NAZARBAYEV UNIVERSITY
NATIONAL LABORATORY ASTANA

International Seminar on
¨Towards Smart Sustainable Cities - Integrated Approaches¨

Organic Photovoltaics Research in Solar Energy Laboratory

of the Center for Energy and Advanced Materials Science

Damir Aidarkhanov,MS

Astana, Kazakhstan, 15-16 June, 2017

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OPV problems vs solutions

- **Relatively low PCE**
- **Stability issues and etc.**

VS

- **New material synthesis (absorption increase)**
- **Device preparation and characterization (optimal structure and performance)**
- **Modeling (testing assumptions and hypotheses against measurements)**

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Projects

- **Bulk heterojunction solar cells based on low-bandgap organic semiconductors and soluble fullerene derivatives**
- **Study of OSC morphology using different microscopy techniques**
- **Stationary and dynamic electrical characteristics of organic solar cells: simulations and experiments**
- **DSSC on the basis of ZnO nanoparticles**

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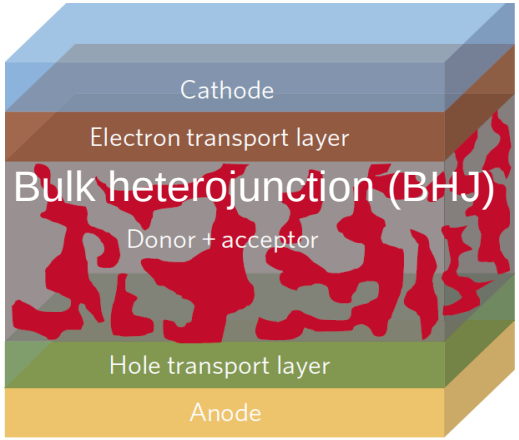
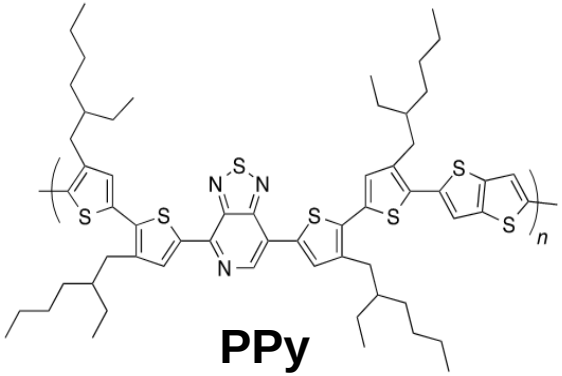
BHJ OSC based on new polymers

Bulk heterojunction (BHJ) OSC



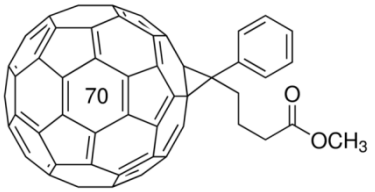
Low band gap copolymers



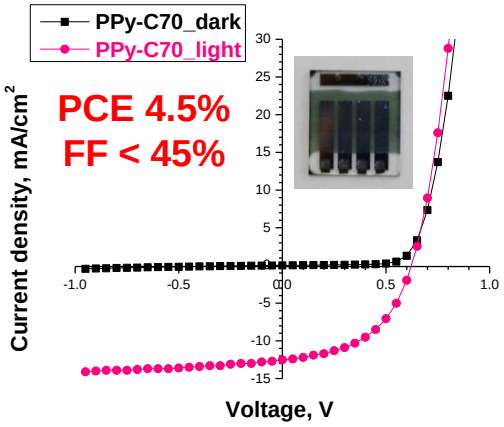
PPy

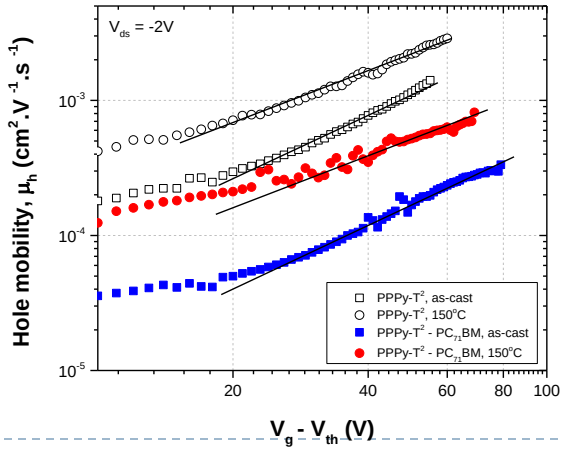
O.A. Ibraikulov et. al., Org. Electron., **2015**, 23, 171-178.

