EE / SE 491 Week 6 Status Report
Apr. 1, 2019 - Apr. 5, 2019
Group: sddec19-20
Project: Ultra-thin electronic skin for real-time health Monitoring
Advisor/Client: Liang Dong

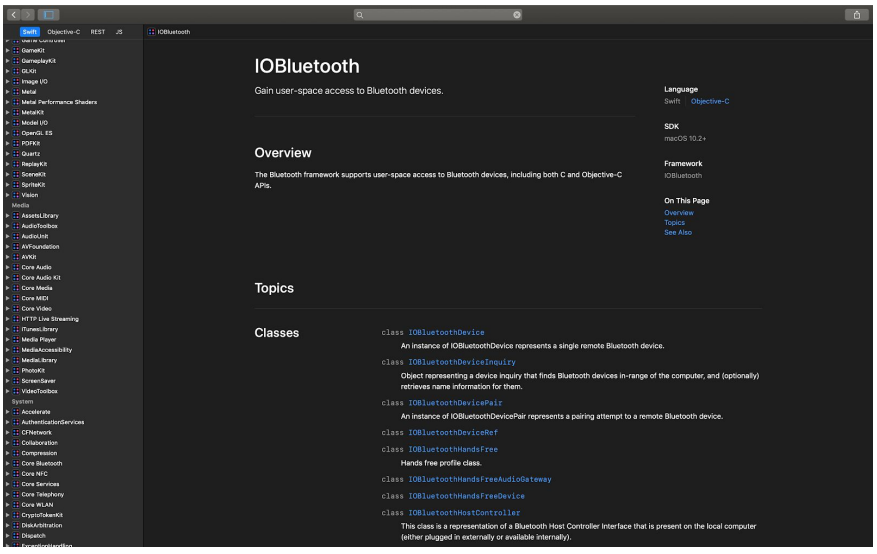
Team Members:
Sovann Chak: Software Architect, iOS Developer
Omar El-Sherbiny: Circuit design and analysis of Sweat sensor
Justin Gordon: Software Developer, Communication research
Sungmin Kang: Circuit design and analysis of Mobility sensor
Sangwon Lee: Circuit design and analysis of ECG, DMD 3D printer

## Passing Week's Accomplishments

### *Software Engineers*

**(Sovann)**

- Completed the design of the prototype and compiled some essential parts from the laboratory to implement the design
    - Raspberry Pi 3 x 2
    - Arduino Uno + Arduino Shield x 2
    - Female Pin cables
- Researched iOS Bluetooth library



- Setup the bluetooth on the Raspberry Pis
    - Various steps are necessary in order to boot an OS onto the Raspberry PI and enable the bluetooth

**(Justin)**

- Learning to using android studio
- Acquired raspberry pis, Arduino boards, and several other parts from Dr. Dongs lab

*Electrical Engineers*

**(Omar)**

- Dr. Dong, our adviser and client, has a picture in mind of how the sensors will be manufactured and how they will operate. However, he refuses to impose his ideas on us; hence, our project has had a significant research component to it.
- Dr. Dong is the Editor-in-Chief of the Sensor and Actuators journal. Both his interest in sensors and experience working with them is unparalleled, so he will still have an input in the final design of the sensor.
- I was asked to perform a literature review and see what kind of sweat sensors are discussed in published peer-reviewed work, then propose a preliminary design of my own.
- So far, 7 articles have been reviewed for sweat sensors ranging in size, operation process, and what data it collects. A brief summary of one of the papers is shown below.

Bio-sensing textile based patch with integrated optical detection system for sweat monitoring

Deirdre Morris[a], Shirley Coyle[a], Yanzhe Wu[a,b], King Tong Lau[a], Gordon Wallace[b], Dermot Diamond[a,*]

[a] Adaptive Sensors Group, National Centre for Sensor Research, School of Chemical Sciences, Dublin City University, Glasnevin, Dublin 9, Ireland
[b] Intelligent Polymer Research Institute, University of Wollongong, NSW 2522, Australia

- This paper discusses a sweat sensor that works using LED lights to test pH levels of sweat and is able to monitor real-time variations in sweat during exercise.The sensor's size is 40mm x 50mm.

# Non-invasive wearable electrochemical sensors: a review

**Amay J. Bandodkar and Joseph Wang**

Department of NanoEngineering, University of California, San Diego La Jolla, CA 92093, USA

- This paper was of paramount aid in the literature review as it pointed to several other papers, some of which have been reviewed, but others have yet to be reviewed. A summary of the sensors discussed is shown in the table below.

