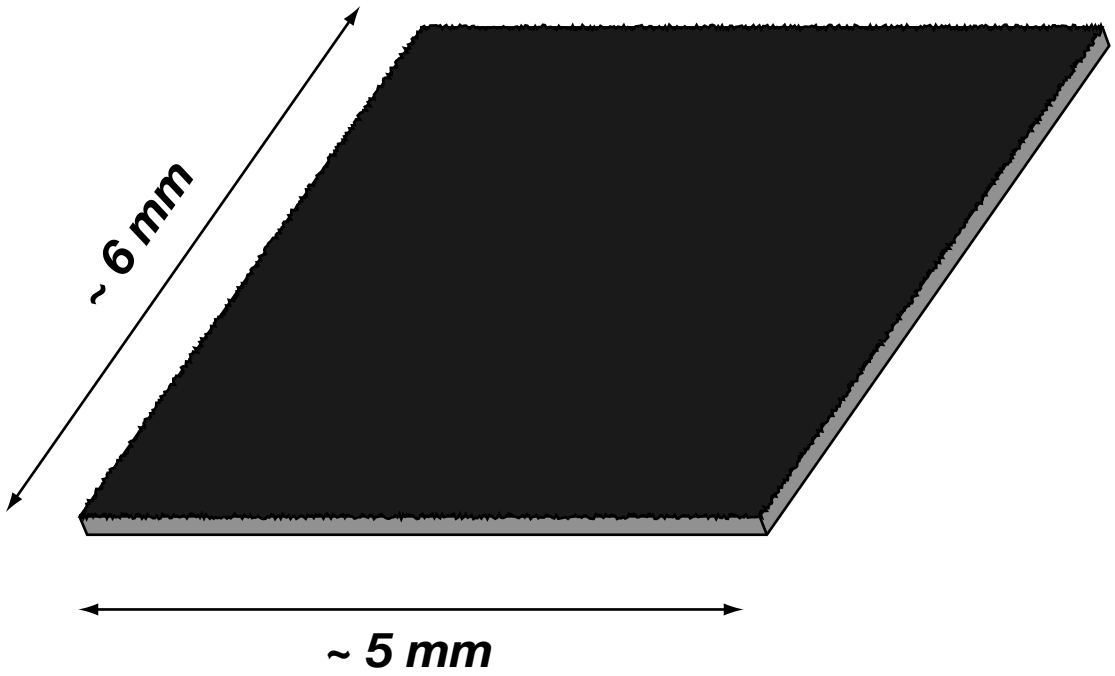
Fabrication process

crystalline Si



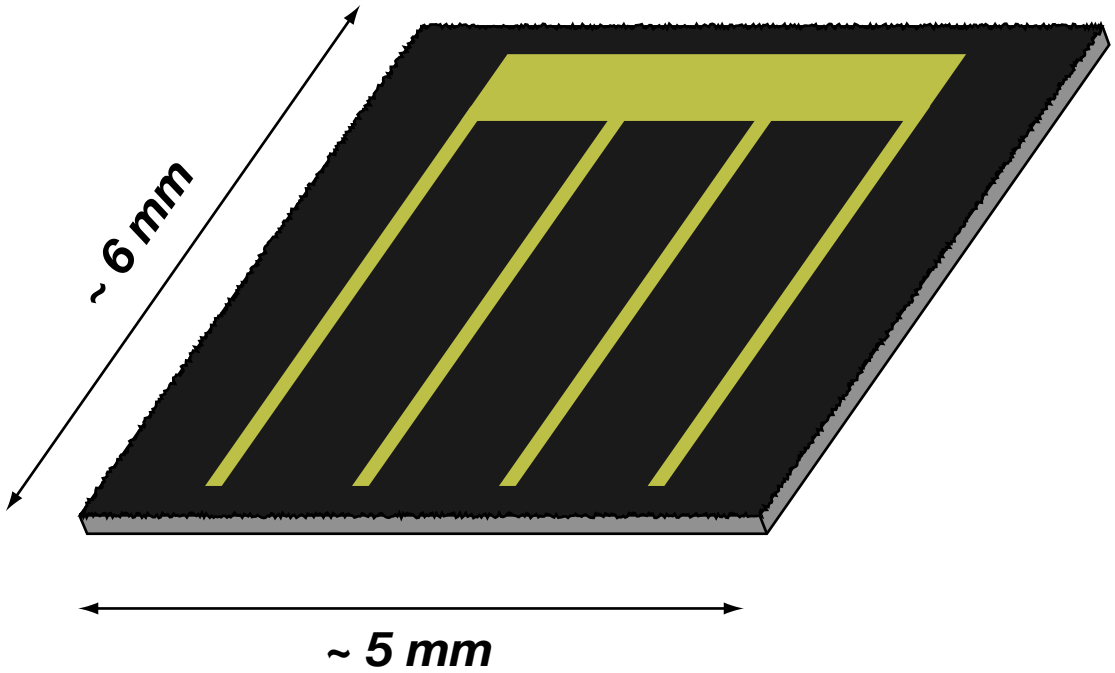
Fabrication process

irradiate with 100-fs laser pulses in SF_6



Fabrication process

