Controlling surface morphology of electrodeposited gold for the preparation of electrochemical aptasensors

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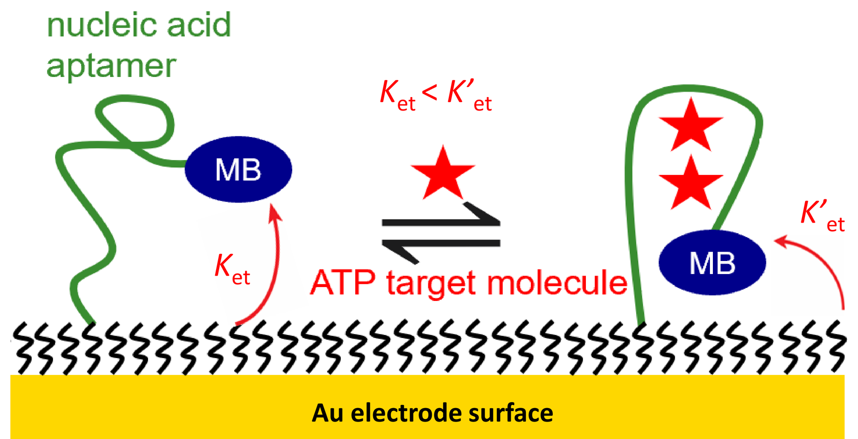
Electrochemical, Aptamer-Based Sensing

What is an electrochemical, aptamer-based sensor?

Electrochemical, aptamer-based (EAB) sensors are electrochemical biosensors that utilize structure-switching aptamer probes attached to electrodes to detect analytes.

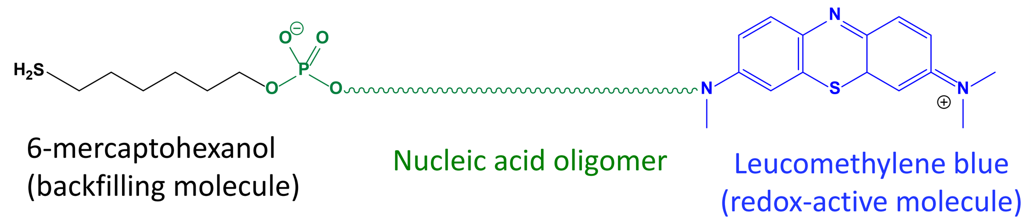
Schematic of target analyte detection



Why EAB Sensing?

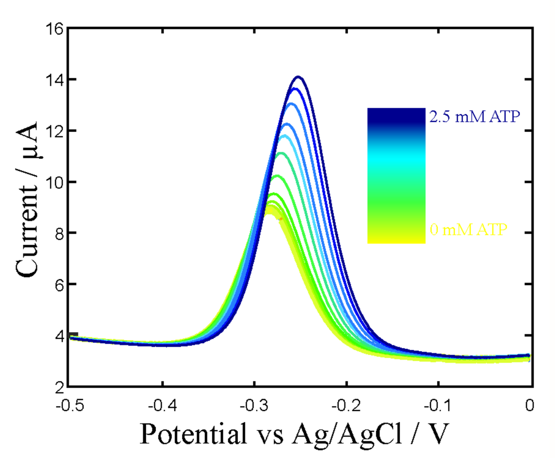
- Reagentless
- Reversible analytical detection
- Highly specific
- Gives rapid results in real time

Components of an EAB sensor

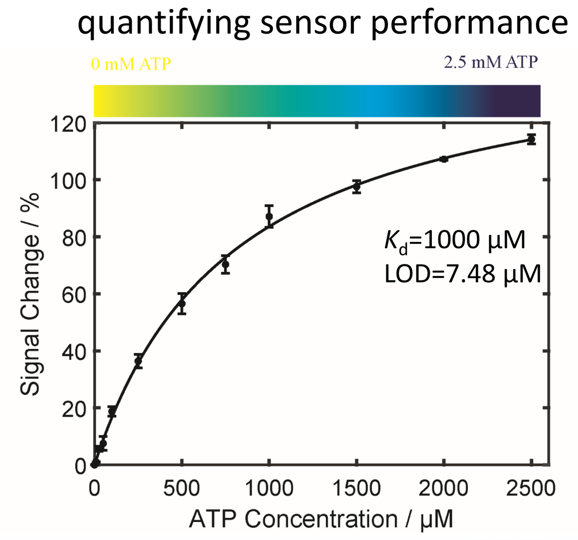


Sensor Interrogation Methods:

Square wave voltammograms (SWVs) for detecting ATP



Langmuir isotherm calibration curve for quantifying sensor performance



Langmuir isotherm parameters

Apparent binding affinity K_d between target analyte and aptamer

S, S_{max} = peak current

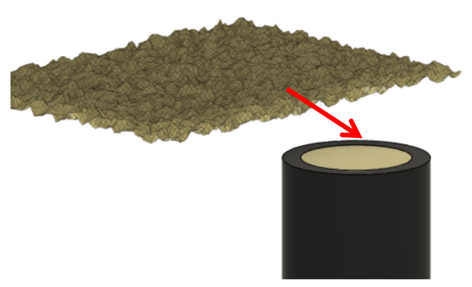
[L] = target concentration

$$\frac{S}{S_{max}} = \frac{[L]}{K_d + [L]}$$

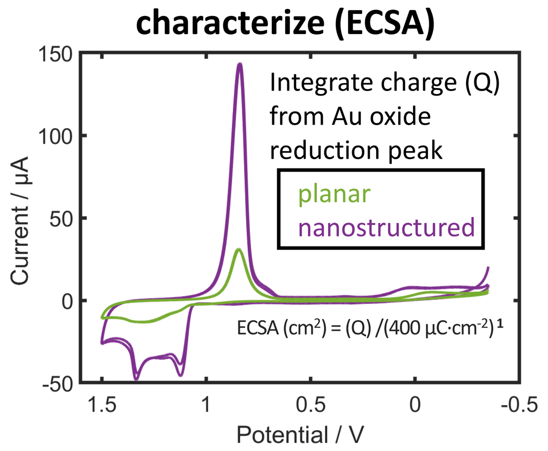
Introduction

Project Goal: Use electrodeposition of gold nanostructures to control the morphology of sensors and investigate its impact on the binding affinity, aptamer packing density, and signal change of EAB sensors on the micro- and macroscale.

Modification of planar Au electrode



CV in 0.05 M H_2SO_4 to characterize (ECSA)



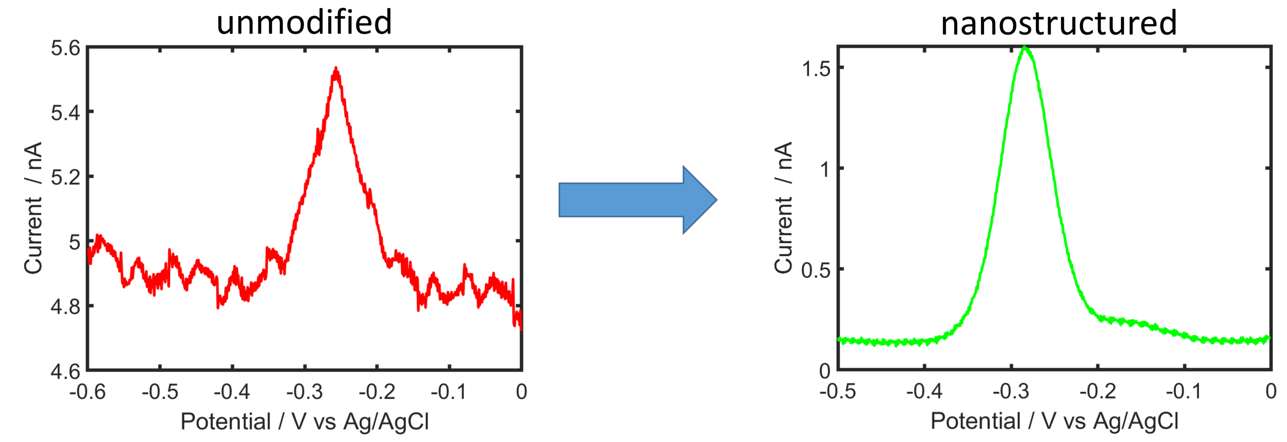
EAB sensor descriptors:

Aptamer packing density

Binding affinity (K_d) between aptamer and target analyte

Target analyte signal change

Electrodeposited Au nanostructures on **microelectrodes** enhances S/N.