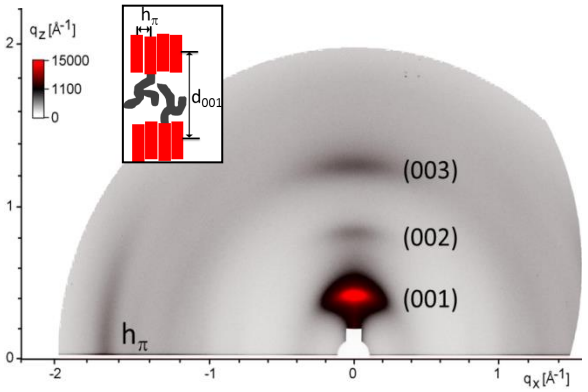
[6,6]-Phenyl C_{71} butyric acid methyl ester



Characterization







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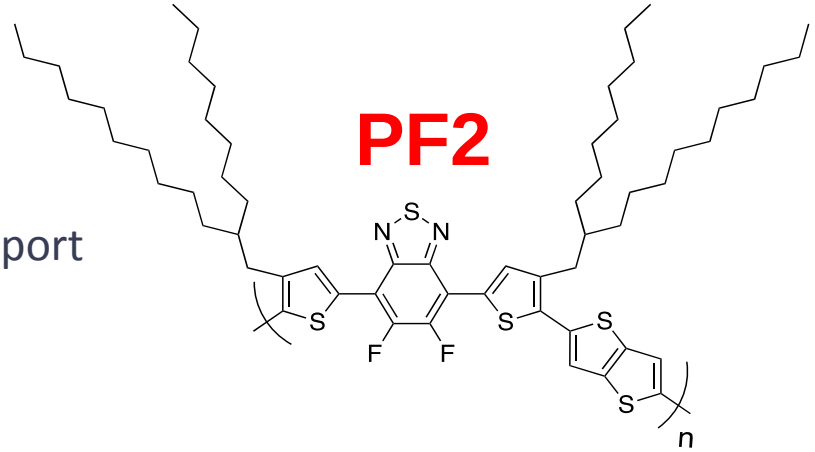
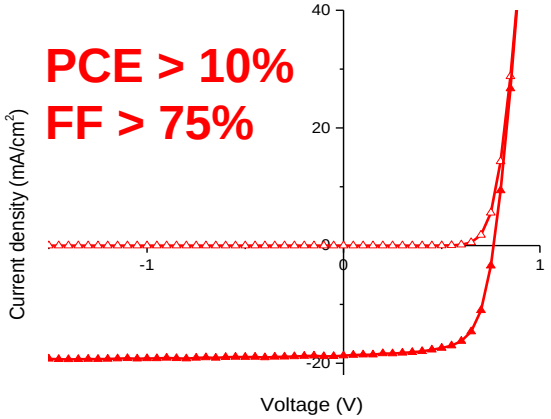
BHJ OSC based on new polymers

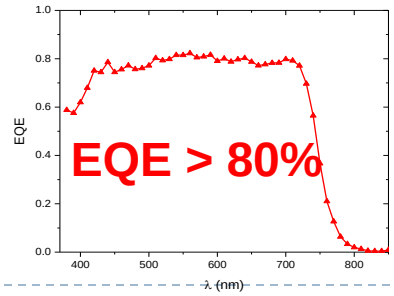
- **Fluorination of polymer backbones**
  - Optimized frontier molecular orbital (FMO) energy levels with low band-gaps
  - Excellent morphology that allows good transport
  - Very pure domains, low recombination rates

