National Nuclear Security Administration

Application of Organic Semiconductor for Direct Radiation Detection

Shae Cole, Anna Erickson

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LANNS
LABORATORY FOR ADVANCED NUCLEAR NONPROLIFERATION AND SAFETY

Consortium for
ENABLING TECHNOLOGIES & INNOVATION

Outline

Introduction

Background

Proposed Device Structure

Fabrication Procedure

Next Steps

Acknowledgements

References

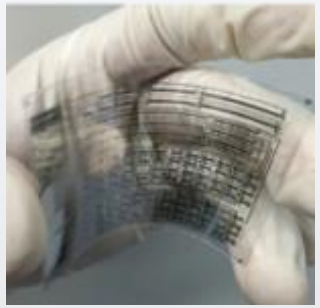
Introduction

What are organic based semiconductors?

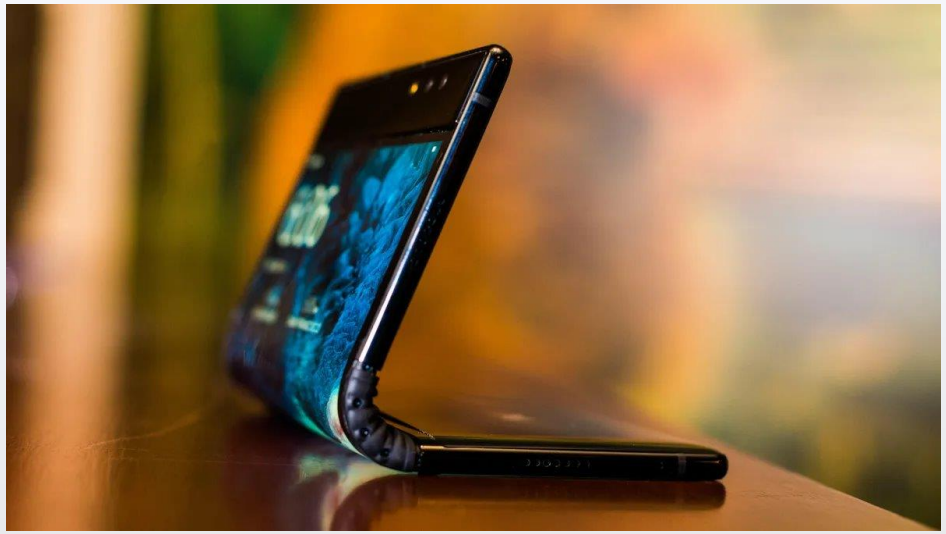
- Carbon and Hydrogen based materials

Current uses

- Organic LED (OLED)
- Organic based Solar Cells (OSC)
- Organic Transistors (OFET)



