FENCES: Ferroelectric nanocomposites for enhanced solar energy efficiency Update May 2022

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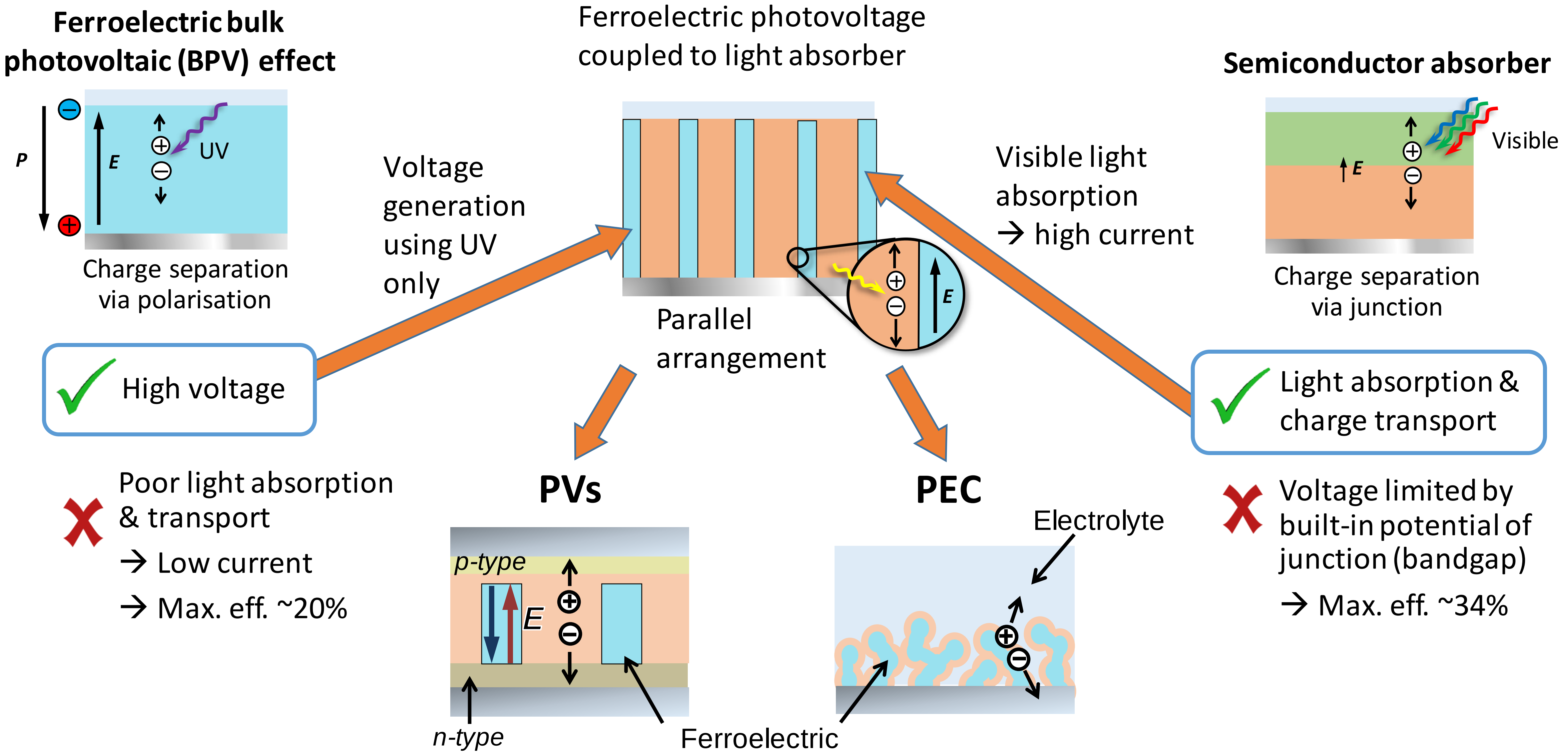
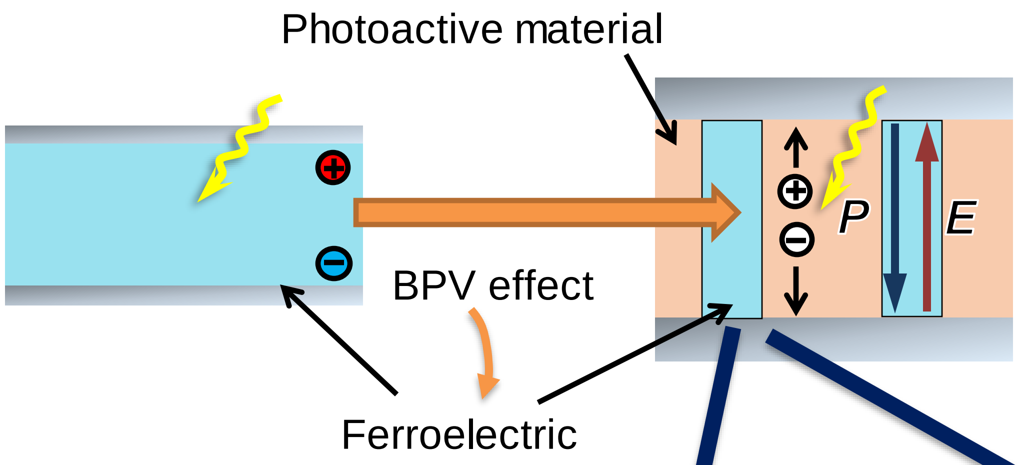
ERC FENCES