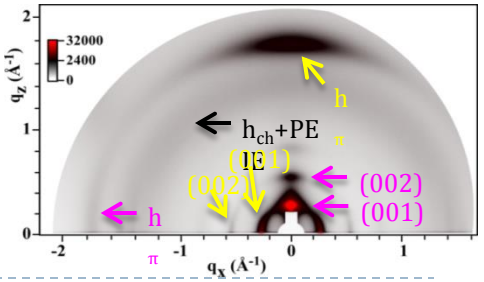


- **Characterization**



	Pure polymer films		BHJ blends
	μ_{OFET} (cm²/Vs)	μ_{SCLC} (cm²/Vs)	μ_{SCLC} (cm²/Vs)
PF2	(1.0 ± 0.2) x 10⁻²	(9.0 ± 0.8) x 10⁻³	(9.5 ± 1.2) x 10⁻³





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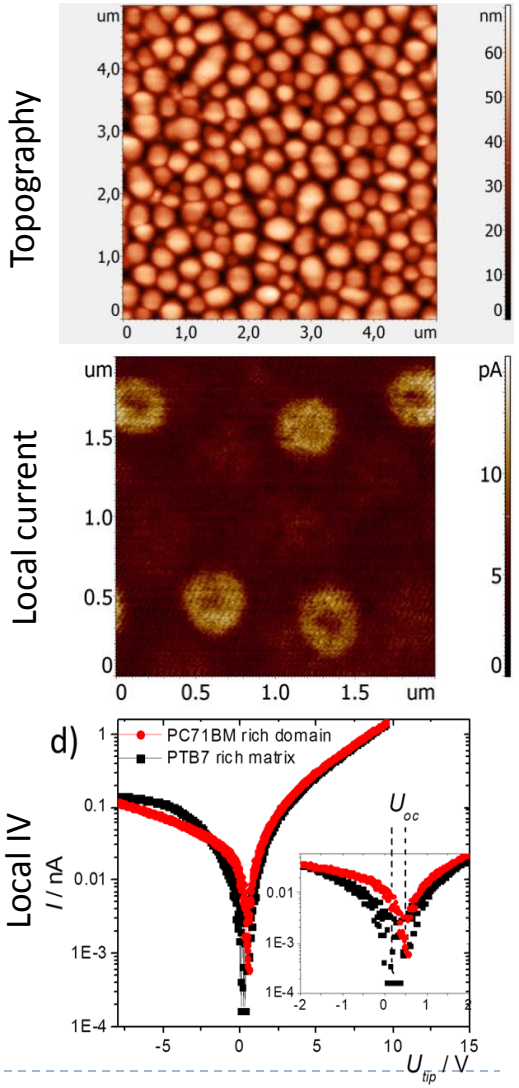
Characterization: Microscopy

- **Scanning Probe Microscopy (SPM)**
  - Atomic force microscopy (AFM)
  - Scanning Tunneling Microscopy (STM)
  - Scanning Near-Field Optical Microscopy (SNOM)
- **Electron microscopy**
  - Scanning Electron Microscopy (SEM)
  - Transmission Electron Microscopy (TEM)
  - Dual beam system (FIB & SEM)
- **Raman and Tip Enhanced Raman Microscopy**



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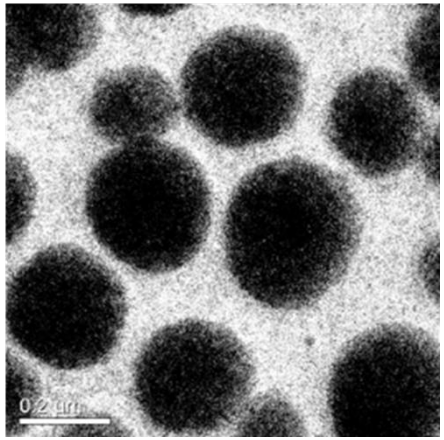
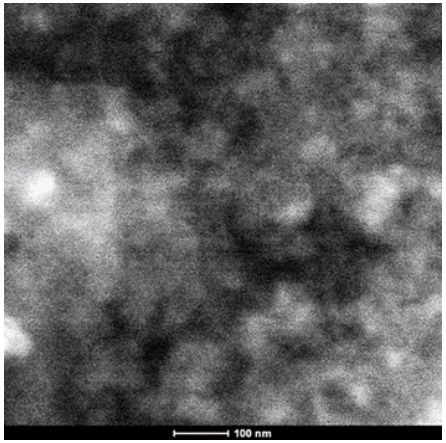
Characterization: Microscopy

Energy Filtered Transmission Electron Microscopy (EFTEM)