Cr/Au contact



Fabrication process

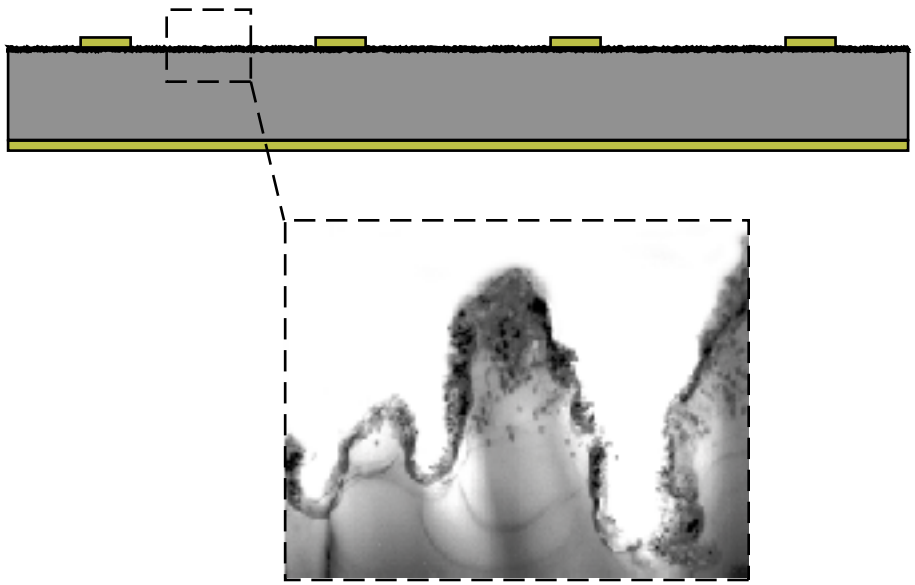
cross section

Fabrication process

Cr/Au contact

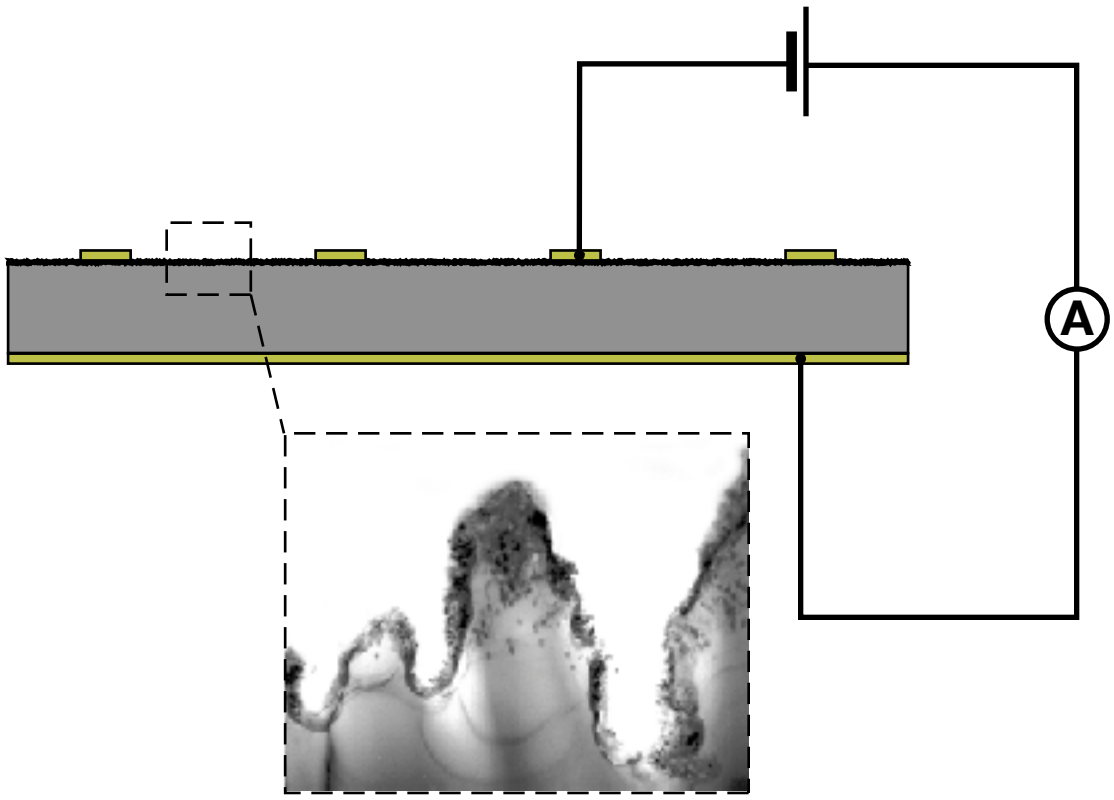
Fabrication process