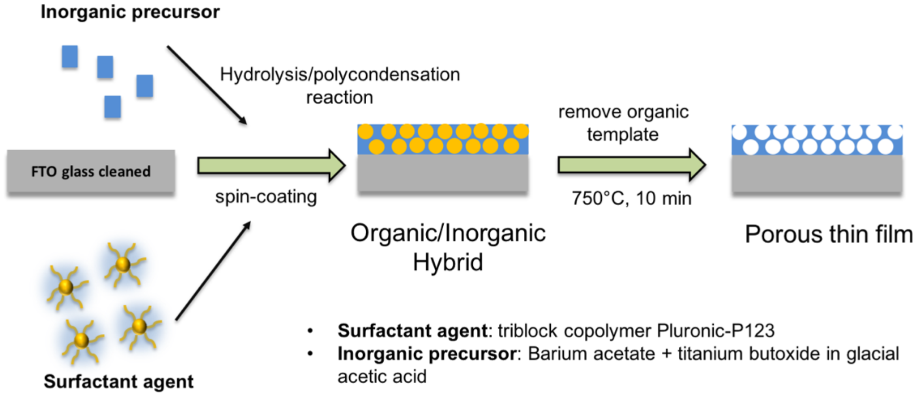


Ferroelectric bulk photovoltaic (BPV) effect
P
E
UV
Charge separation via polarisation
High voltage
Poor light absorption & transport
→ Low current
→ Max. eff. ~20%
Voltage generation using UV only
Ferroelectric photovoltage coupled to light absorber
E
Parallel arrangement
Visible light absorption
→ high current
Semiconductor absorber
Visible
E
Charge separation via junction
Light absorption & charge transport
Voltage limited by built-in potential of junction (bandgap)
→ Max. eff. ~34%
PVs
p-type
E
n-type
PEC
Electrolyte
Ferroelectric

FENCES: synthesis

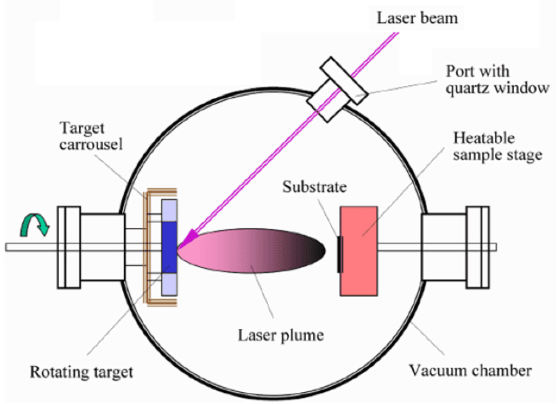


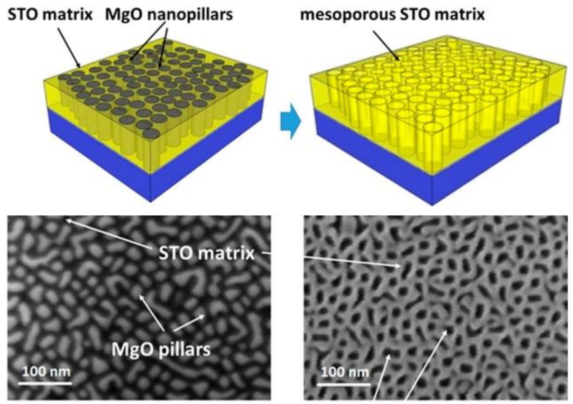
Solution-based



- **Surfactant agent**: triblock copolymer Pluronic-P123
- **Inorganic precursor**: Barium acetate + titanium butoxide in glacial acetic acid

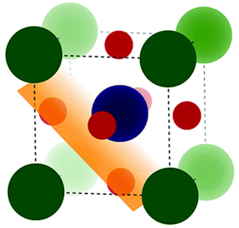
Pulsed Laser Deposition



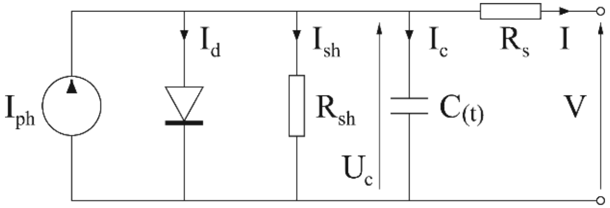


FENCES: modelling & measurement

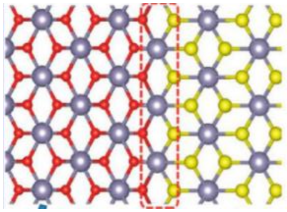
Modelling (collaboration with Dr Keith Butler)