Springer Nature



Angela Lang/CNET

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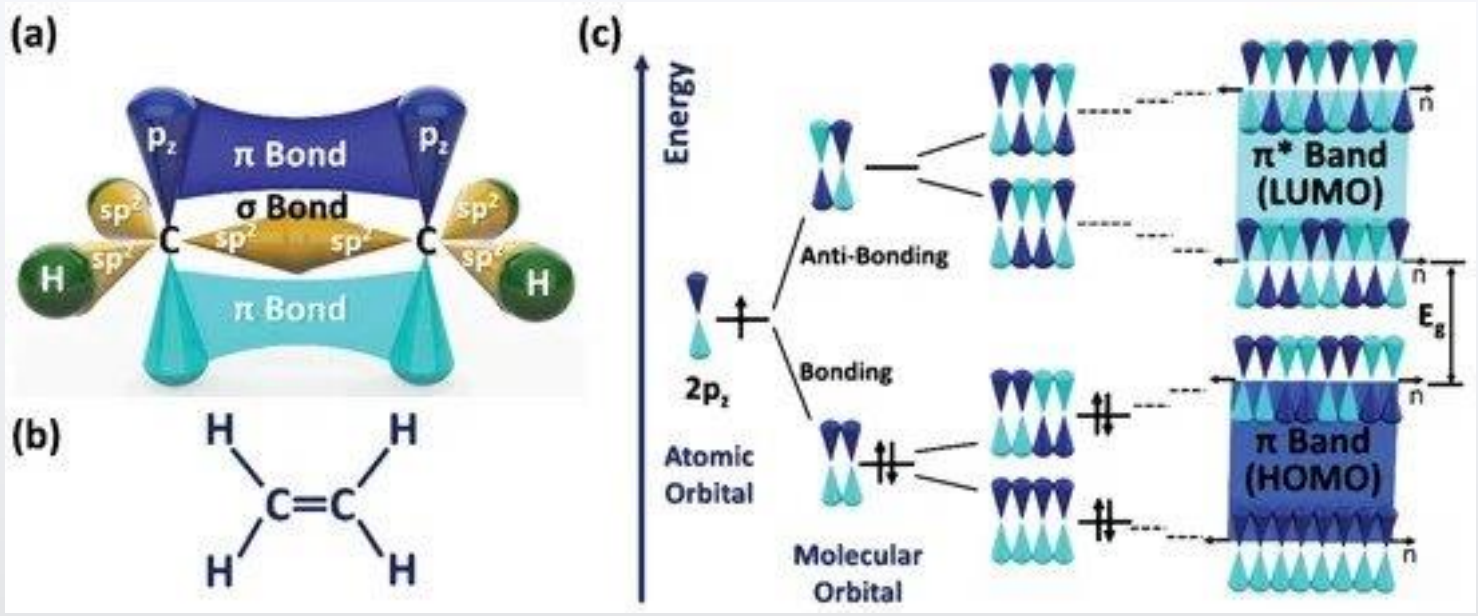
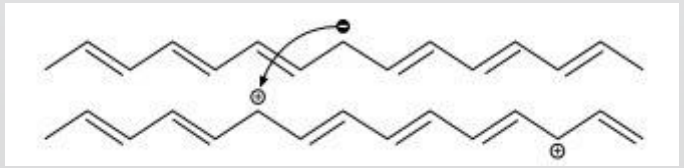
PCMAG.COM

