Optoelectronic devices using laser-microstructured silicon

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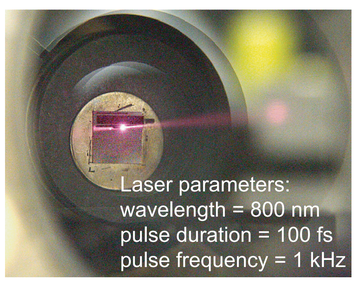
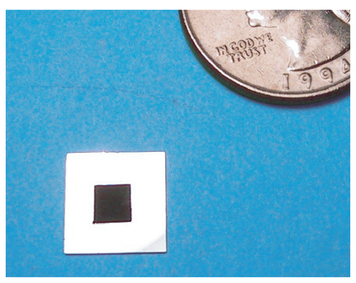
Introduction – irradiation process

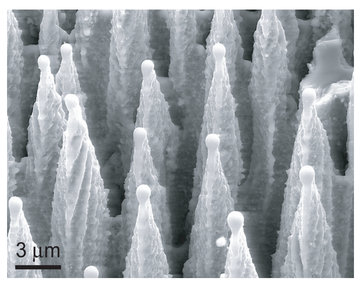
We irradiate a crystalline silicon wafer with femtosecond laser pulses in the presence of gaseous sulfur hexafluoride (SF_6) to produce a visually black surface that is roughened on a micrometer size scale.

The outer 300 nm of the roughened surface is highly disordered silicon doped with ~ 1% sulfur.

This surface layer has unique optical and electronic properties that make it appealing for use in a photodetector and solar cell.



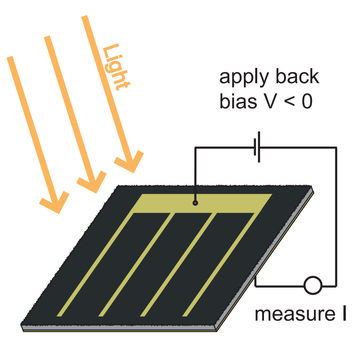


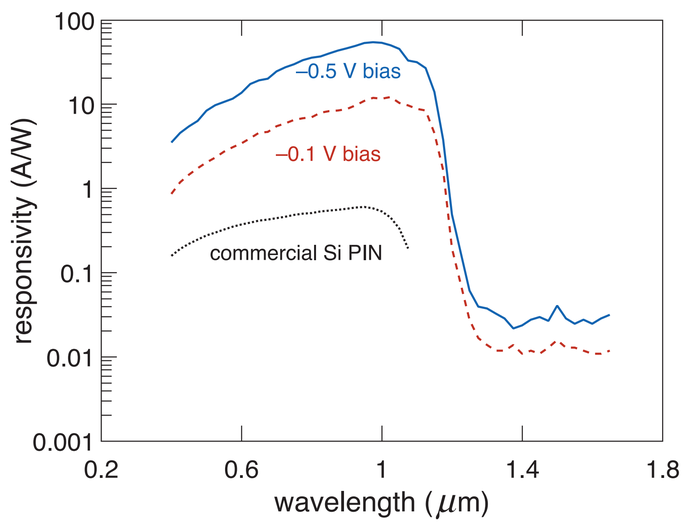


Photodetectors and solar cells

Photodetector

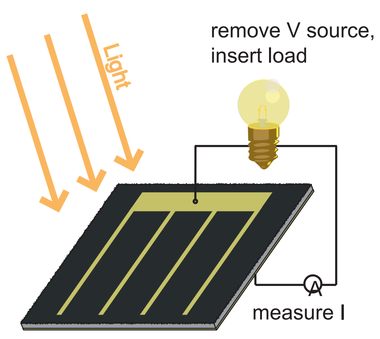
Our detectors are much more sensitive than commercial silicon detectors. The response is two orders of magnitude higher in the visible and 5 orders of magnitude higher in the infrared.

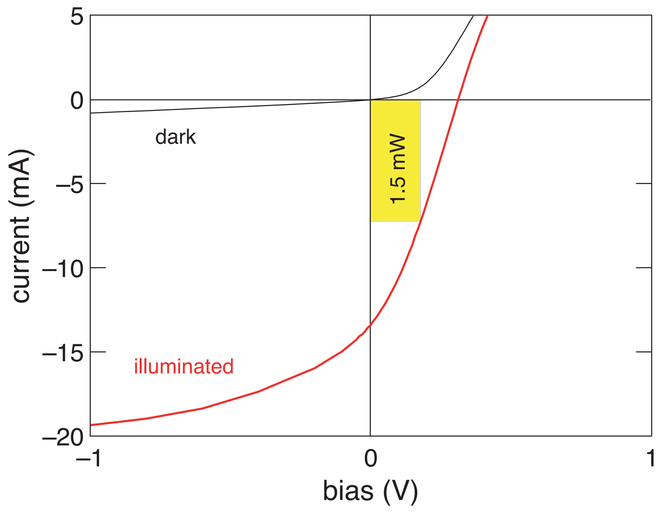




Solar cell

Prelimanary results indicate that our samples convert light to electrical energy at an efficiency of ~2%.

