Fabrication of a Thin Film Transistor (TFT) Based Biosensor for Antioxidants

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Abstract

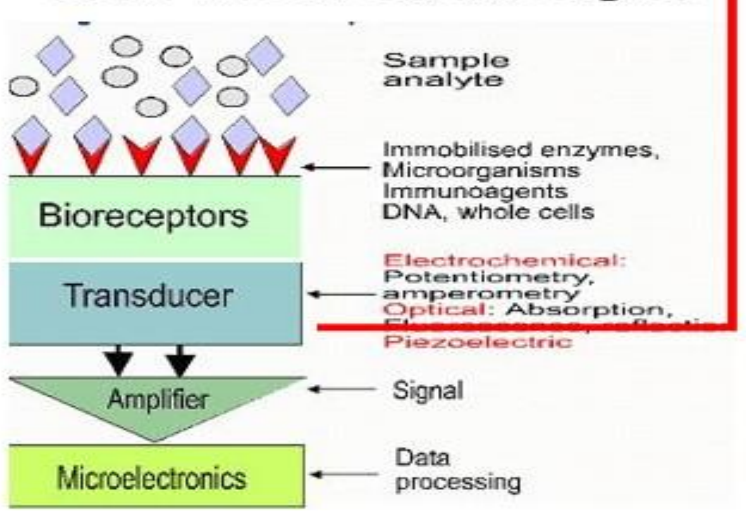
Printed biosensors for antioxidants based on the immobilization of the enzyme Tyrosinase are currently being investigated in Ana Aria's Lab at EECS, UC-Berkeley. Capacitive measurements are being used as detection method, but it is believed that other electrical devices could help to im prove biosensors performance. In this project, thin film transistor (TFT) were fabricated using printing techniques and flexible substrates. Inkjet was used to print Au source, drain and gate electrodes in two different transistor architectures, and blade coating or gravure printing was employed to deposit the semiconductor. All layers were characterized regarding their morphology and thickness, and the successful printing was demonstrated. Currently, Tyrosinase is being incorporated to the structures in order for them to be used in biosensing.

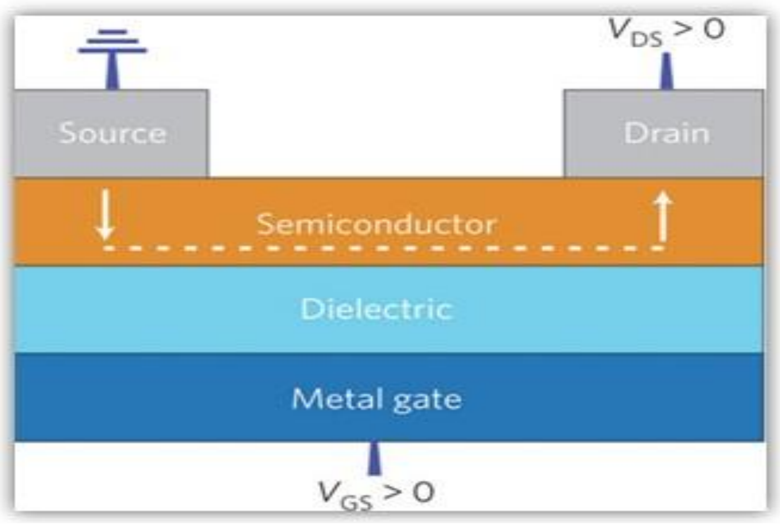
Introduction

Biosensors:

- Biological molecule as recognition element
- Transducer to transform the recognition event into a readable signal

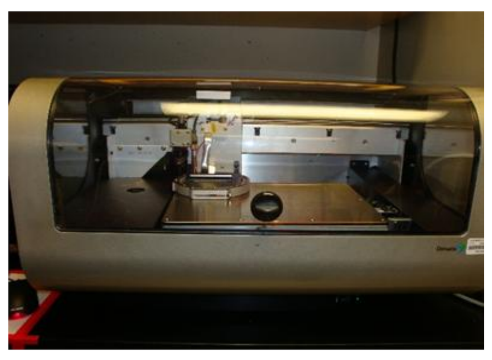
Thin film transistor (TFT): Amplifying electrical component





Methods

1. Printing Methods



Inkjet Printing (Gate & S/D electrodes)

Gravure Printing (OECT semiconductor)