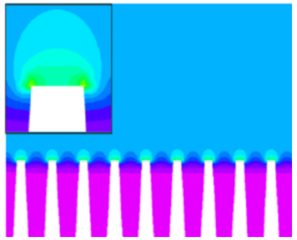
Computational screening



Equivalent circuits



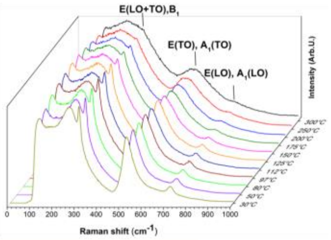
DFT: polarization & interfaces

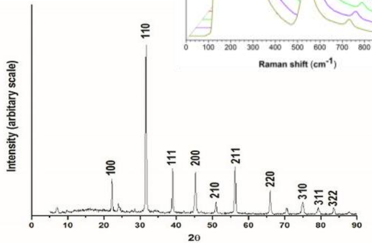


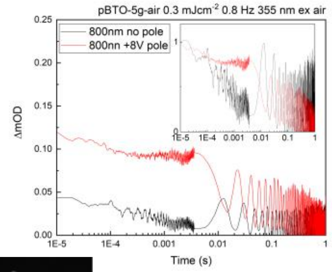
Finite Element

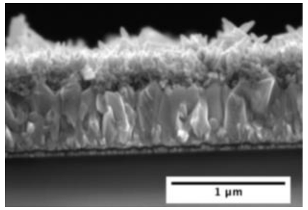
Characterisation

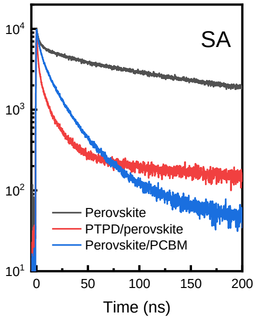
XRD, Raman, SEM, PL, tr-PL, TAS etc…



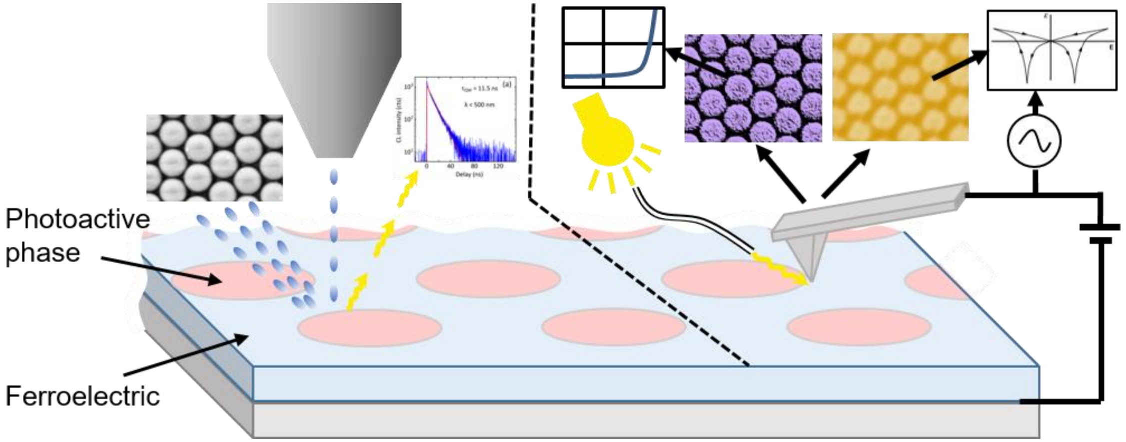






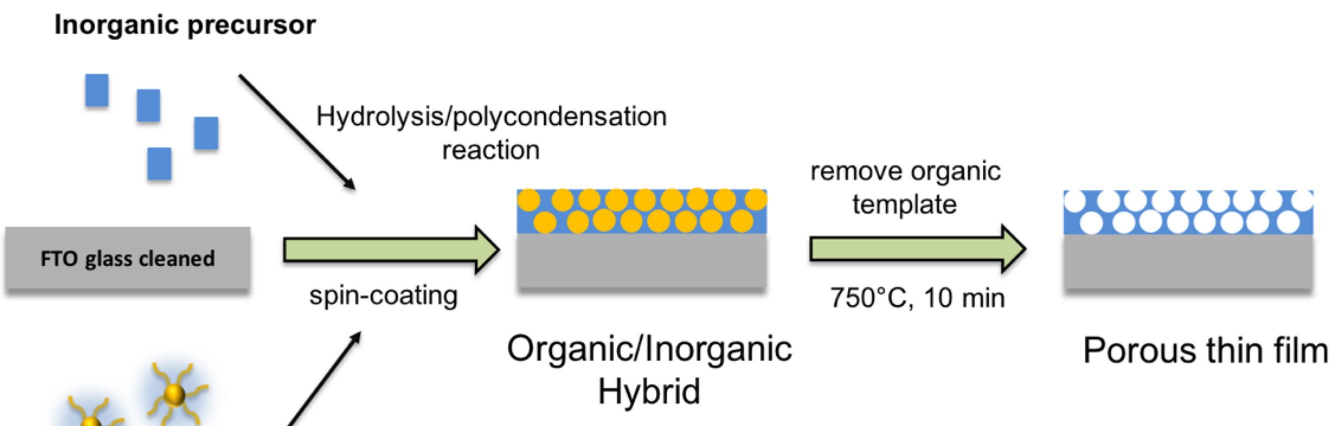


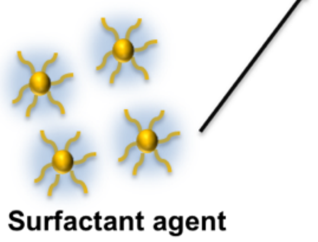
Coupled AFM, pc-AFM, PFM with tr-CL-SEM mapping



