Fabrication of Nanoneedle Array for High Throughput Biomarker Detection in a Lab-On-a-Chip Device

Hesaam Esfandyarpour[1, 2], Rahim Esfandyarpour[1, 2], R. Fabian Pease[1], Ron W. Davis[2, 3]

[1]Department of Electrical Engineering, Stanford University
Center for Integrated Systems, CISX B103, Stanford, CA, 94305
hesaam@stanford.edu, tel: (650) 723.4566 fax: (650) 723.4659
[2] Stanford Genome Technology Center
[3]Department of Biochemistry & Department of Genetics, Stanford University

Impedance biosensors are a class of electrical biosensors that show promise for point-of-care and other applications due to low cost, ease of miniaturization and label-free operation. We have previously introduced the Nanoneedle, a label-free biosensor, which has the potential of measuring single molecule interactions useful for protein biomarker detection and DNA sequencing.

Our coaxial nanoneedle consists of four thin-film layers. The middle core is made of metal or doped semiconductor. This layer is surrounded by an insulating layer, surrounded by another metal area, followed by yet another protective insulator area. The probe molecule is immobilized on the nanoneedle. A target analyte being captured by the probe molecule modulates the impedance of the needle (Fig.1).

We discuss the fabrication process for an array of needles in a microchannel and show images of successfully fabricated devices in different structures (Fig. 2, 3a).

We also performed finite element modeling of impedance modulation in the nanoneedle during the capture of the target biomolecule. We study the various parasitic impedances involved within the device structure. By studying the effect of these impedances, the device geometry and the frequency regime of operation are optimized for achieving high sensitivity and low concentration detection (Fig. 3b).

In addition, we study a modified structure by etching few nanometers of the middle insulation layer and observe its affect as a 43% improvement in impedance modulation in detection. The geometry helps to localize fringing field effects therefore increasing sensor sensitivity. We also discuss about the capture rate of the biomolecules on the tip of nanoneedle in a microchannel to determine the detection limit of the system.

References:

[1] H. Esfandyarpour, Fabian Pease, Ron Davis, EIPBN 2008.
[2] H. Esfandyarpour, et al., International COMSOL Conference, Proceeding of, Oct. 4-6, 2007, pp. 169-173.