References

[1]Trasatti, S.; Petrii, O. A. *Pure Appl. Chem.* **1991**, *63* (5), 711–734.

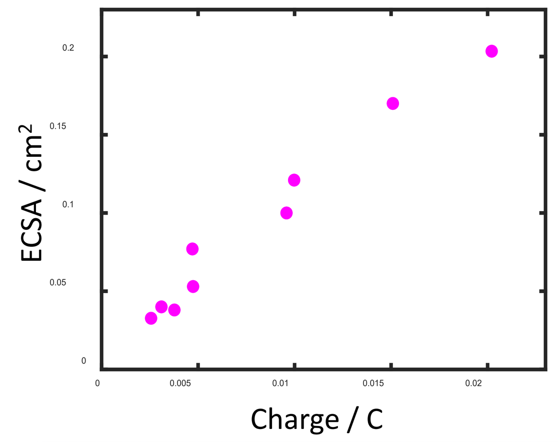
[2]Liu, Y.; Canoura, J.; Alkhamis, O.; Xiao, Y. *ACS Appl. Mater. Interfaces* **2021**, *13* (8), 9491–9499.

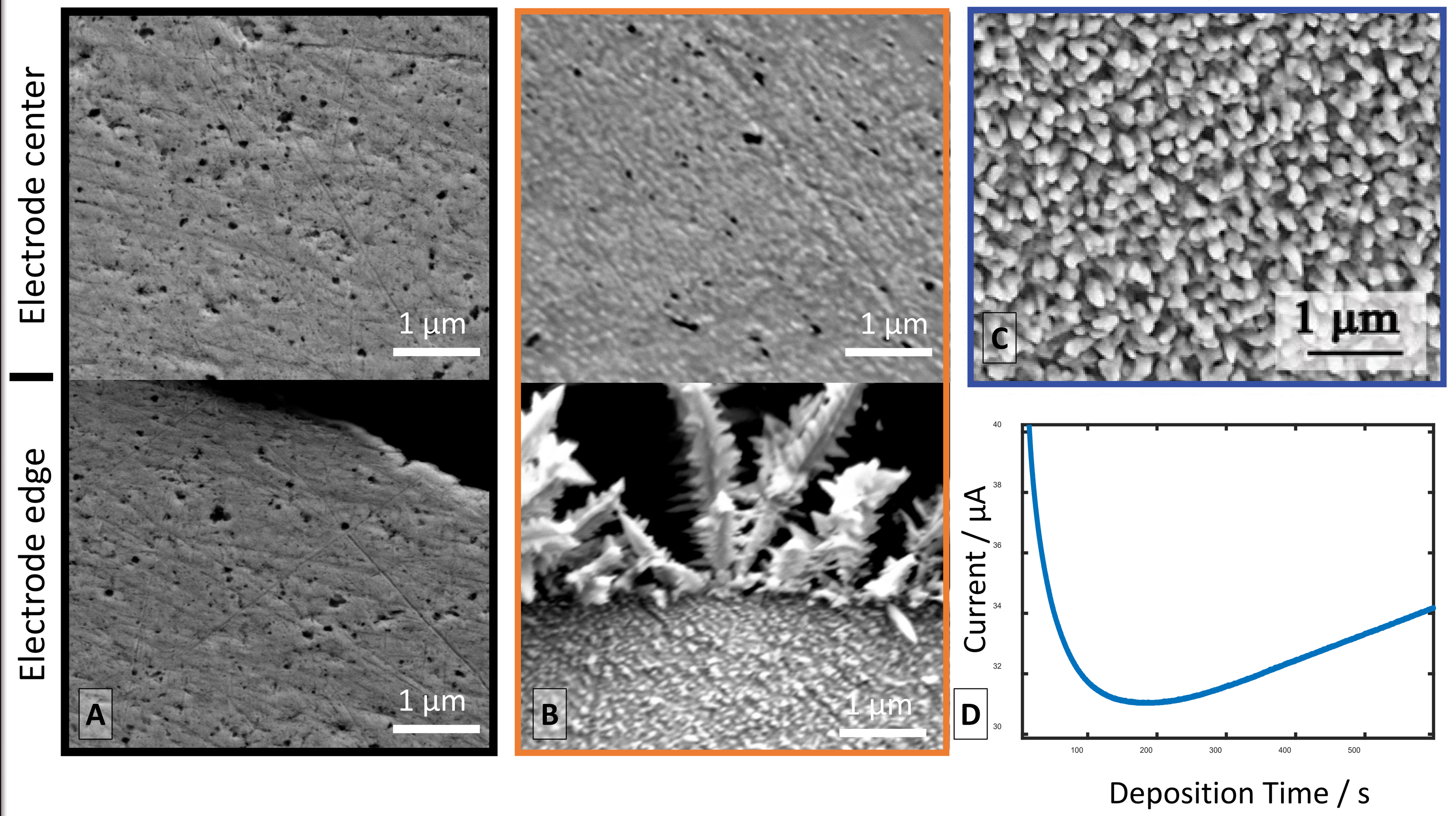
Nanostructured Macroscale EAB Sensors

Constant potential electrodeposition of Au nanostructures to control morphology.