Nanostructured ferroelectric thin films

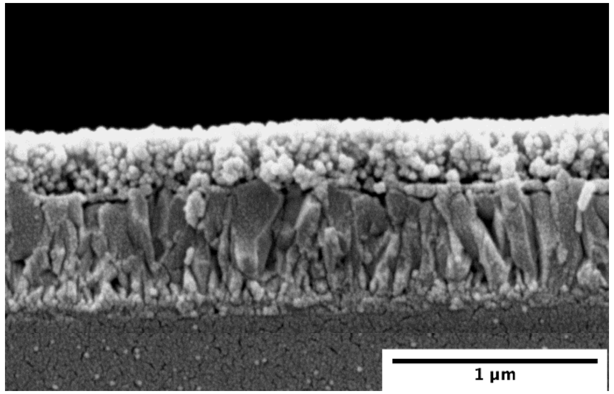
Adriana Augurio

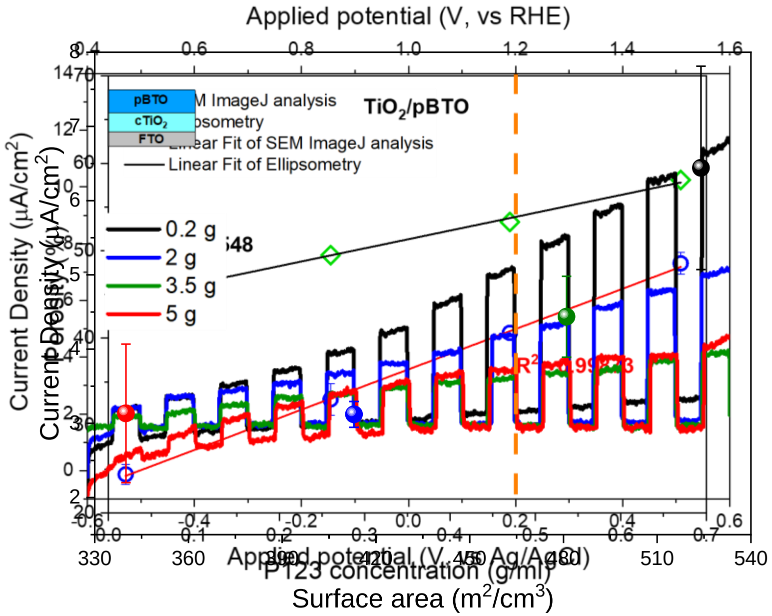


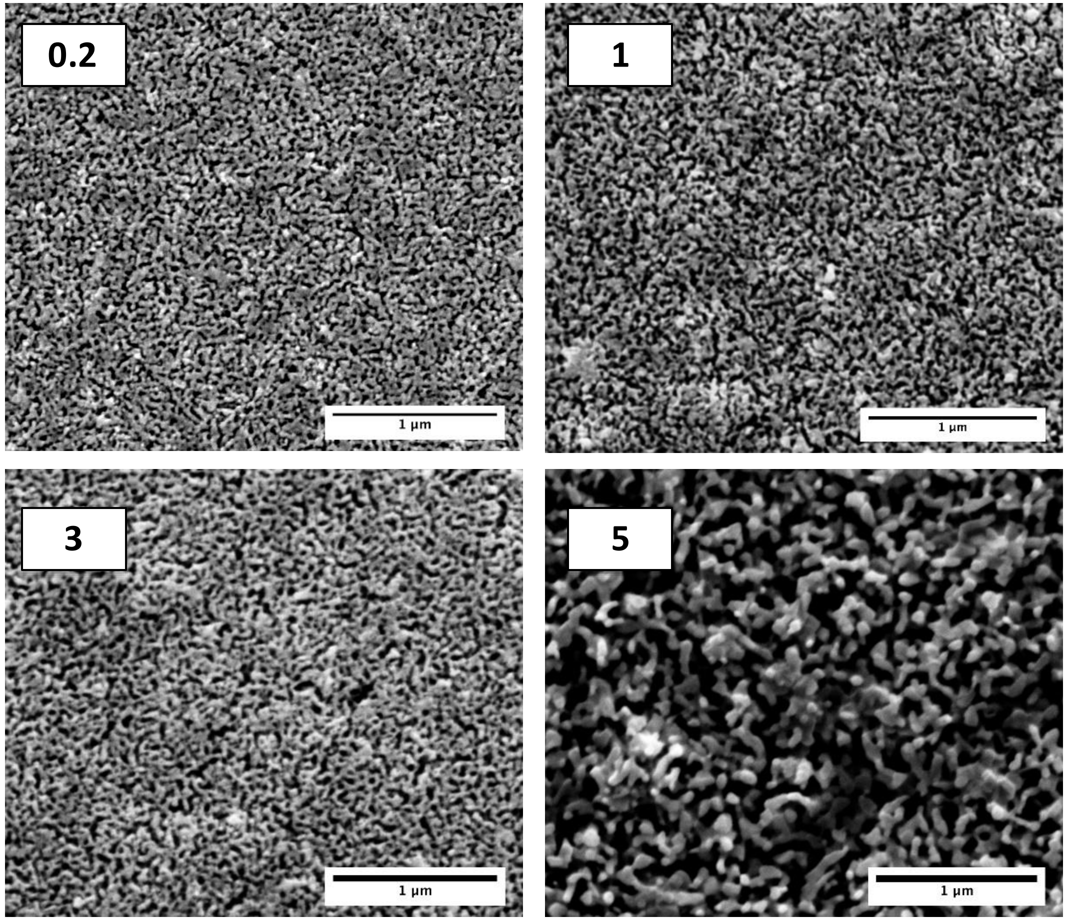


- **Surfactant agent**: triblock copolymer Pluronic-P123
- **Inorganic precursor**: Barium acetate + titanium butoxide in glacial acetic acid