Blade Coating (OFET semiconductor)

2. Characterization Methods

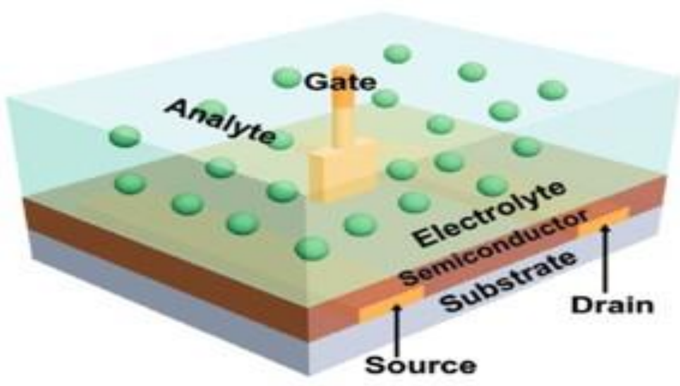
Dektak (profile measurement)

Optical Microscope (morphology)

3. Other Methods

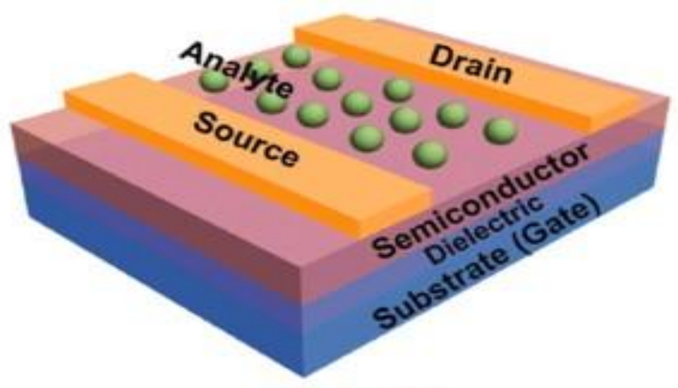
- Parylene Chemical Vapor Deposition (CVD) for dielectrics
- Cellulose Acetate Dip Coating (encapsulation)
- Plasma treatment for substrates (surface modification)

Architecture



OECT
(Organic ElectroChemical Transistor)

- Simple to fabricate:
  - Stable in liquid
  - Low operating voltage
  - Easier integration to microfluidics because gate is separated



OFET
(Organic Field-Effect Transistor)

- Enzyme and semiconductor are exposed
- Potential to improve the limit of detection

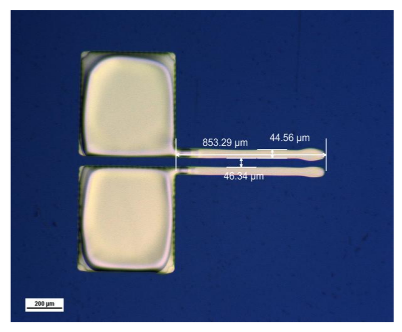
Acknowledgement

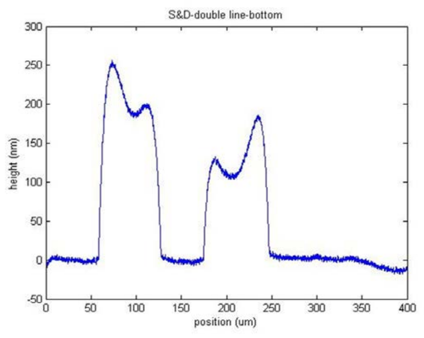
I would like to thank everyone in Professor Ana Arias' lab, especially my mentor Dr. Felippe, along with all the members of TTE, E3S for all their contributions.
Felippe J Pavinatto acknowledges Fapesp – Brasil, for funding part of the research.