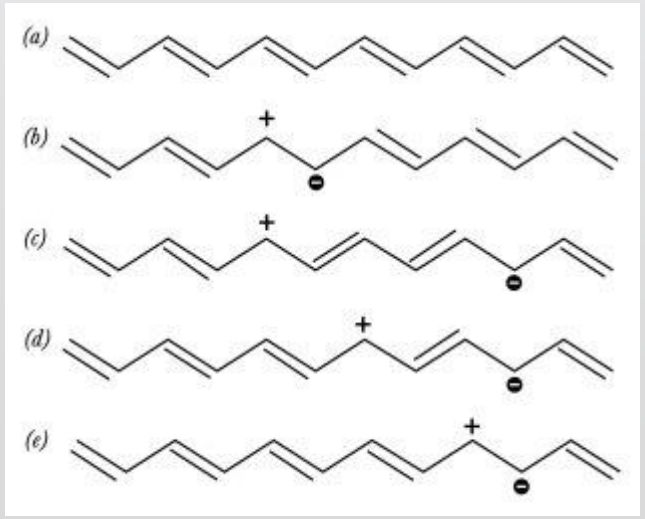
Background



Heydari Gharahcheshmeh



Heeger Alan, et al



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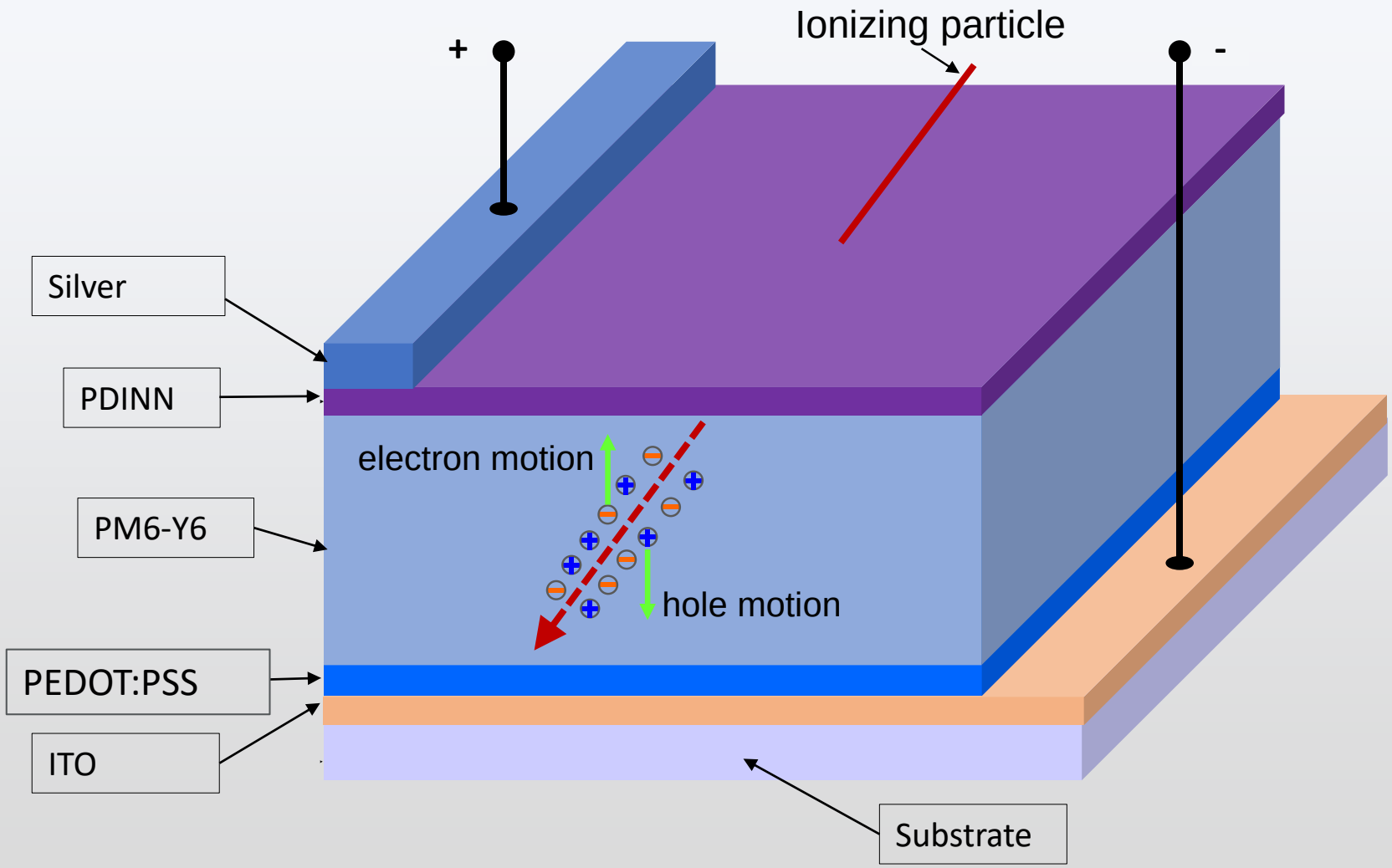
HOMO- Highest Occupied Molecular Orbit

LUMO- Lowest Occupied Molecular Orbit

Proposed Device Structure



Depiction by Yuguo Tao

Device Structure

- Glass Substrate
- Two electrode films (Silver and ITO)
- Interaction Volume (PM6-Y6 or Y7)
  - Copolymer Film
  - Bulk Heterojunction

- Buffer Layers
  - Hole Transport Layer (HTL)
    - PDOT:PSS or ZnO
  - Electron Transport Layer (ETL)
    - PDINN or MoO_3