→ Porous $BaTiO_3$





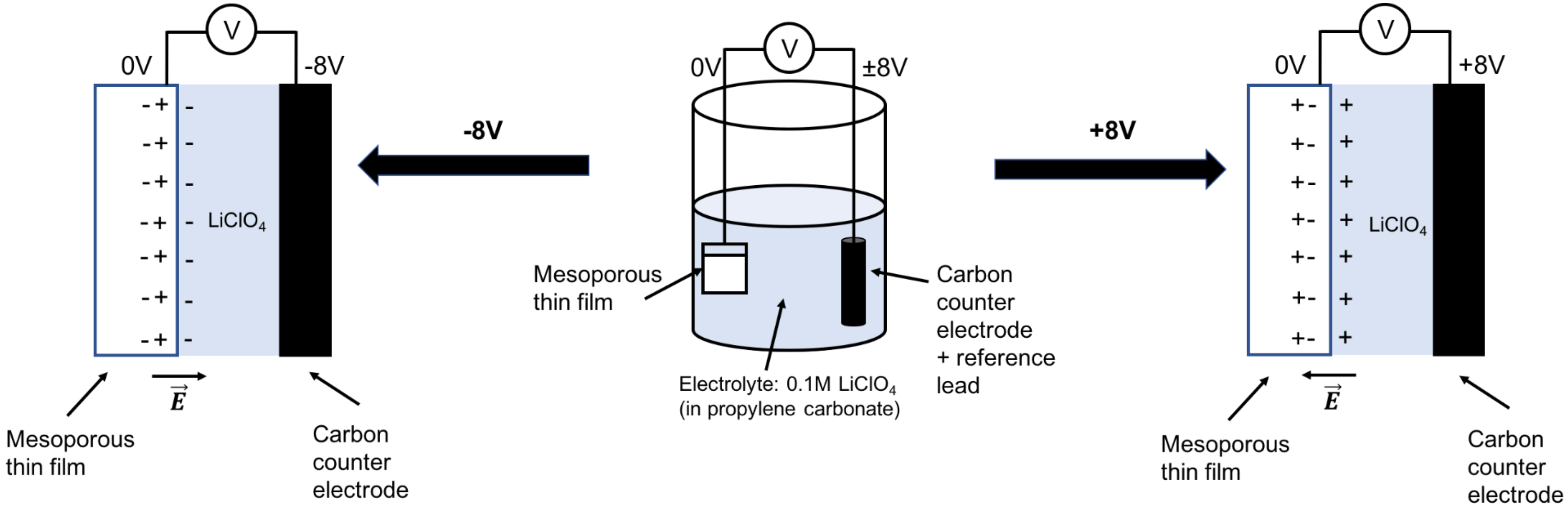


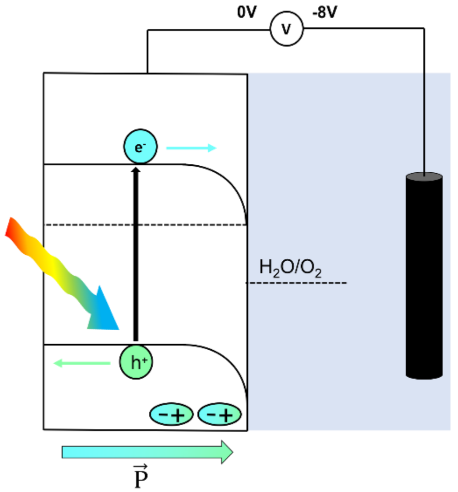
ACS AMI, accepted **(2022): 10.1021/acsami.1c17419**

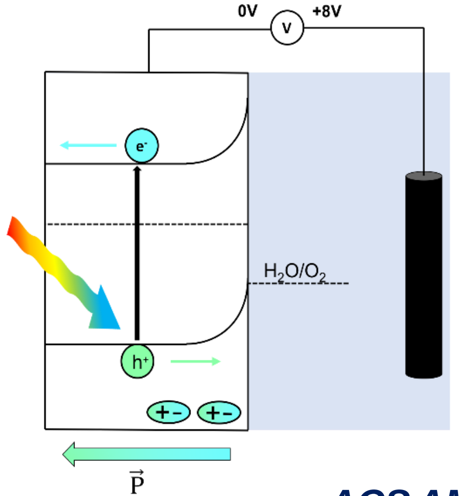
Nanostructured ferroelectric thin films

Adriana Augurio

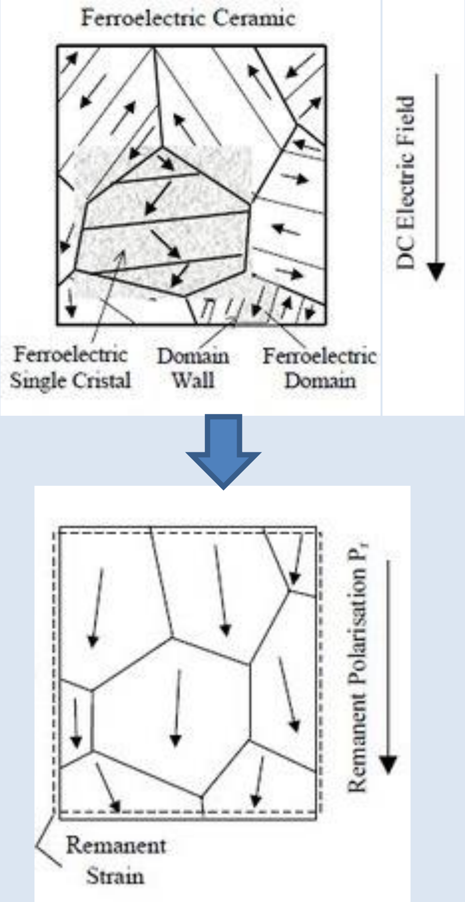
Electrochemical poling







(Poling)



10.13140/RG.2.2.31771.05921

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Nanostructured ferroelectric thin films