black silicon/silicon junction



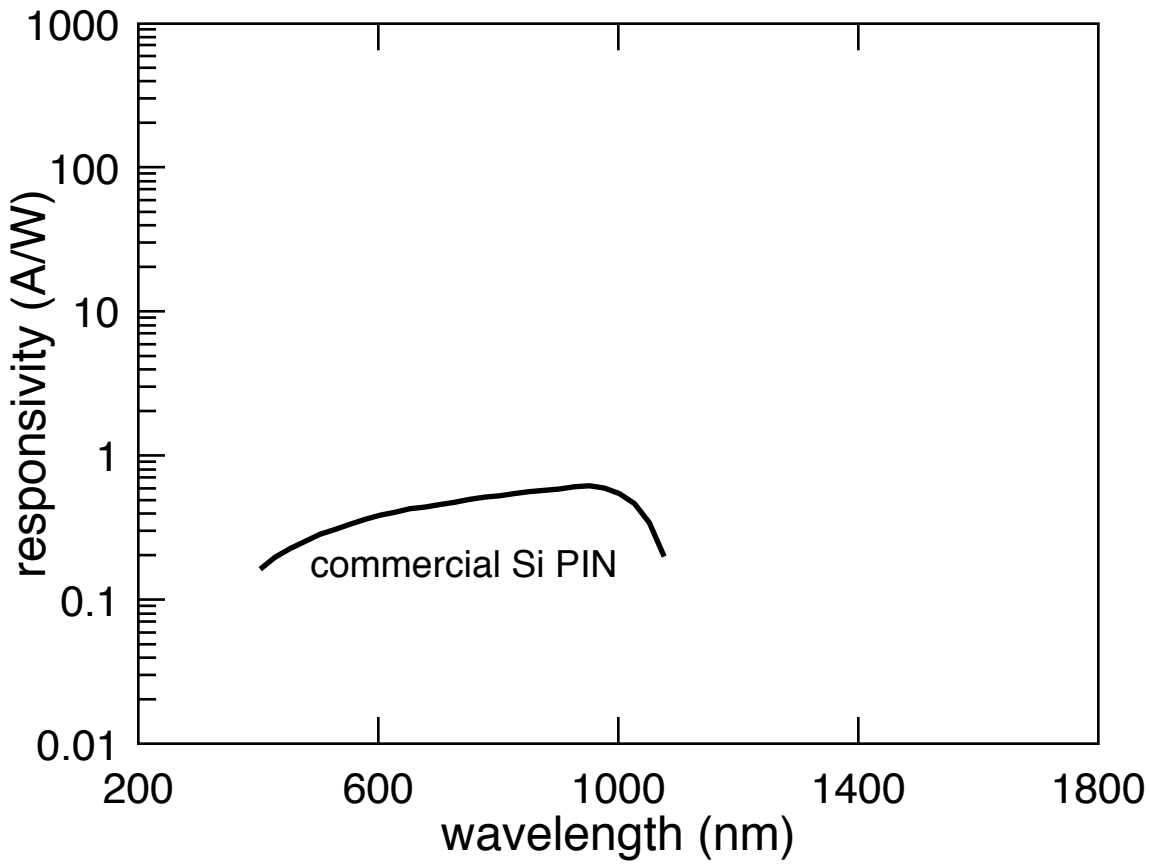
Results

IV characteristics



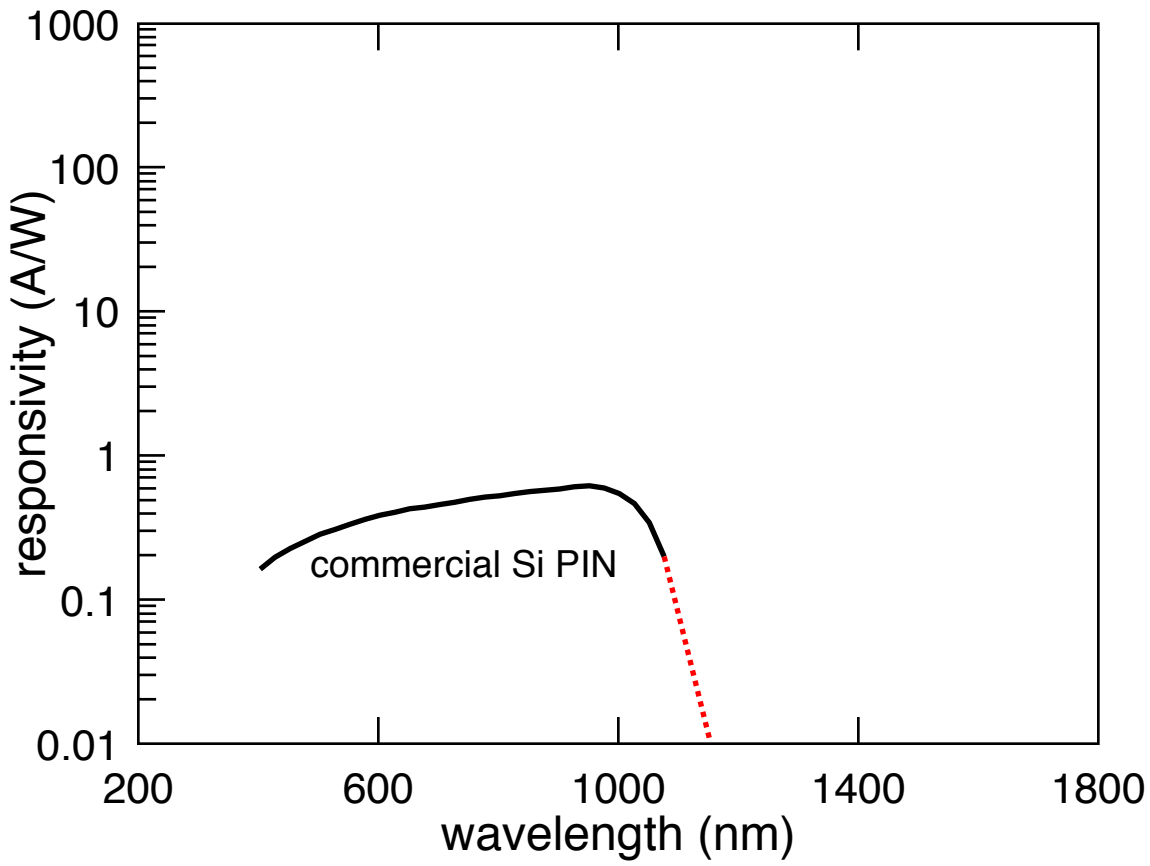
Results

responsivity



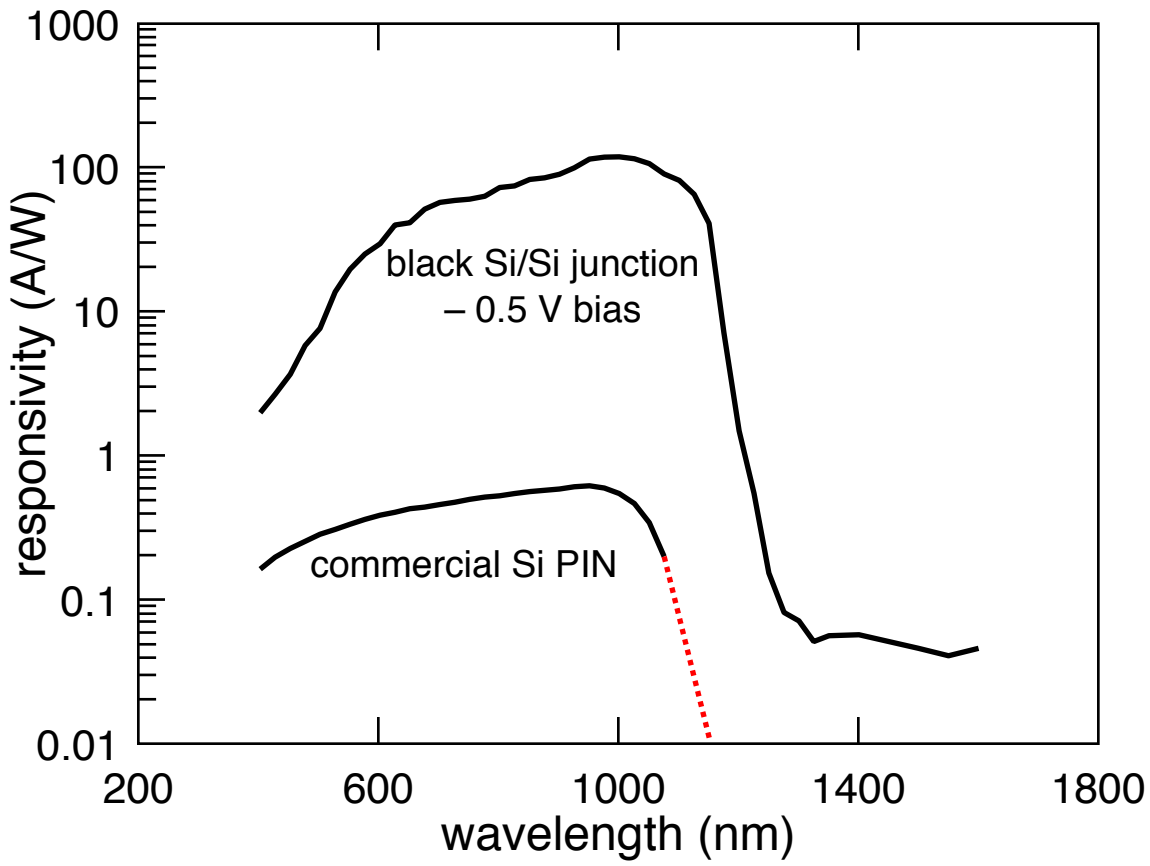
