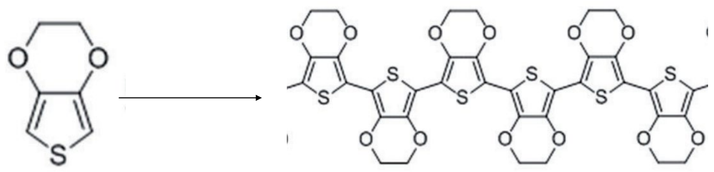
Operando Electron Microscopy of the Electrochemical Polymerization of Beam Sensitive Conductive Polymers

Vivek Subramanian[1], David C. Martin[1, 2]

1. Materials Science and Engineering, University of Delaware 2. Biomedical Engineering, University of Delaware

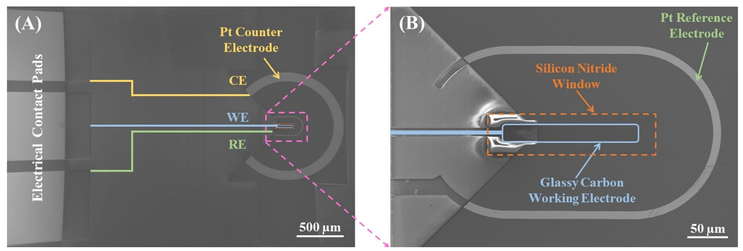
Introduction

- Conjugated polymers have been of recent interest for interfacing the electronically conducting metallic or semi-conducting biomedical devices with the ionically conducting living tissue due to their ability to conduct both electronically and ionically[1]
- Poly(3,4-ethylenedioxythiophene)(PEDOT) has received particular attention due to its excellent chemical, mechanical and thermal stability
- Current focus is on observation, quantification and understanding the nucleation and growth of the electrodeposition of PEDOT and its derivatives for a better control over the structure and properties of these polymeric materials



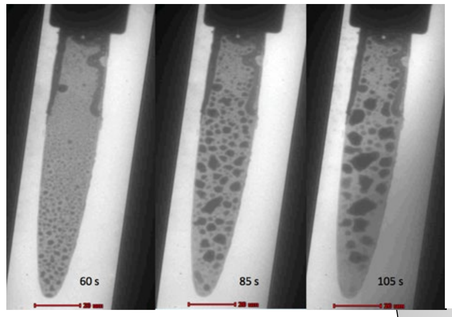
Polymerization reaction of PEDOT

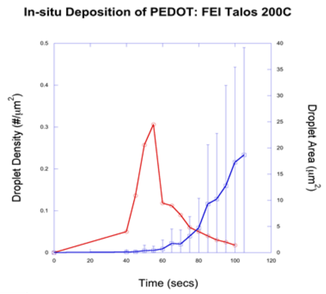
E-chips



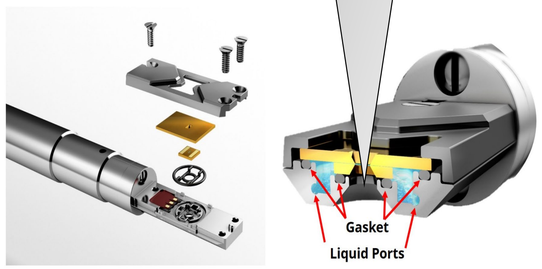
Scanning electron micrograph of an E-Chip[2]

In-situ TEM



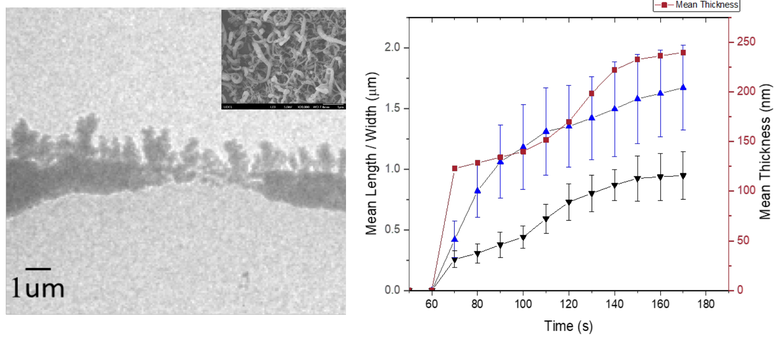


Nucleation and growth of PEDOT
Dose: 10-20 e/A²



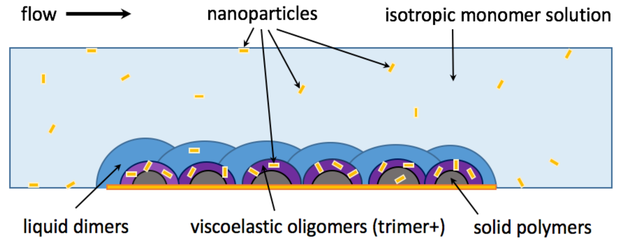
In-situ TEM holder from Protochips, Inc.

Nanofibril Nucleation and Growth



Nucleation and growth of PEDOT with a fibrillar morphology using in-situ TEM (inset: SEM of PEDOT:PAA nanofibrils)

Flowing Nanoparticles



- A future study will focus to differentiate the solid-like and liquid-like clusters by observing the manner in which flowing nanoparticles interact with them.

Conclusions

- The monomers react with each other to form higher molecular weight liquid-like and solid-like oligomeric species(clusters) that precipitate out of the isotropic monomer solution
- The clusters then coalesce and increase in size and thickness to deposit on the working electrode as a dark, solid and stable conjugated polymer film
- By tracking the velocity profile of PEDOT nanofibrils we were able to understand the nuances involved in the fibril formation process

Acknowledgements

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References

1. Martin, *MRS Comm.*, 2015
2. Liu et.al, *ACS Macro Letters*, 2015