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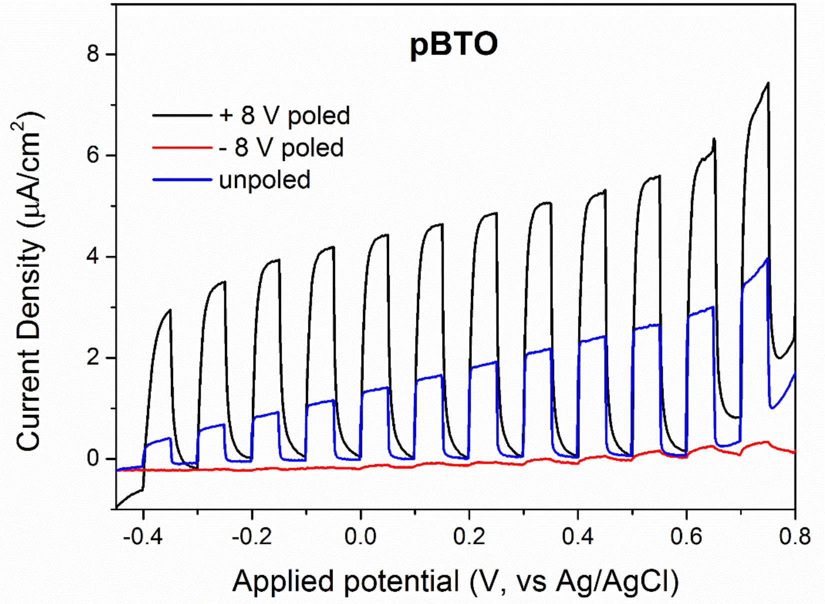
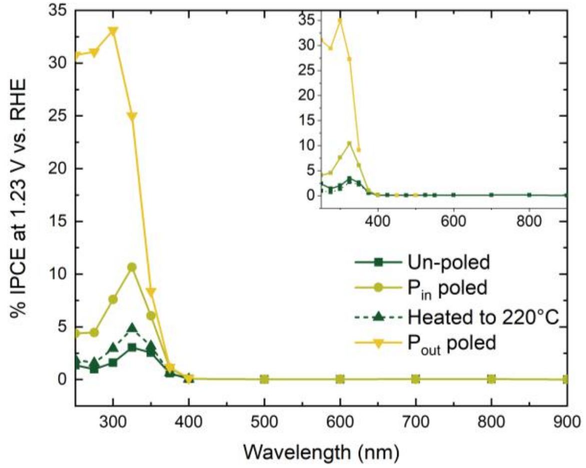
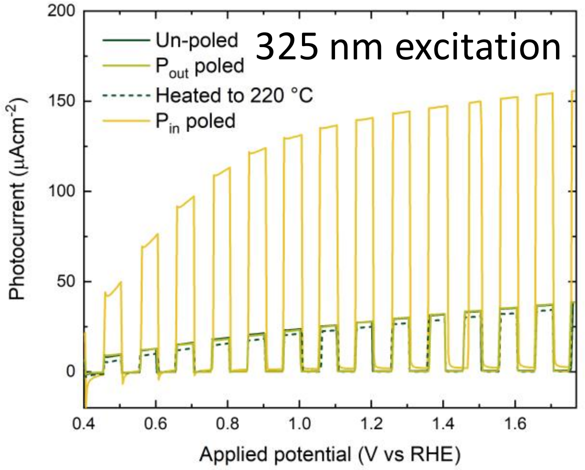
PEC water splitting

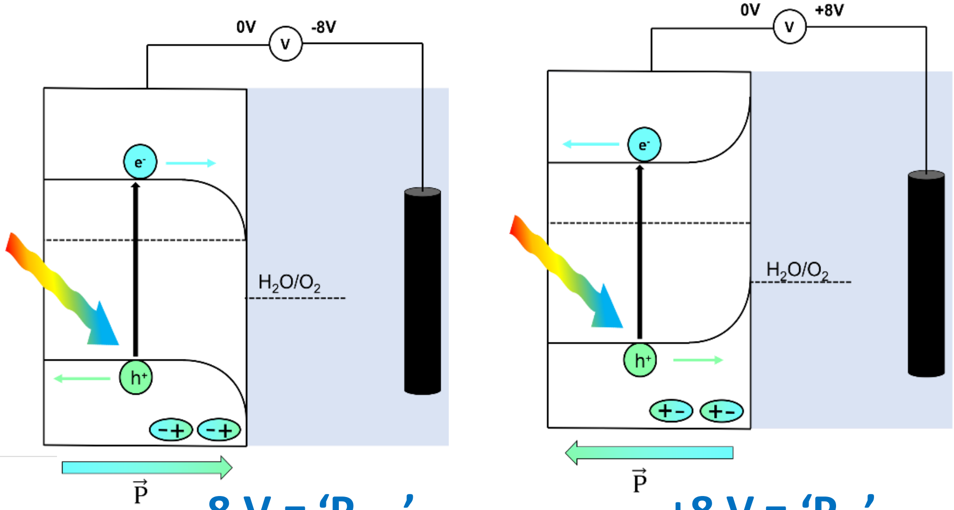


PEC results confirm positive poling increases photocurrent density as expected





IPCE indicates effect strongest at short wavelength (due to wide bandgap)



-8 V = ‘P_{out}’ **+8 V = ‘P_{in}’**

- 3-electrode half cell configuration
- AM 1.5 simulated solar light
- 1 M NaOH electrolyte
- $BaTiO_3$ forms photo**anode**
- Testing activity for water **oxidation**
- Requires electron injection (at positive bias)
- Upward band bending promotes oxidation