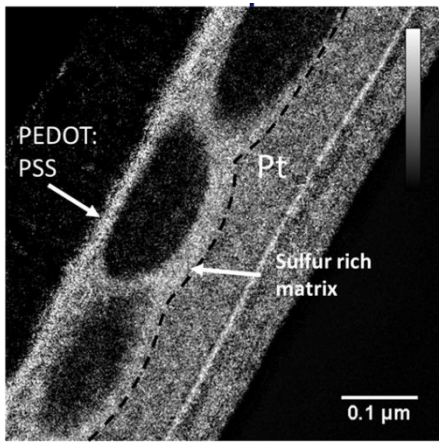
Sulfur maps (with DIO) | Carbon maps (no DIO)

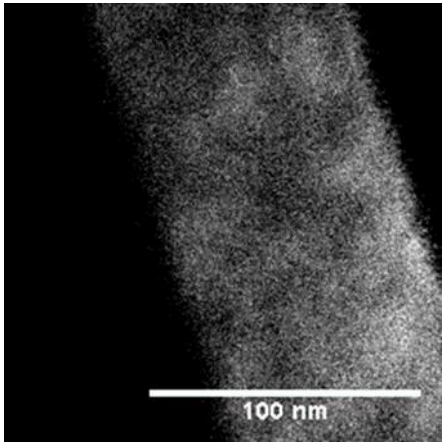
Top view



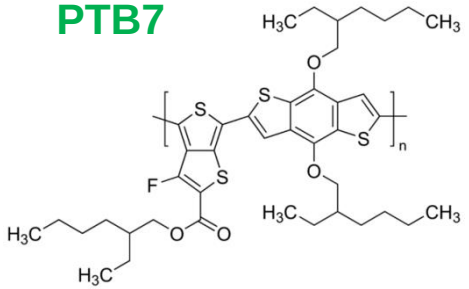


Cross-section





PTB7



Poly({4,8-bis[(2-ethylhexyl)oxy]benzo[1,2-*b*:4,5-b′]dithiophene-2,6-diyl}{3-fluoro-2-[(2-ethylhexyl)carbonyl]thieno[3,4-*b*]thiophenediyl})

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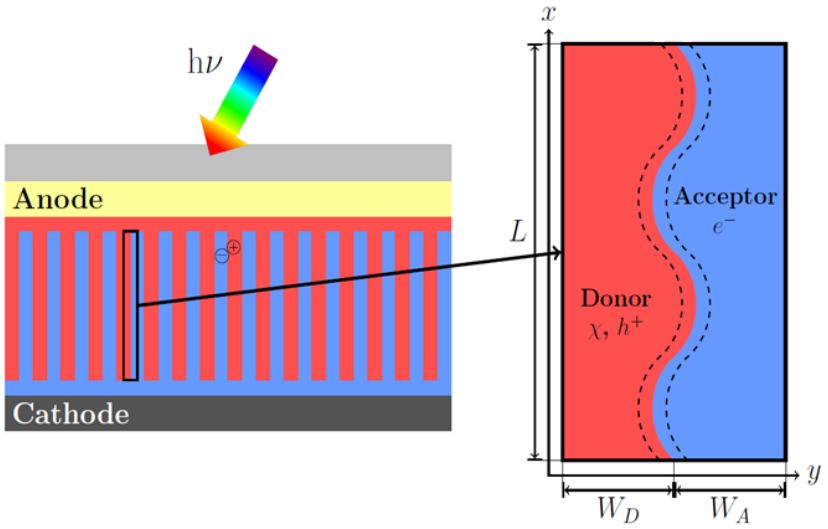
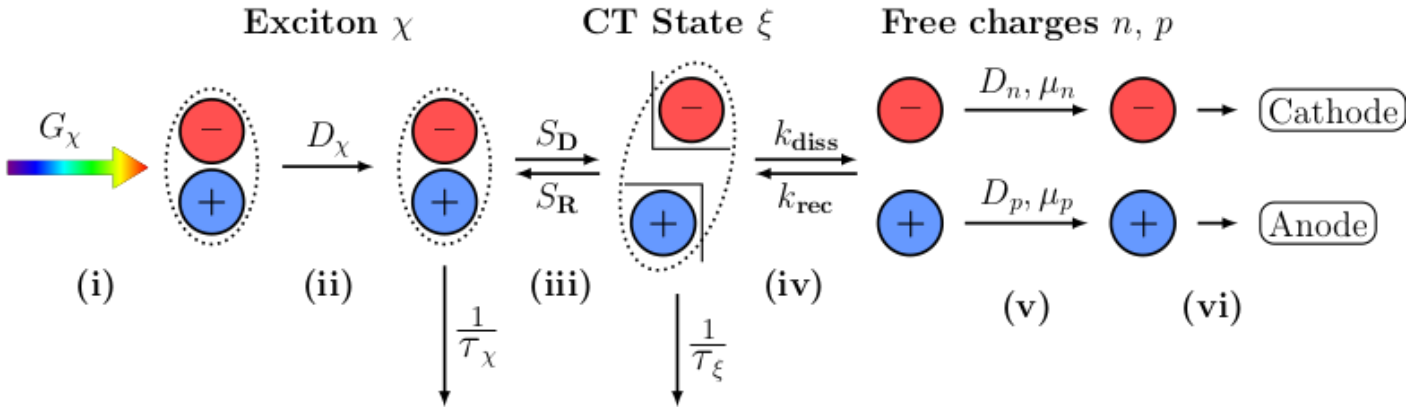
Simulation: 2D drift-diffusion model

