Development of a Biomedical Sensor for Disease Specific Antigen Detection

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Introduction

The use of biomedical sensors for both self-diagnosis and routine disease monitoring has become popularized among U.S. citizens over the past decade. Disposable sensor devices such as a UTI dipstick and HIV tests are available to the general population and are highly used in medical care facilities for disease diagnosis. Benefits of increasing the availability of such sensors include:

- Providing care to the elderly, disabled, or non-communicative population.
- Non-invasive screening for high-impact conditions or infectious diseases.
- Diagnosing diseases earlier and reducing patient travel requirements and health care costs.

Objective

Develop and construct a biomedical sensor to detect a high-impact disease or condition prevalent in nursing home environments. Two detection methods will be assessed:

- Impedance based detection in a nanospring sensor.
- Immunoassay based detection for a point-of-care disposable sensor.

Methods

Nanospring Sensor

1) Collaborate with GoNano Tech. Inc and U of I to obtain nanospring device. (Figure 1)
2) Thiolate nanosprings via vapor phase deposition of MPTMS. (Figures 2 and 3)
2) Modify β-galactosidase enzyme by SPDP to create reactive PDS groups.
3) Covalently bond enzyme to nanospring mat though disulfide bonds. (Figure 4)
4) Conduct impedance tests before and after covalent bonding of enzyme.

Point-of-Care Sensor

1) Design and fabricate device appropriate for use in a nursing home setting. (Figure 10)
2) Use basic antibody-antigen ELISA for disease detection. (Figures 11 and 12)

Nanospring Sensor

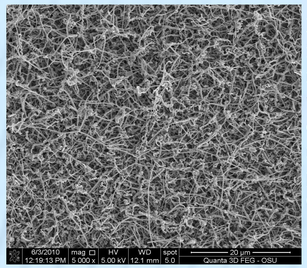

Figure 1 – SEM image of nanospring mat with surface area of 300 m^2/g. Silica nanosprings provided by GoNano Tech. Inc.

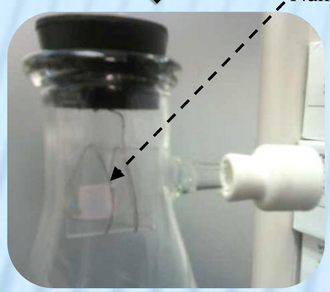

Figure 2 – 1 cm^2 nanospring mat on ITO electrode and glass.

MPTMS (g)

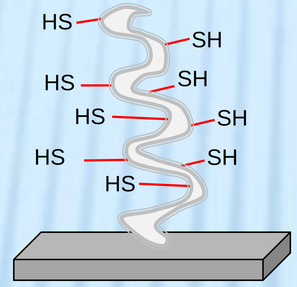

Figure 3 – Thiolated nanosprings.

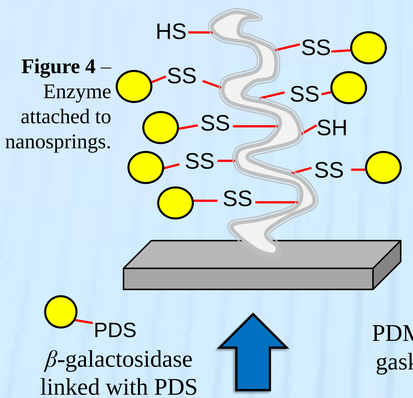

Figure 4 – Enzyme attached to nanosprings.

β-galactosidase linked with PDS

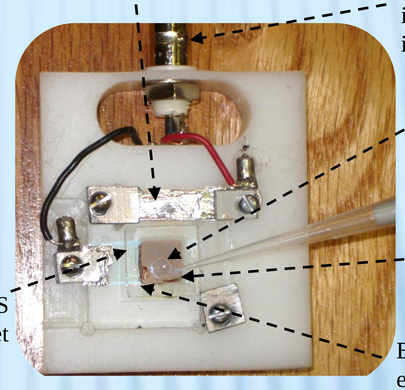

Figure 5 – Jig used for impedance testing provided by University of Idaho.

Impedance Testing Details

- Electrodes are separated by a 200 µm PDMS gasket.
- 60 µL of 0.1-100 mM PBS buffer solutions were used to measure impedance.
- Connection between electrodes and wiring created by Al foil.

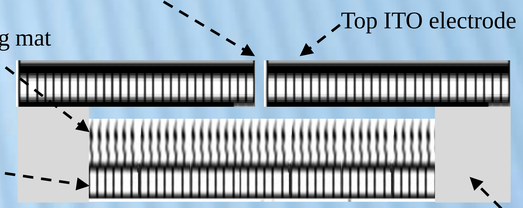

Figure 6– Cross section view of nanospring sensor.