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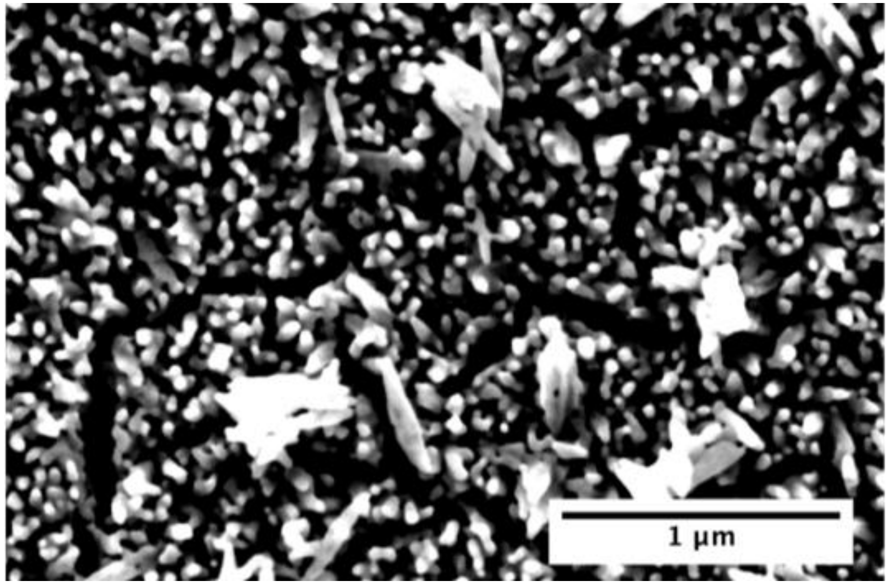
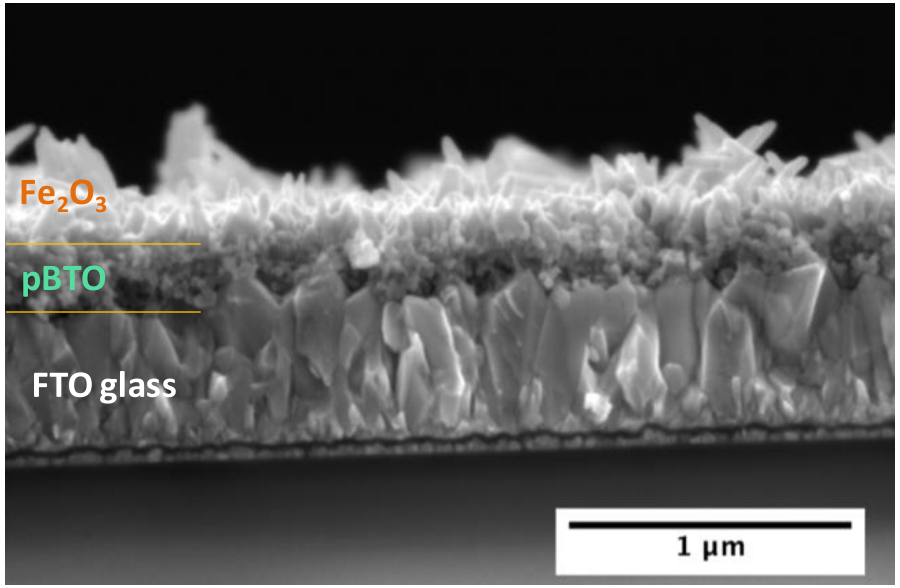
Nanocomposite photoelectrodes: BTO/Fe_2O_3

Qian Guo

Adriana Augurio


- Hydrothermal growth of Fe_2O_3 nanowires in $BaTiO_3$ pores
- 0.15 M $FeCl_3$ and 1 M $NaNO_3$
- 100°C for 1 h
- Annealed at 800°C (10°C/min) for 10 min