Applying a potential of -0.2 V to gold electrodes for 120 s (B) and 600 s (C) in a solution of 10 mM $HAuCl_4$/0.5 M H_2SO_4 gave rise to unique surface characteristics. (A) depicts an unmodified electrode. (D) depicts the *i-t* curve, which results from the nucleation and growth processes of Au nanostructures on the electrode surface.

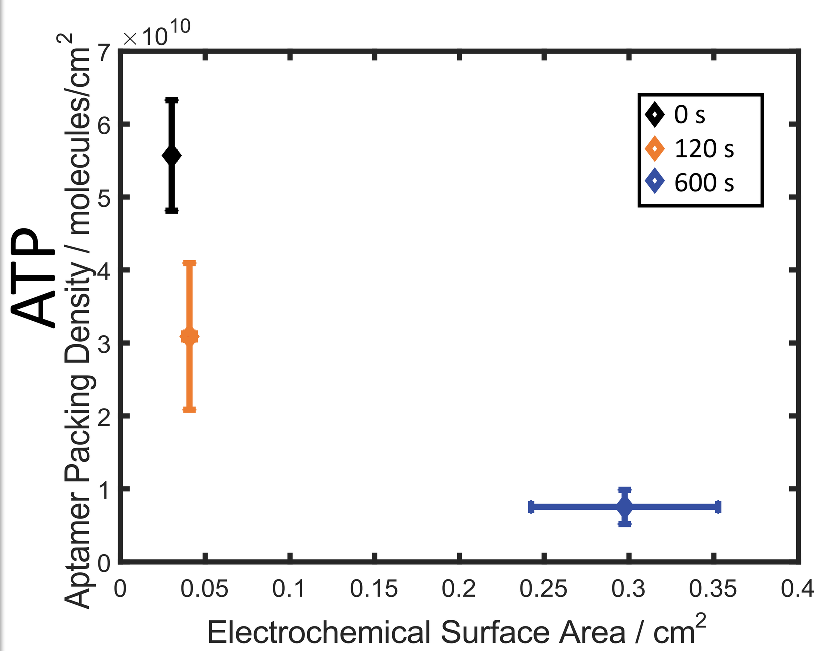
Charge associated with growth of nanostructures