- **Model geometry**



- **Model physics**



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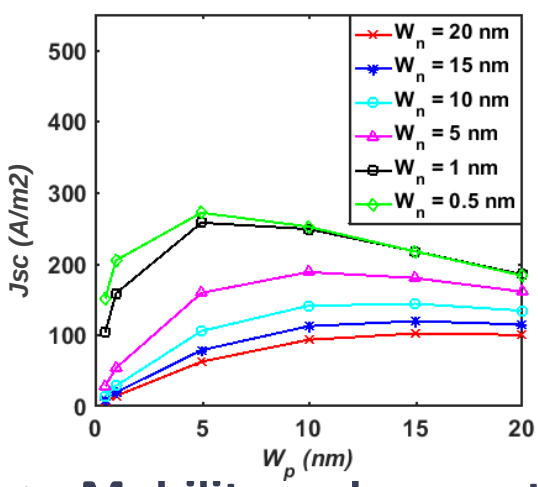
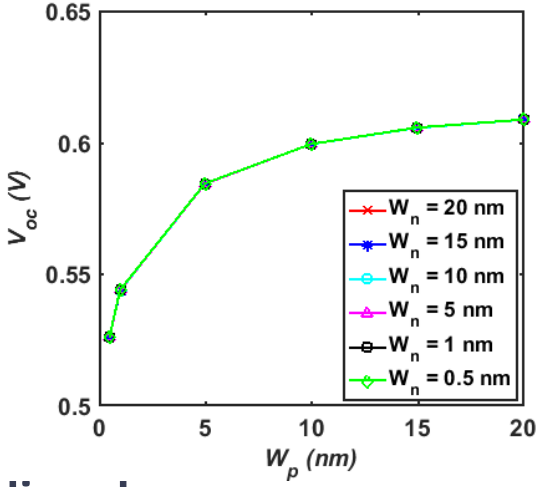
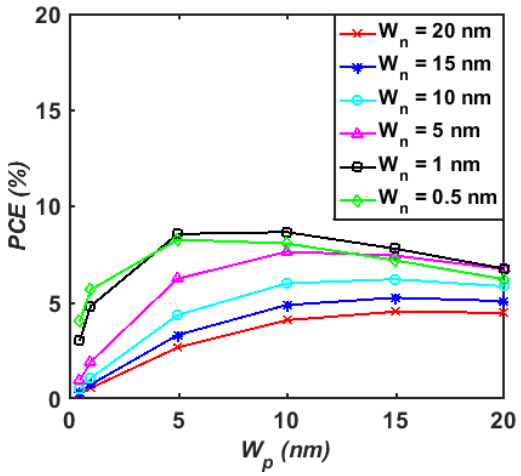
Simulation: 2D drift-diffusion model