Fabrication Process and Results

OECT Fabrication

1. Source and Drain Inkjet (Au)





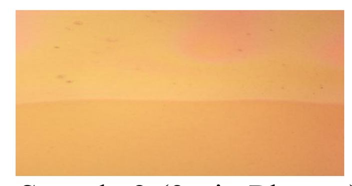
Source and Darin	Width (µm)	Height (nm)	Channel Distance (µm)
Single Line	44 ± 1	132 ± 57	52.49
Double Lines	67.5 ± 5	93.8 ± 51.3	46.34
Triple Lines	95 ± 6	31.3 ± 4.6	52.62

2. Semiconductor (PEDOT:PSS) Gravure

Solution:

- CMC: 3 g/L
- PEDOT: 4.02 g/L
- Threalose: 1% w/v
- Triton x100: 0.05% w/v

Sample 1 (30s Plasma)

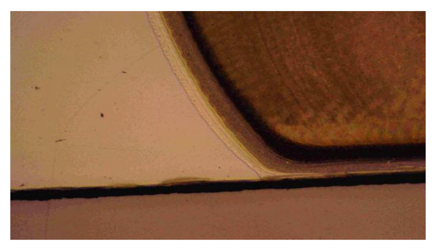


Sample 2 (3min Plasma)

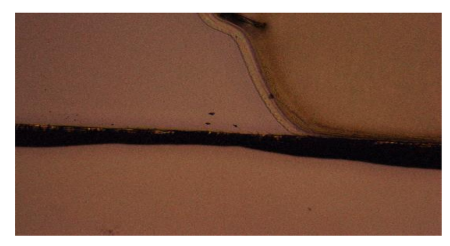
3. Cellulose Acetate Coating

Solution:

- 2.5 % (w/v) cellulose acetate
- THF/acetone: 3:2 in volume
- Extraction speed: approximately about 2.43 mm/s



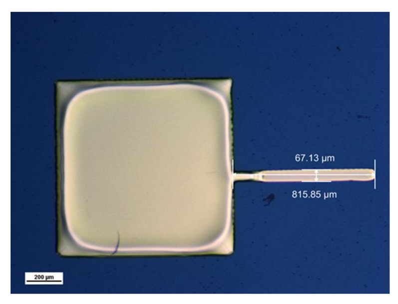
Before Immersion

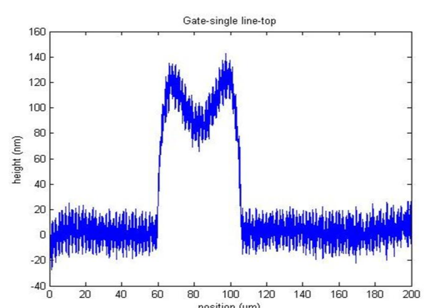


After Immersion

OFET Fabrication

1. Gate Inkjet (Au)

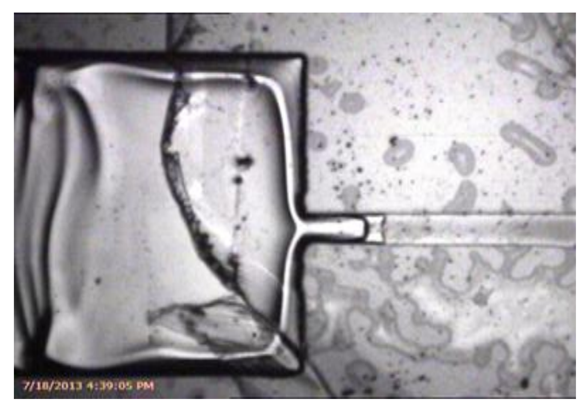




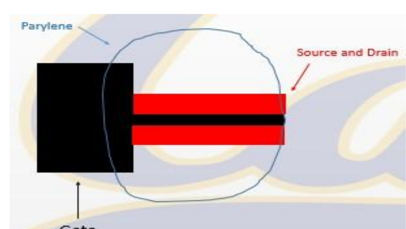
Gate	Width (µm)	Height (nm)
Single Line	30 + 1	43 ± 2
Double Lines	51 ± 5	71 ± 1
Triple Lines	105 ± 20	99 ± 1

2. Parylene CVD

- Chemical vapor deposited poly(p-xylylene) polymers
- Used as dielectric barriers



3. Source and Drain Inkjet (Au)



4. Semiconductor (Blade Coating)
Substrate: Parylene Solution: PEDOT Ink

5. Cellulose Acetate Coating
(Same protocol as in OECT Fabrication.)

Conclusions and Perspectives

OECT

- All the layers of the device were successfully fabricated and encapsulated
- Integration and testing underway

OFET

- Gate, S/D, semiconductor and dielectric (parylene) layers were successfully deposited
- Assembly and encapsulation of the device ongoing

*Tyrosinase will be incorporated to the semiconductor in both devices, and they will be tested in biosensing by other students in the group.

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