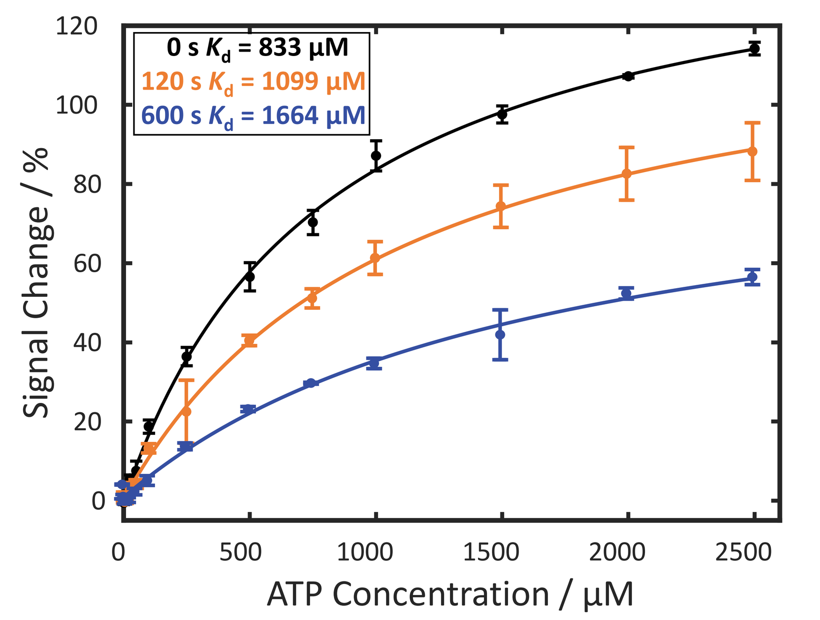


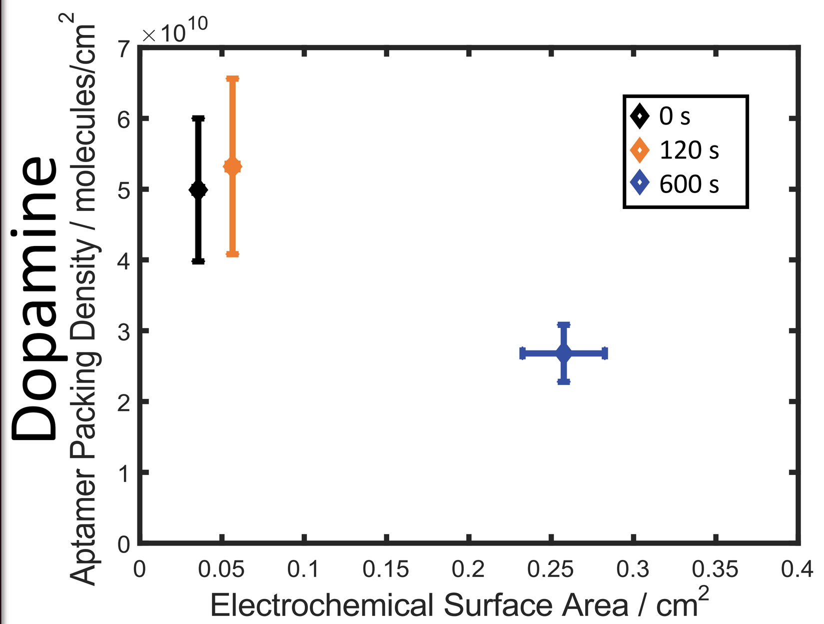
EAB sensor performance dependent on electrodeposition conditions for both target analytes tested..