Results

responsivity



Results

responsivity

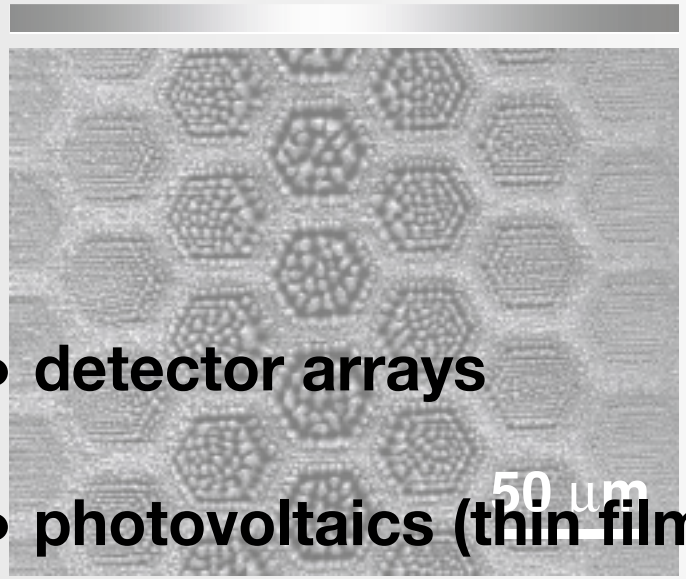


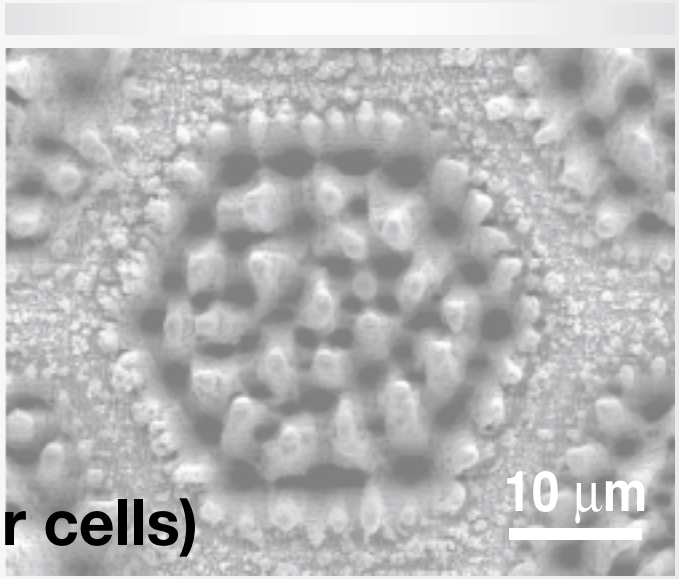
Results

black silicon/silicon photodiode

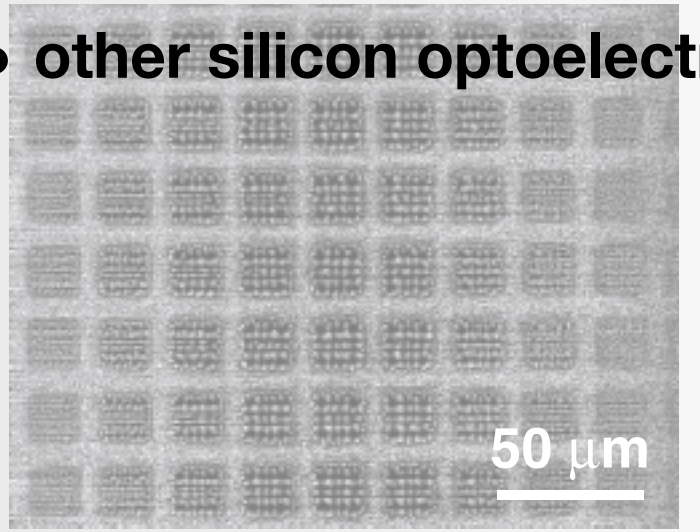