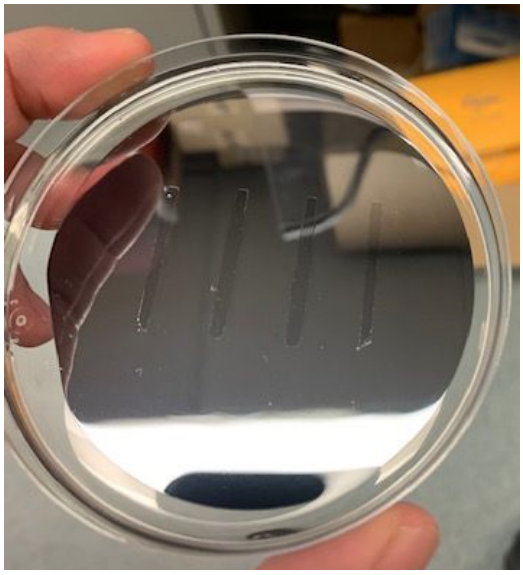
| Platform[a] | Biofluid | Recognition element | Technique | Analyte | Refs |
|---|---|---|---|---|---|
| Denture | Saliva | Glass membrane | Potentiometry | pH | [9] |
| Partial chrome-cobalt denture | Saliva | Lanthanum fluoride | Potentiometry | Fluoride | [10] |
| Mouthguard | Saliva | Lactate oxidase | Amperometry | Lactate | [12] |
| Graphene on silk | Saliva | Peptides | Resistometry | *Staphylococcus aureus* | [13] |
| Polytetrafluoroethylene | Tears | Bare gold | Conductometry | Electrolytes | [18] |
| Gas-permeable membrane | Tears | Bare platinum | Amperometry | Oxygen | [19] |
| Polypropylene | Tears | GOx | Amperometry | Glucose | [21] |
| Polyimide | Tears | GOx | Amperometry | Norepinephrine and glucose | [23] |
| PET contact lens | Tears | GOx | Amperometry | Glucose | [24–26] |
| PET contact lens | Tears | Lactate oxidase | Amperometry | Lactate | [28] |
| Cotton (underwear) | Sweat | Bare carbon | Amperometry | β-nicotinamide adenine dinucleotide and hydrogen peroxide | [41] |
| Polyimide/Lycra blend | Sweat | Sodium ionophore | Potentiometry | Sodium | [43] |
| Cotton yarn | Sweat | Hydrogen, ammonia, and potassium ionophore | Potentiometry | pH, ammonium, and potassium | [45] |
| Polyester | Sweat | Ag/AgCl | Potentiometry | Chloride | [46] |
| Gas-permeable membrane | Sweat | Platinum | Amperometry | Oxygen | [47] |
| Elastomeric stamps | Sweat | Bare carbon | Voltammetry | Uric acid | [49] |
| Temporary tattoo | Sweat | Lactate oxidase | Amperometry | Lactate | [50] |
| Temporary tattoo | Sweat | Polyaniline | Potentiometry | pH | [51] |
| Temporary tattoo | Sweat | Ammonium ionophore | Potentiometry | Ammonium | [52] |
| Temporary tattoo | Sweat | Sodium ionophore | Potentiometry | Sodium | [53] |
| Parylene skin patch | Sweat | Lactate oxidase | Conductometry | Lactate | [54] |

Before this paper, I only thought of having a sweat sensor on a patch, but this paper opened the door to a variety of other sensor platforms.

- A meeting with Dr. Dong is scheduled next Tuesday to present the literature review, and the preliminary design.

## (Sungmin)

(Sungmin)Manufactured some PDMS, and be familiar with this skill.
(Sungmin)Make sure the direction for mobility sensor.
(Sungmin)Think about measuring resistivity using four-point probe