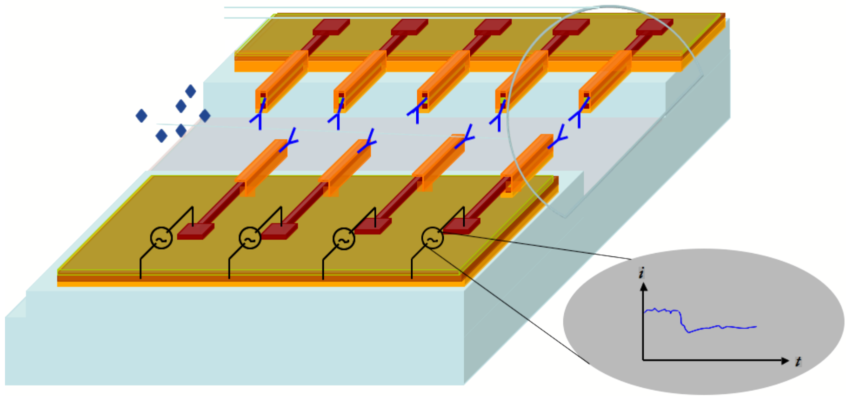


Fig.1 Schematic of Nanoneedle Array in Microfluidic for Biomedical Detection

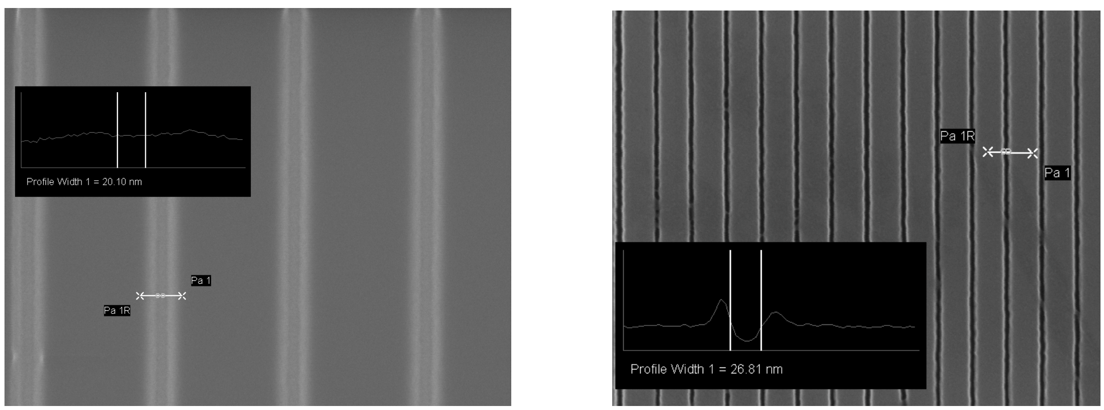
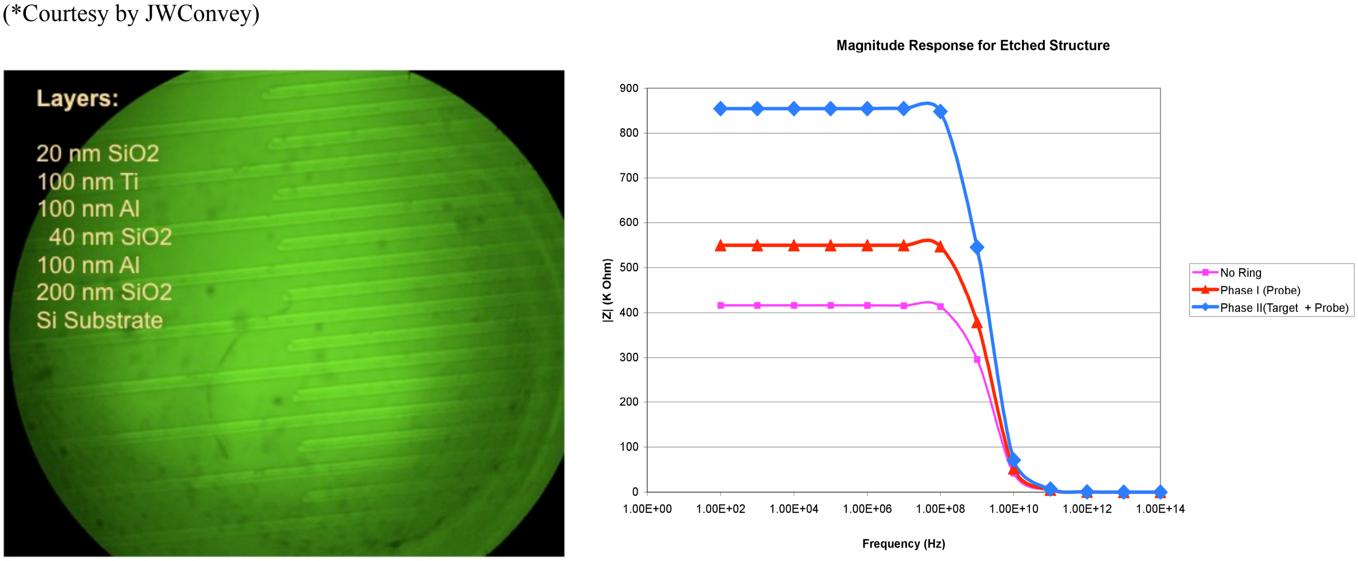


Fig.2 Fabrication of Nanoneedle array; left: after exposure; right: after post processing
(*Courtesy by JWConvey)



Interdigitate Coaxial Needle Array

Fig.3 Micrograph of Interdigitate Nanoneedle array (left), Impedance Modulation in bare needle, loading and sensing phases for etched structure, FEM results (right)