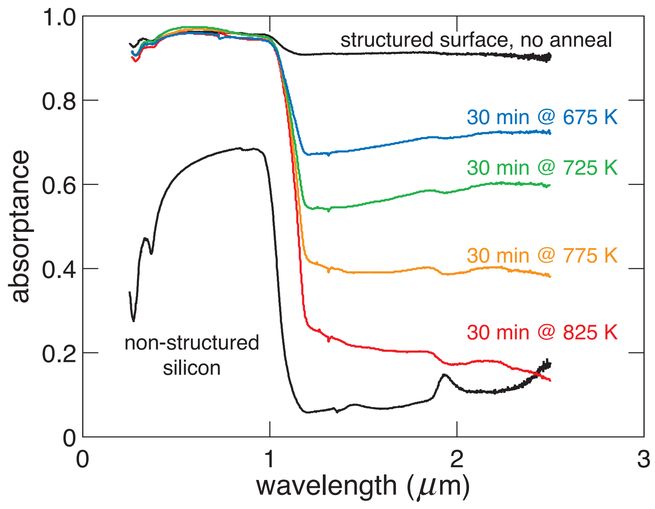




New optical and electronic properties

Increased absorption of visible and infrared light

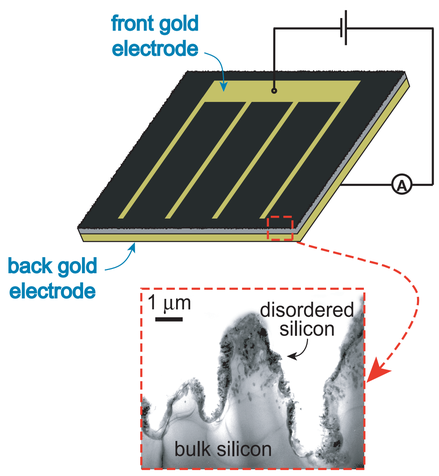
The structured and sulfur-doped surface absorbs more visible and infrared light than an unstructured silicon wafer.

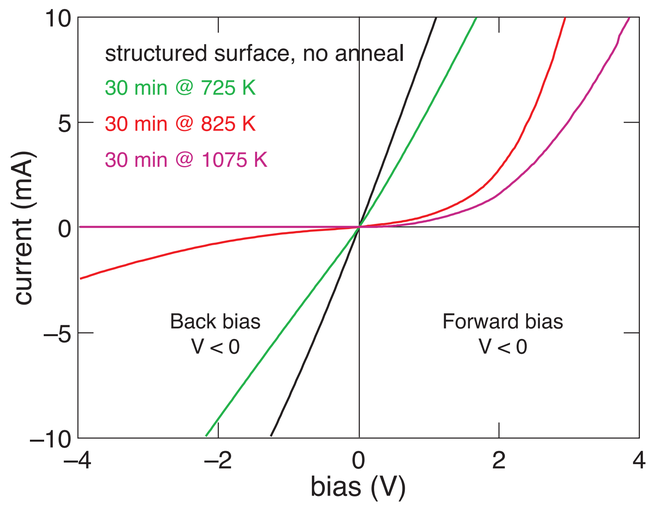


Absorption of infrared light decreases with increasing annealing temperature.

Diode behavior after annealing

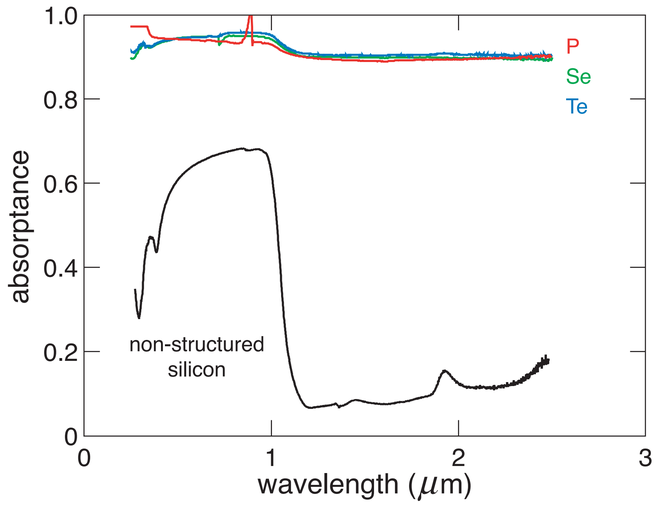
After annealing, the structured/sulfur-doped surface layer and the bulk silicon form a rectifying diode junction.





Future work – new dopant materials

Irradiation of solid phase films on silicon reveals other dopants with increased absorption of visible and infrared light. We are exploring the photodetector and solar cell response using these dopants.



An advantage of our process is that absorption occurs in the thin 300 nm surface layer allowing the possibility for thin film detectors and solar cells.

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