Porous Silicon Flakes on a Flexible Substrate for Real-Time Biosensing using Smartphone Technology

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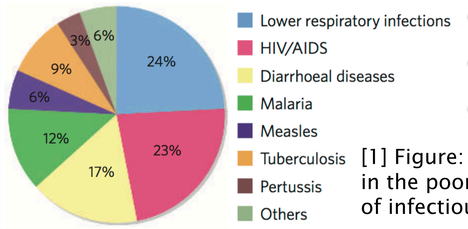
Motivation

Low Cost Diagnostics:

- Cannot rely on expensive lab equipment
- Must not take long time to get results
- Especially needed in developing world
- Smartphones are ubiquitous and can be easily implemented in a point-of-care system

Meeting ASSURED Criteria:

- Affordable
- Sensitive
- Specific
- User-Friendly
- Rapid and Robust
- Equipment Free
- Deliverable to Users



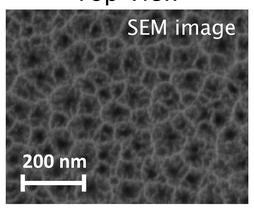
[1] Figure: More than half the deaths in the poorest countries are a result of infectious and parasitic diseases

Porous Silicon as a Biosensor

[2] Porous Silicon (PSi) Properties:

- Large internal surface area ($> 100\ m^2/cm^3$)
- Widely tunable pore size ($\sim 1 - 100\ nm$)
- Easy to fabricate (electrochemical etching)

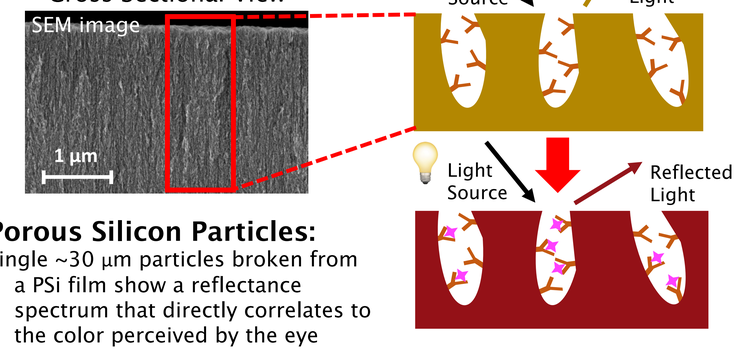
Top View



Operating Principle:

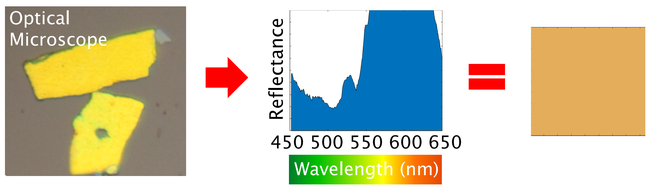
- Multilayer PSi film selectively reflects certain colors of light
- When pores are partially or completely filled, the reflected color changes

Cross-Sectional View



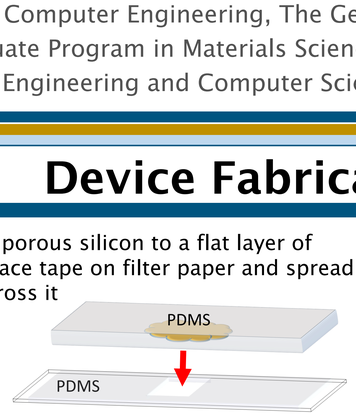
Porous Silicon Particles:

Single ~30 µm particles broken from a PSi film show a reflectance spectrum that directly correlates to the color perceived by the eye

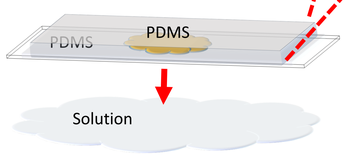


Device Fabrication

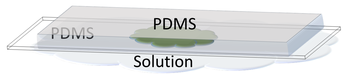
1 Attach porous silicon to a flat layer of PDMS; place tape on filter paper and spread PDMS across it