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Proposed Device Structure

Electron Donor

PM6 – PBDB-T-2F

Chemical Formula

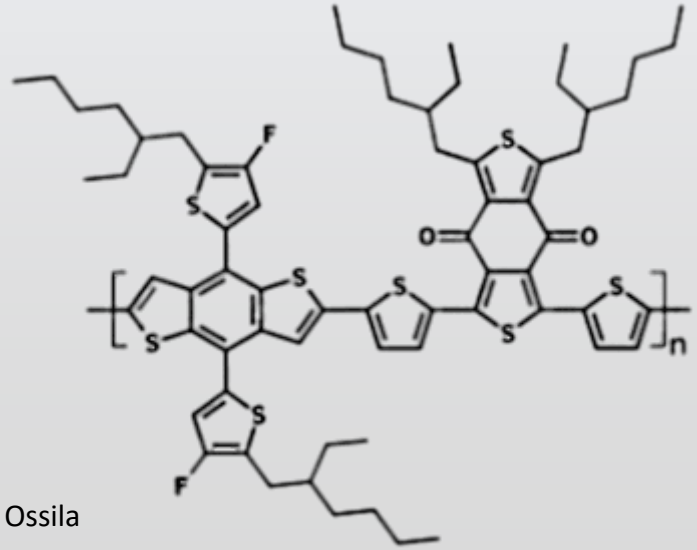
- $C_{68}H_{76}F_2O_2S_8$

HOMO

- -5.45 eV

LUMO

- -3.65 eV



Ossila

Electron Acceptor

Y6 – BTP-4F

Chemical Formula

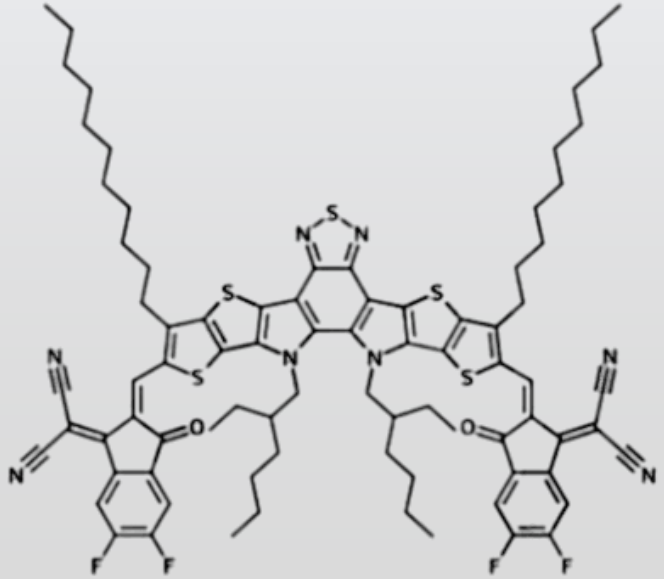
- $C_{82}H_{86}F_4N_8O_2S_5$

HOMO

- -5.65 eV

LUMO

- -4.10 eV

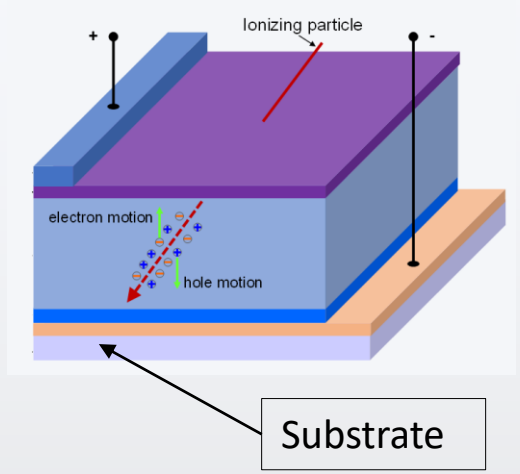


Ossila

Fabrication Procedure

Current Cleaning Procedure

- Physical Scrub in DI Water and Soap
- Sonication at 40°C for 30 minutes in DI Water and Soap
  - DI Water and Soap
  - DI Water
  - Acetone
  - IPA



Manufacturer Recommendations

- Sonicate 20 minutes in Acetone
- Dry off
- Sonicate 20 minutes in IPA
- UV Ozone Treatment
- Vacuum Oven