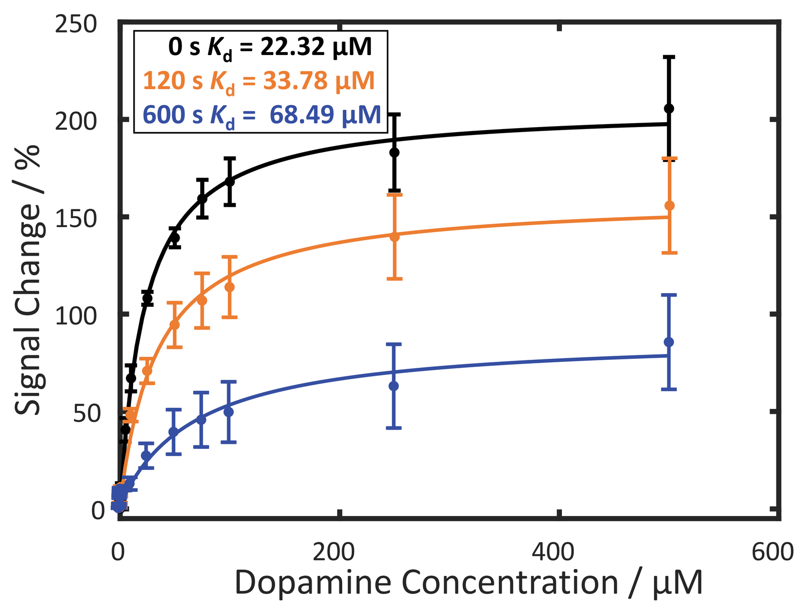
Aptamer Probe Packing Density



Langmuir isotherm calibration curves for detection of target analyte



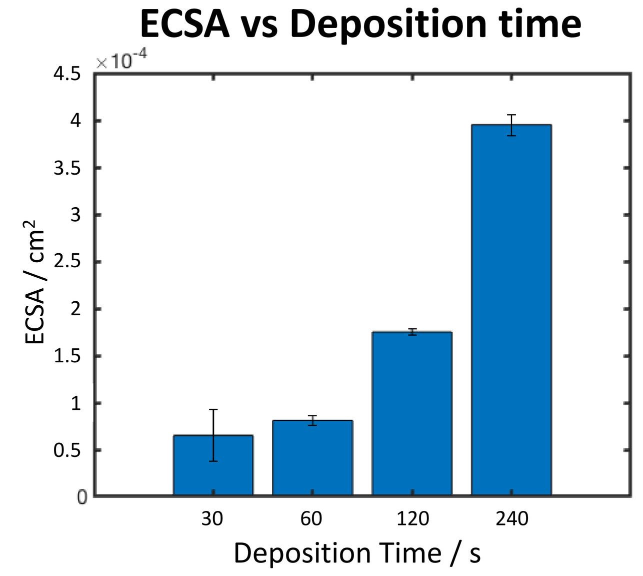




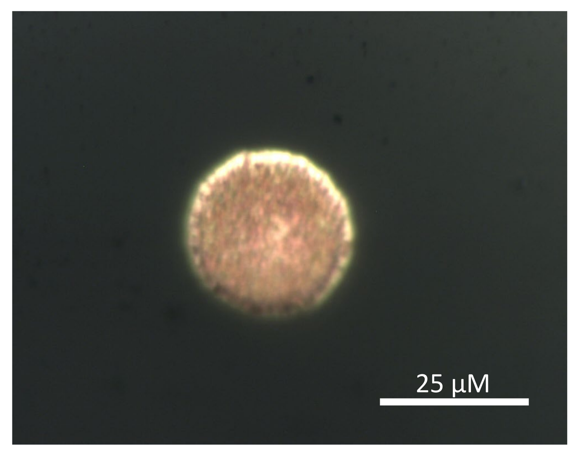
Nanostructured Microscale EAB Sensors

Surface area enhancement via constant potential electrodeposition.