- **nearly 100x larger signal in visible**
- **10^4 larger signal in near-IR**
- **quantum efficiency >> 1, gain!**
- **response time: rise 10 ns, fall 30 ns**

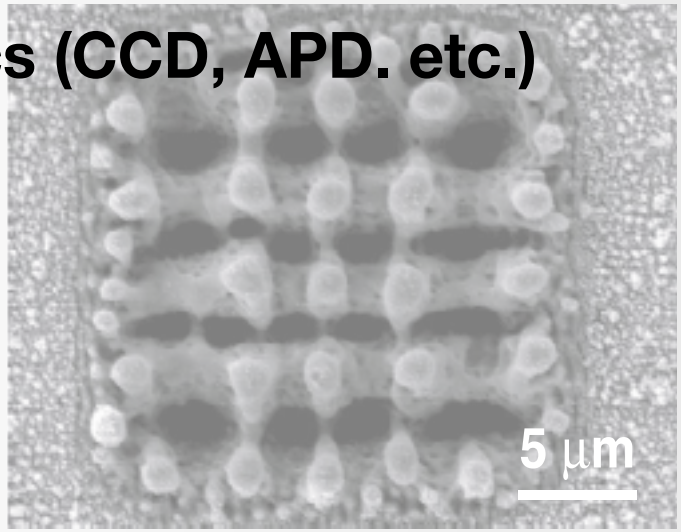
Future Directions





- detector arrays
- photovoltaics (thin film solar cells)
- other silicon optoelectronics (CCD, APD. etc.)





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