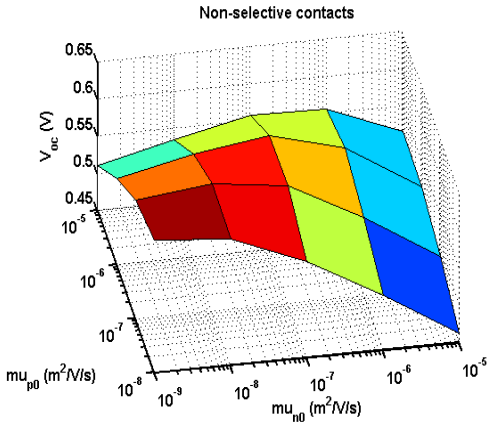
- **Morphology variation (domain size)**

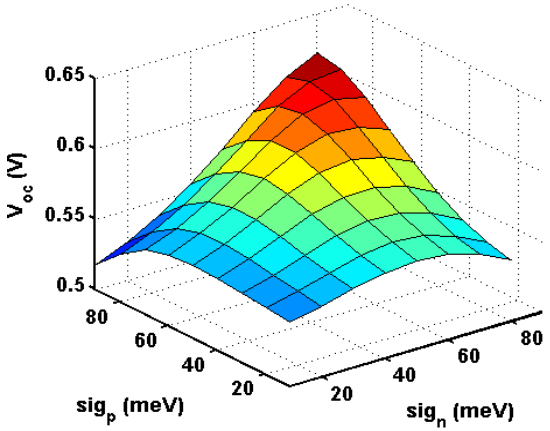






- **Mobility and energetic disorder**





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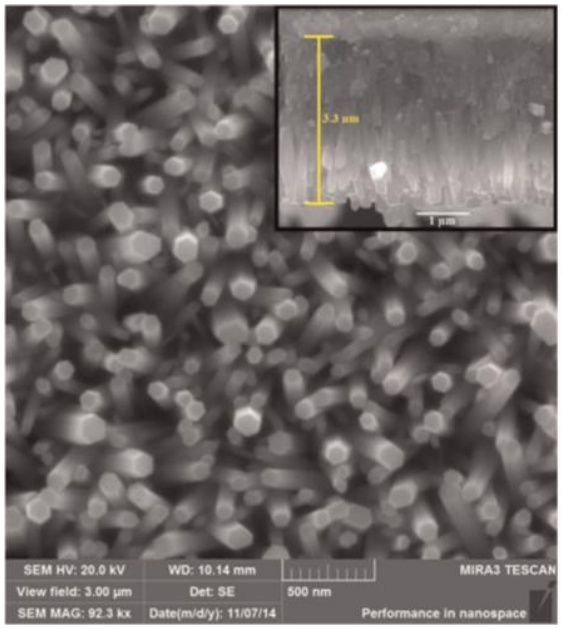
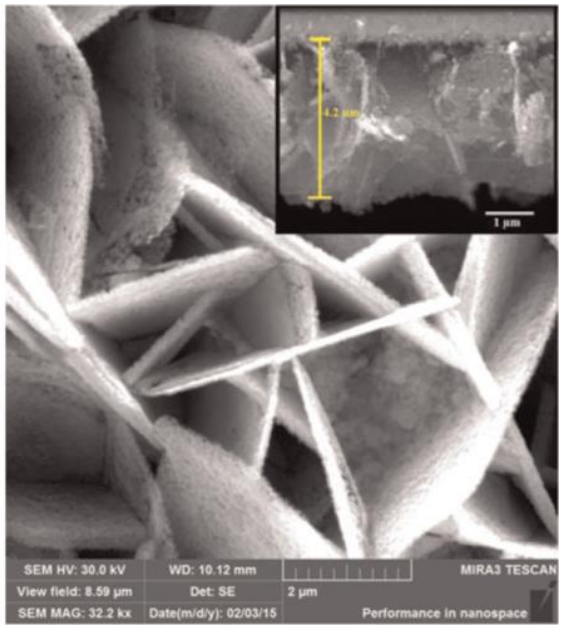
DSSC: ZnO nanostructures

- **Two different ZnO nanostructures synthesis**





- **Chemical and electrochemical deposition**
- **Structural and optical characterization: more defect states in sheet morphology**

