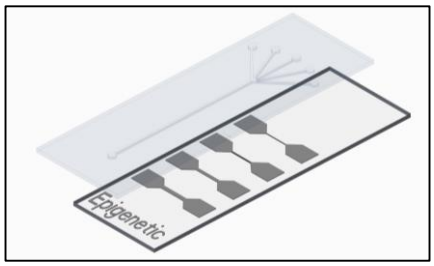
Development of EIS-based device sensing epigenetic changes for early cancer detection

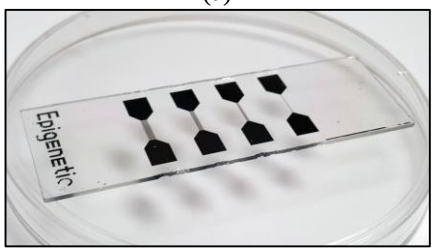
In this project, Electrochemical Impedance Spectroscopy (EIS) based biosensors were developed using microfabrication technology. EIS is a powerful method of analyzing the complex electrical impedance of a system with the relatively short measuring time with high accuracy potentially in real-time.

A design of prototype micro system. Interdigitated Ni electrodes were deposited and patterned on glass substrates as shown in Fig. 1. Each device consists of four sensing spots to allow statistical analysis or microarray detection. PDMS microfluidic chamber with five inlets and one outlet was replicated by replica molding from a 100 µm thick SU-8 master structure.

Glucose at 240 mg/dl was tested and measured using the prototype microsensing system. The complete frequency spectrum from 100 to 150 kHz was scanned at steady state with EDAQ Z100 EIS System. Impedance data was obtained with potentiostat measurements. The Nyquist plot of the measured glucose was shown in Fig. 2a. The proposed system can be depicted with the equivalent circuit in Fig. 2b, where the interfacial layer at the working electrode is represented by a charge transfer resistance R_{ct} in a parallel combination with a capacitance C_{dl} accounting for the electrical double layer at the interface, and a series Warburg impedance Z_w describing depletion of the redox species at the interface. Additionally a series resistance R_s accounts for the uncompensated solution resistance. Using the Nyquist plot shown in Fig. 2b, the values for R_s and R_{ct} are determined of 3 kΩ and 58 kΩ, respectively.



(a)



(b)

Figure 1. (a) design of micro-sensing system. (b) image of Ni electrodes.

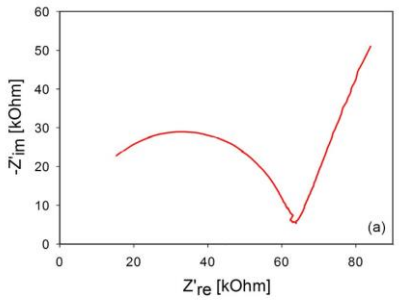


Figure 2. (a) measured Nyquist plot of 240 mg/dl glucose. (b) equivalent circuit for impedance spectroscopy measurements and analyzed.

A. List of Internal PI/Co-PI

- Hong-Gu Kang, Assistant Professor, Department of Biology
- In-Hyouk Song, Assistant Professor, Department of Engineering Technology
- Byoung Hee You, Associate Professor, Department of Engineering Technology
- Xiaopeng Li, Assistant Professor, Department of Chemistry and Biochemistry

B. List of External Partners

N/A

C. List external grants submitted related to the MIRG grant

- Xiaopeng Li (PI), NSF-DMR, requested $436,908, Super Metal-Organic Nanowires (SMON): Self-Assembly of Next Generation Nanowires at Solid/Liquid Interface Using Metallo-supramolecules"

D. List of external grants awarded related to the MIRG grant

- Hong-Gu Kang (PI), March 2016 – February 2021, $786,023, NSF-IOS. CAREER-Characterization of epigenetic factors and their regulatory roles in modulating transposable elements, plant immunity and transgenerational inheritance.
- Xiaopeng Li (PI), June 2015 – May 2018, $437,924, NSF-CHE, Design and Self-Assembly of Giant Metallo-Supramolecules Based on Density of Coordination Sites.

E. List any planned external grant submissions related to the MIRG grant

N/A