ECSA vs Deposition time



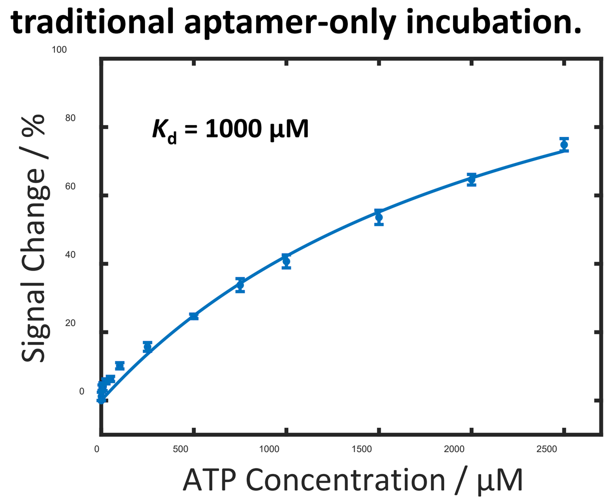
Optical image of 120 s deposited ME



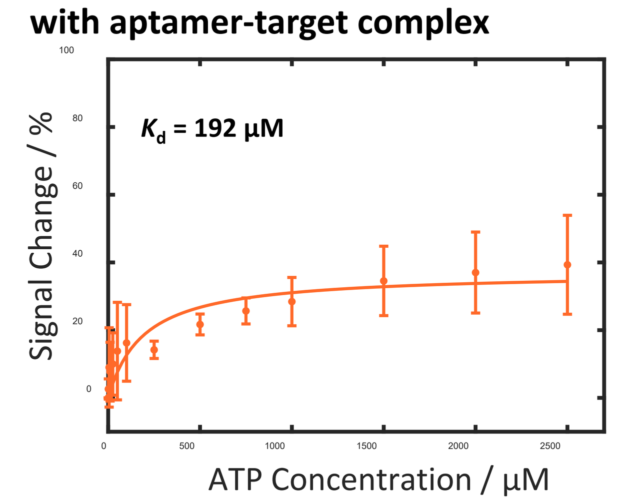
Aptamer-only vs Aptamer-target complex EAB sensor immobilization

The *Aptamer-target immobilization*[2] method led to a lower aptamer packing density, and decreased signal changes observed on the microscale. This decrease in signal change contradicts the trend reported in the literature[2].

EAB sensor titration of ATP with traditional aptamer-only incubation.



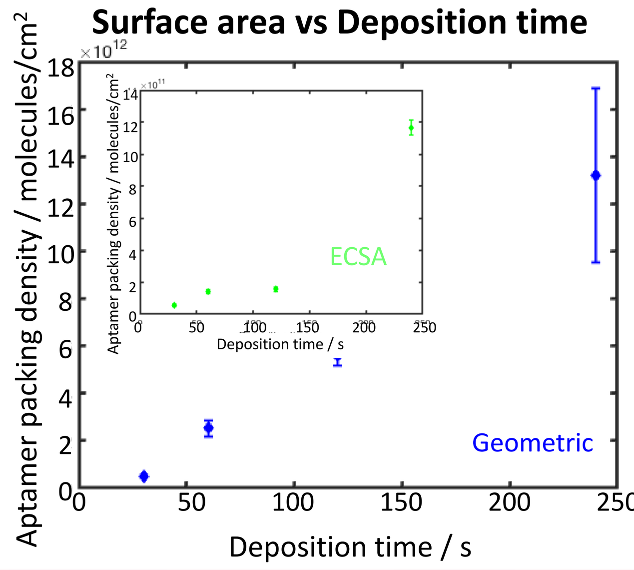
EAB sensor titration of ATP with fabricated with aptamer-target complex



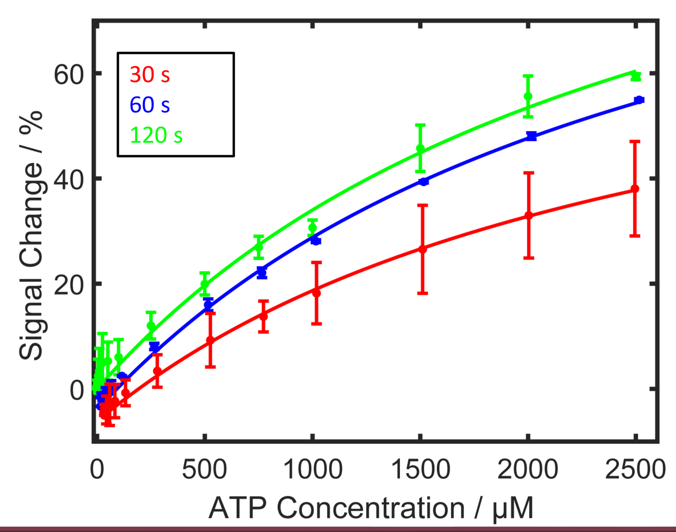
Effects of electrodeposition on EAB sensor performance

Enhancing the ECSA increased the aptamer packing density and ATP signal change for microscale sensors.

Surface area vs Deposition time



Langmuir isotherm fit on ATP calibration curves



Conclusions and Future Work

Conclusions:

- Target-assisted immobilization decreases sensing performance on the microscale.
- Enhancing the ECSA decreases sensing performance on the macroscale and increases performance on the microscale.

Future work:

- Microscale: Test operational stability of microelectrode EAB sensors and acquire more data for the detection of target molecules that vary in size.
- Macroscale: Fabricate sensors for large molecule targets such as thrombin to verify sensing trends.

Acknowledgements

FSU Startup Funds

Lab website:
https://www2.chem.fsu.edu/~lazenby/