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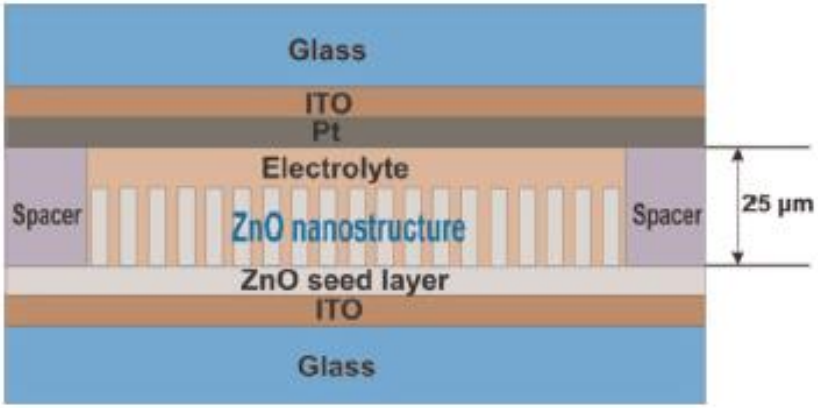
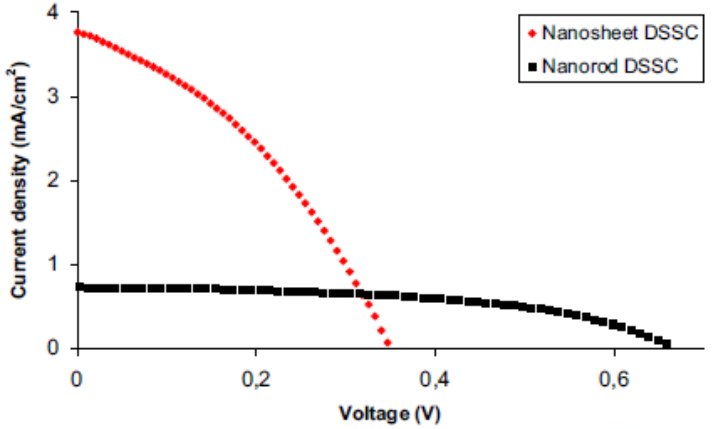
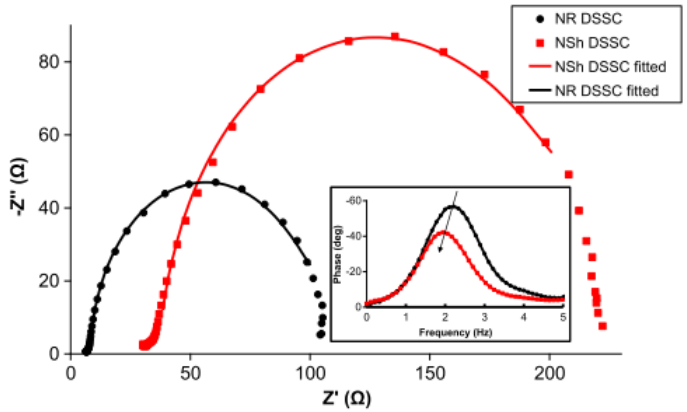
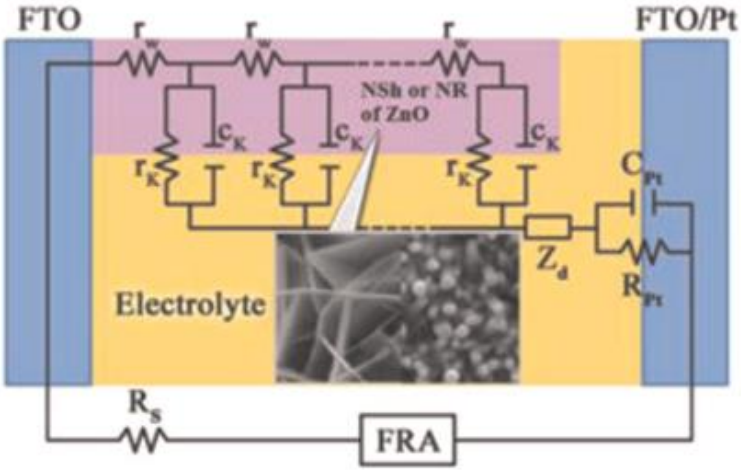
DSSC: ZnO nanostructures

- **DSSC fabrication and characterization**









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Thank you for attention!

- **Partners**

- **Contacts:**
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