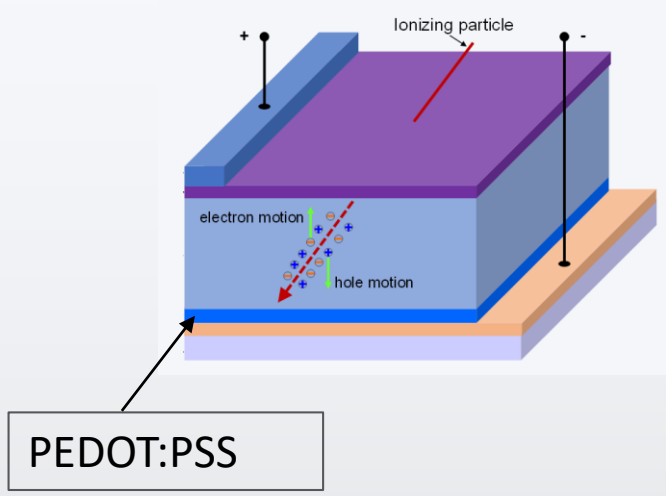
Fabrication Procedure

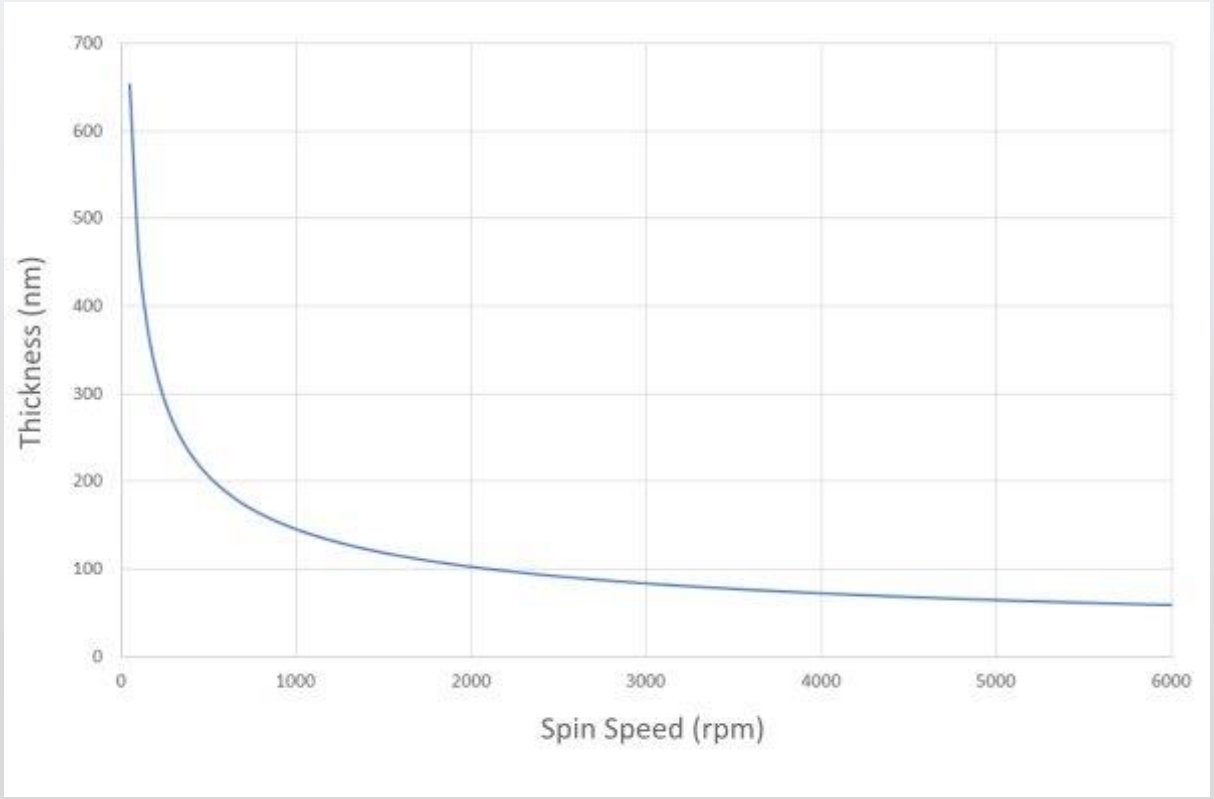
Development of PEDOT:PSS (HTL)

- Filtration with Nylon Filter

Deposition of PEDOT:PSS Layer (HTL)

- Target Thickness 70 nm (Friedel)
  - RPM 4000 for 30 seconds
  - Annealing Temperature 200°C