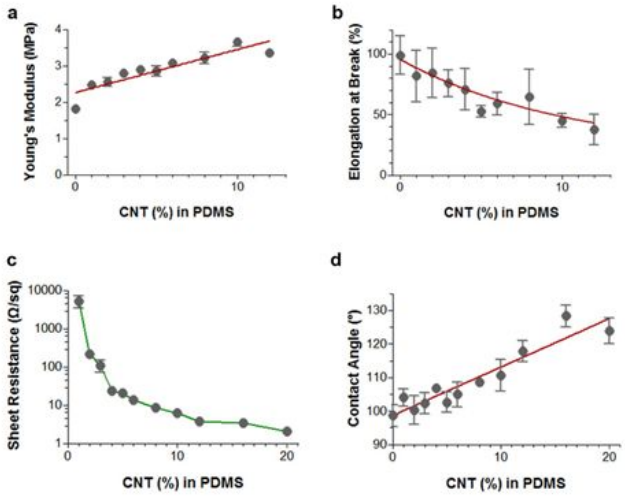


**(Sangwon)**

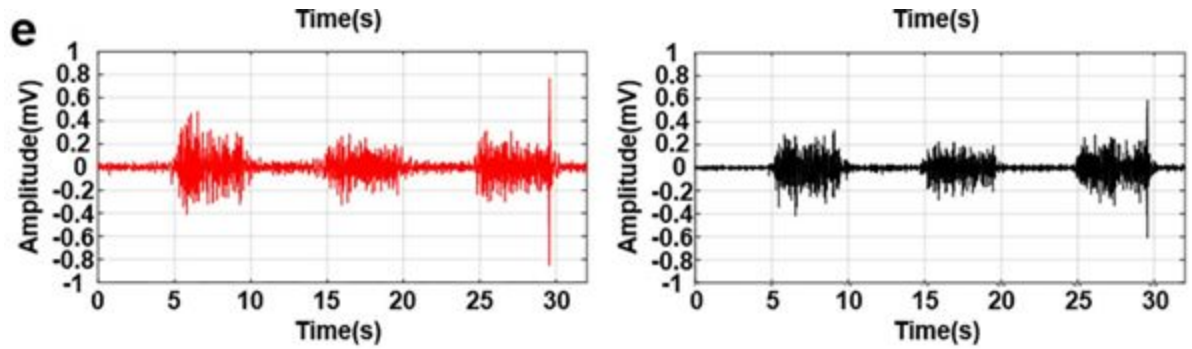
- Manufactured some PDMS, and be familiar with this skill.(with Sungmin)
- Make sure the direction for mobility sensor. (with Sungmin)
- Think about measuring resistivity using some tool (with Sungmin)

- Plan for develop

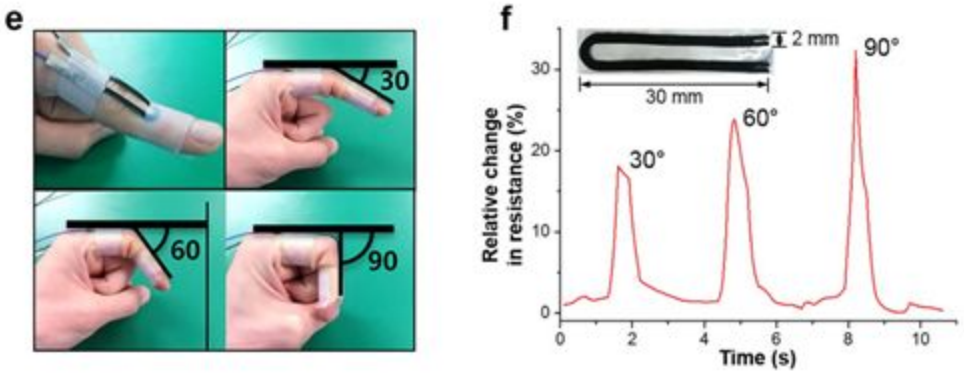
  Since we are using Graphene and PDMS a lot for sensor we can make different type of materials based on the mix rate of graphene and PDMS. Graphene has high conductivity, PDMS has transparent and flexible. For bio sensor, we need both characteristics conductivity and flexibility. Here is some chart of ratio of two materials and characteristics.




Following figure compare mixture of CNT/PDMS electrode and normal Ag/AgCl electrode.




As we can see we can use not only flexible sensor but also conductive enough or better to compare with other normal sensors.




Flexibility test and resistance

## Individual Contributions

| Team Member | Contribution | Weekly Hrs | Total Hrs |
|---|---|---|---|
| Sovann | | 7 | 45 |
| Justin | Working in android studio to become familiarized with android app creation. | 6 | 43 |
| Omar | Literature review | 7 | 37 |
| Sungmin | | 7 | 38 |
| Sangwon | Practice fabrication sensor with | 7 | 45 |

| | | | |
|---|---|---|---|
| | Sungmin and research for better sensor materials. | | |

## Plans for Next Week

(Sungmin)Putting graphene on the PDMS
(Sungmin)Getting mobility sensor using tape
(Sovann) Learn how to solder
(Sovann) Prepare breadboards with the Arduinos and Raspberry Pis
(Sovann) Continue iOS development course (http://CS193p.stanford.edu)
(Sovann) Write up proposal email necessary to order the final parts for the prototype
(Sangwon) learn how to print sensor in Kapton tape, using wafer, PDMS
(Sangwon) Practice printing sensors on Kapton tape.
(Justin) Further work with android studio and practice projects
(Justin) Help to order parts from ETG
(Justin) Begin learning about interfacing with sensors(if available)
(Omar) Finish review of literature
(Omar) Make a preliminary design of sweat sensor and present it to client