Results

Table 1 – The effects of enzyme attachment and PBS concentrations on impedance using two-way ANOVA analysis.

Factor	Frequency	Significance
10 mM PBS vs. 100 mM PBS	10 kHz	p = 0.5
Thiolated vs. enzyme modified	10 kHz	p = 0.09

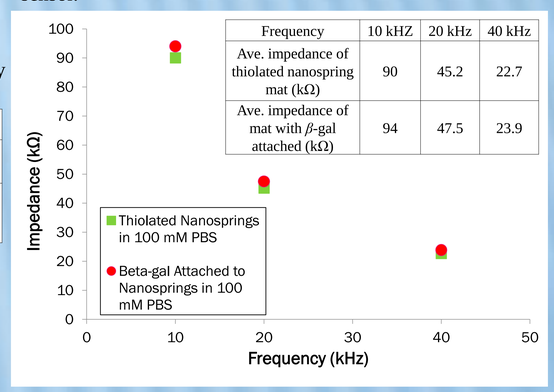

Figure 7 – Impedance measurement of nanosprings with and without β-galactosidase attached.

Point-of-Care Sensor

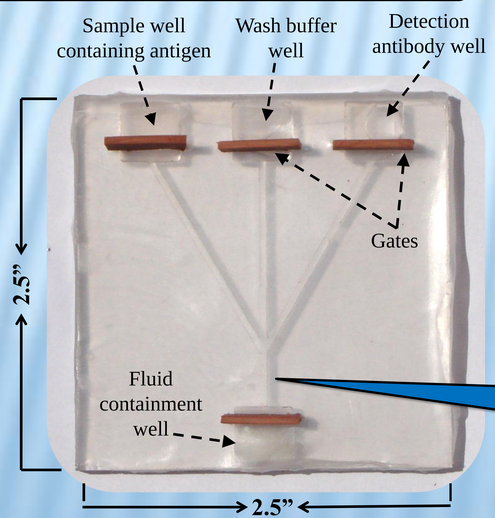

Figure 10 – Microchannel device point-of-care sensor.

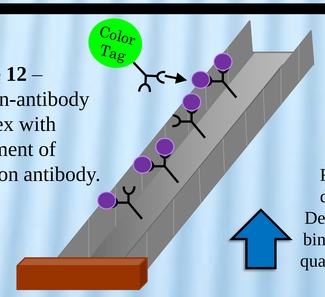

Figure 12 – Antigen-antibody complex with attachment of detection antibody.

From antibody detection well: Detection antibody binds to antigen for qualitative detection of antigen.

From sample well: Antigen of interest in the sample is “caught” by the bound antibodies.

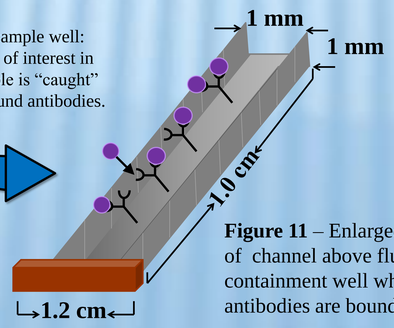

Figure 11 – Enlarged view of channel above fluid containment well where antibodies are bound.

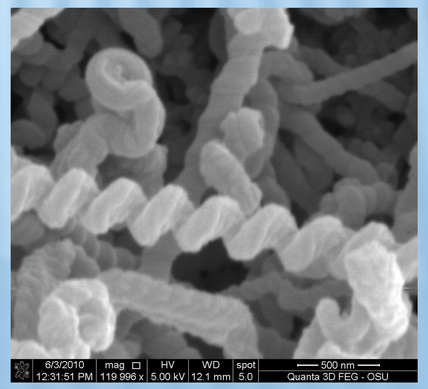

Figure 8 – SEM plan view of helical nanosprings modified with β-galactosidase

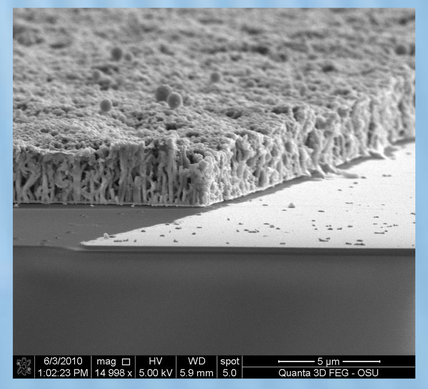

Figure 9 – SEM cross sectional view of nanosprings modified with β-galactosidase.

Acknowledgements – Dr. Christine Kelly, Dr. Karl Schilke, Dr. Philip Harding, Manfred Dittrich, GoNano, UI BANTech, Meghan Hemphill-Johnston, Curtis LaJoie, Chris Tasker & Kelsey Yee