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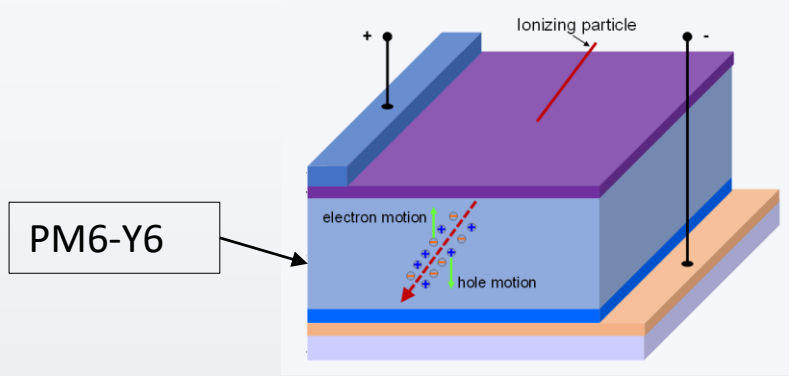
Fabrication Procedure

Development of PM6-Y6

- Polymer Blend of 1:1.2
- Dissolved in Chlorobenzene at 10 mg/mL
- Mixed for a minimum of 3 hours before deposition



Deposition of PM6-Y6

- Spin Coat on top of PEDOT:PSS
  - 15-50 micro-liters
  - Dynamically
  - 100-4000 RPM
  - Annealing at 90 Degrees Celsius

Variation of Thickness & Method of Deposition

- Methods
  - Spin Coater
  - Drop Coating
- Thickness Variation
  - 1-10 um

Fabrication Procedure

Preparation of PDINN (ETL)

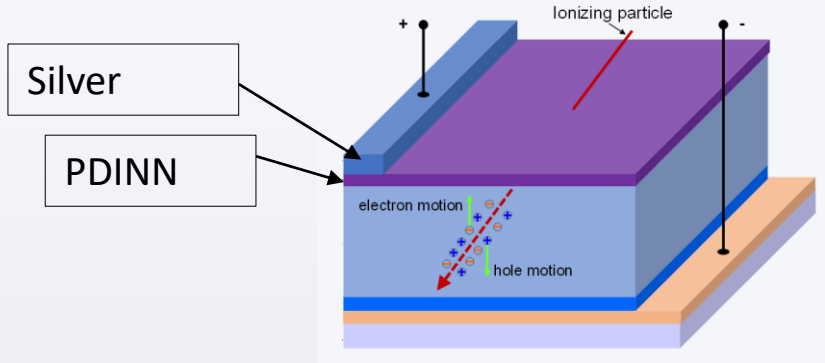
- Dispersion into Methanol
  - 1 mg/mL

Deposition of PDINN

- Spin Coat
  - 3000 RPM for 30 seconds
  - Target Thickness 5-10 nm

Deposition of Ag (Silver) or Al (Aluminum)

- Thermal Evaporation
  - Ag Target Thickness of 100 nm
  - Al Target Thickness of 90 nm



Glove Box from TE

Next Steps

Fabrication Optimization
- Annealing Temperatures
- Plasma Treatment
- BHJ deposition

Improvement of BHJ
- Tertiary Polymer Film
- Changes in Donor and Acceptor Polymer

Flexible substrates
- Improved Geometric Efficiencies

Multi-Layered OPV
- Larger Detection Volume

Testing Sensitivity to Ionizing Radiation
- Proton Beams
- Electrons Beams
- X-ray Beams

Testing Radiation Degradation
- Protons
- Electrons
- X-ray's

Emory

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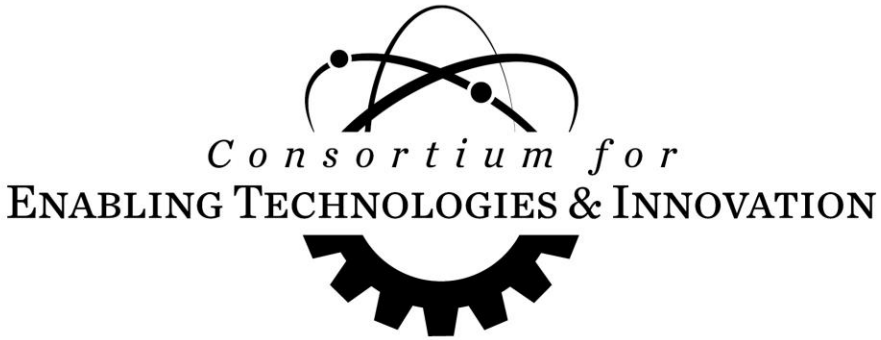

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