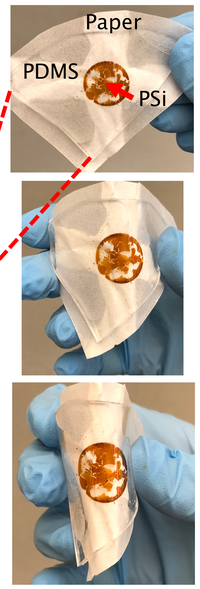


2 Peel tape off the paper and place the porous silicon/PDMS unit to paper/PDMS. Bake at high temperature in oven

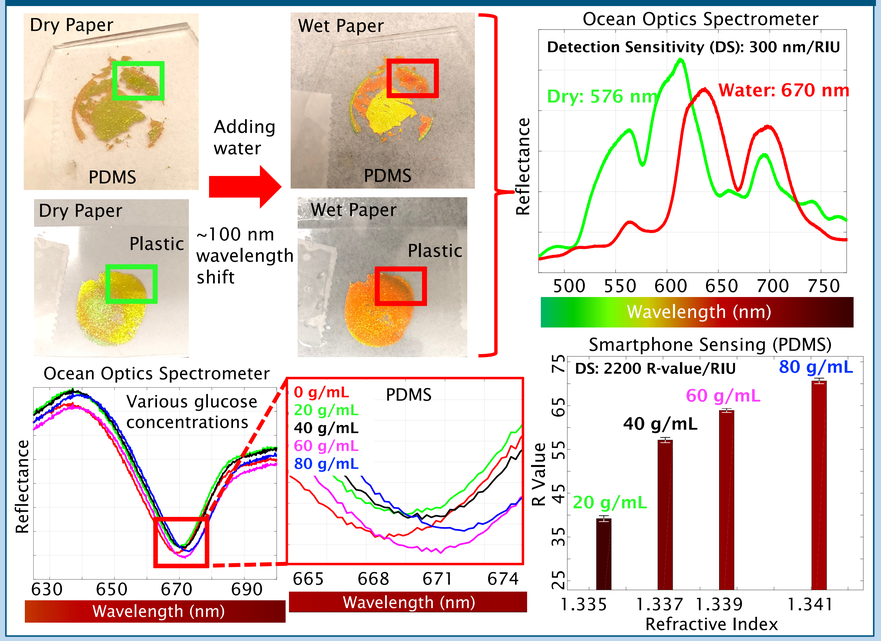


3 Place device paper first in solution and observe color change



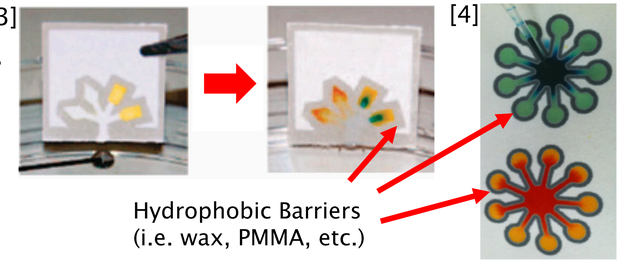


Sensing with Glucose



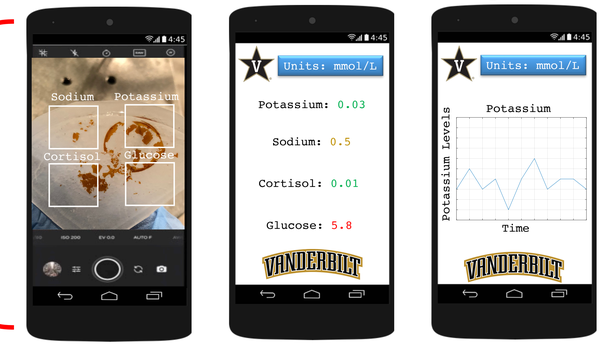
Future Work

- Change fabrication steps to prevent hydrophobic PDMS from entering the pores of the porous silicon



- Create a user-friendly app to test different analytes simultaneously

Proposed app design



Conclusions

- Demonstrated that PSi can be transferred directly onto flexible PDMS or plastic films without compromising spectral integrity
- Presented new approach for low-cost, easy-to-use biosensor using a combination of PDMS, paper, and hydrophobic barriers with PSi and smartphone
- Demonstrated that using RBG data from a smartphone camera can be used instead of a traditional spectrometer to accurately measure sensing events in PSi

References:

[1] Yager, Paul, et al. "Microfluidic diagnostic technologies for global public health." *Nature* 442.7101 (2006): 412.
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