Fe_2O_3 nanorods grown within BTO pores

Nanocomposite photoelectrodes: BTO/Fe_2O_3

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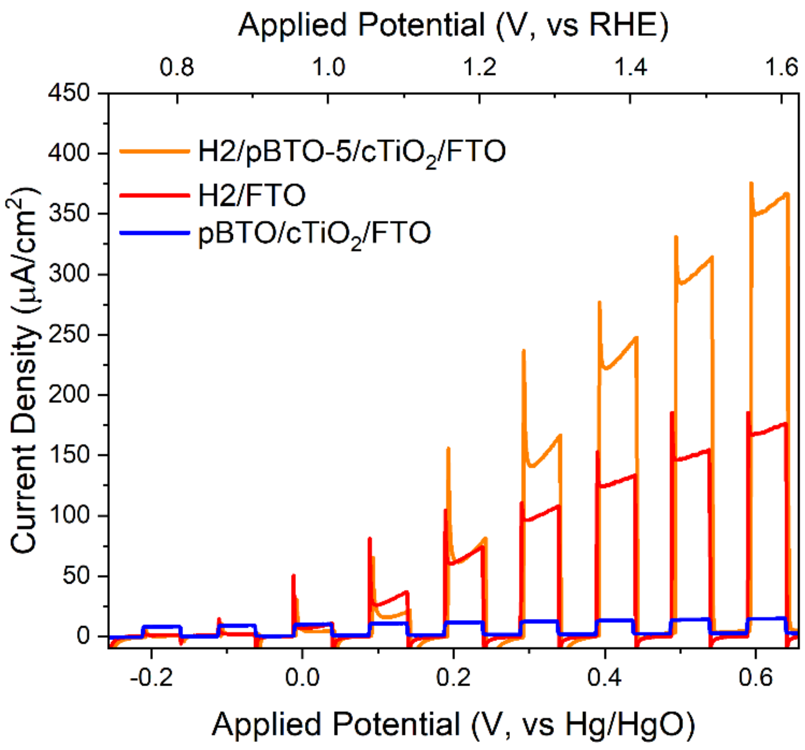
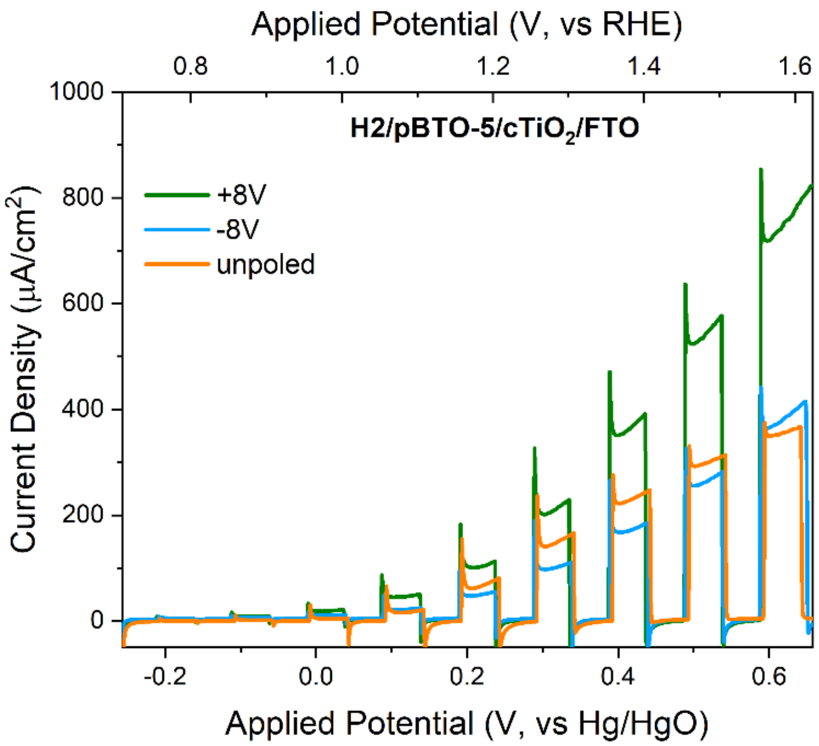
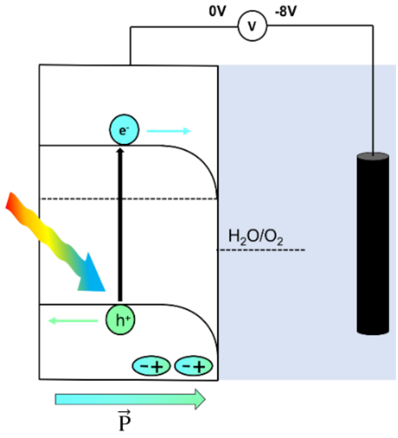
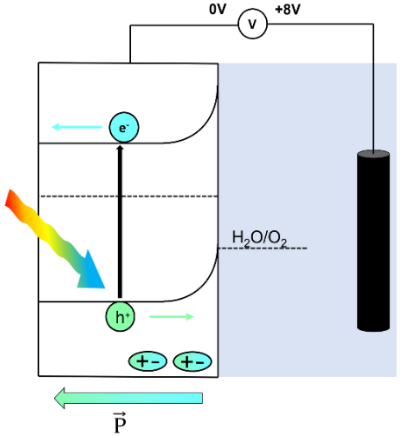


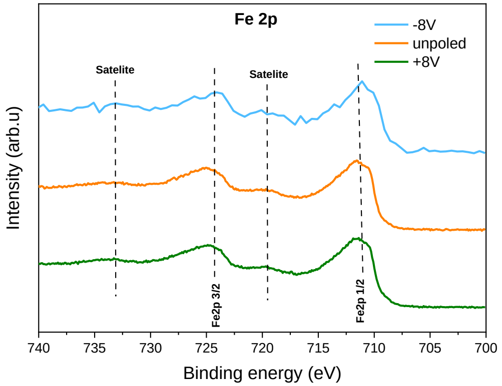


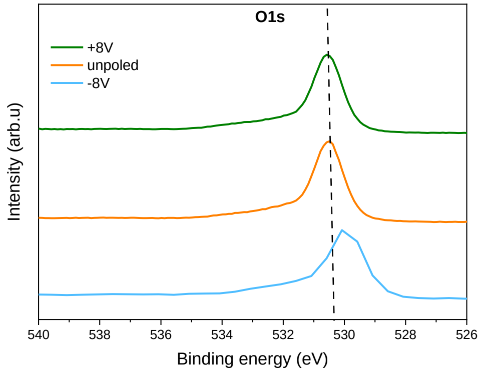


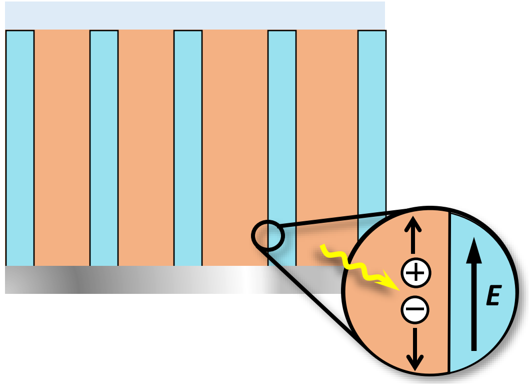
-8 V = ‘P_{up}’



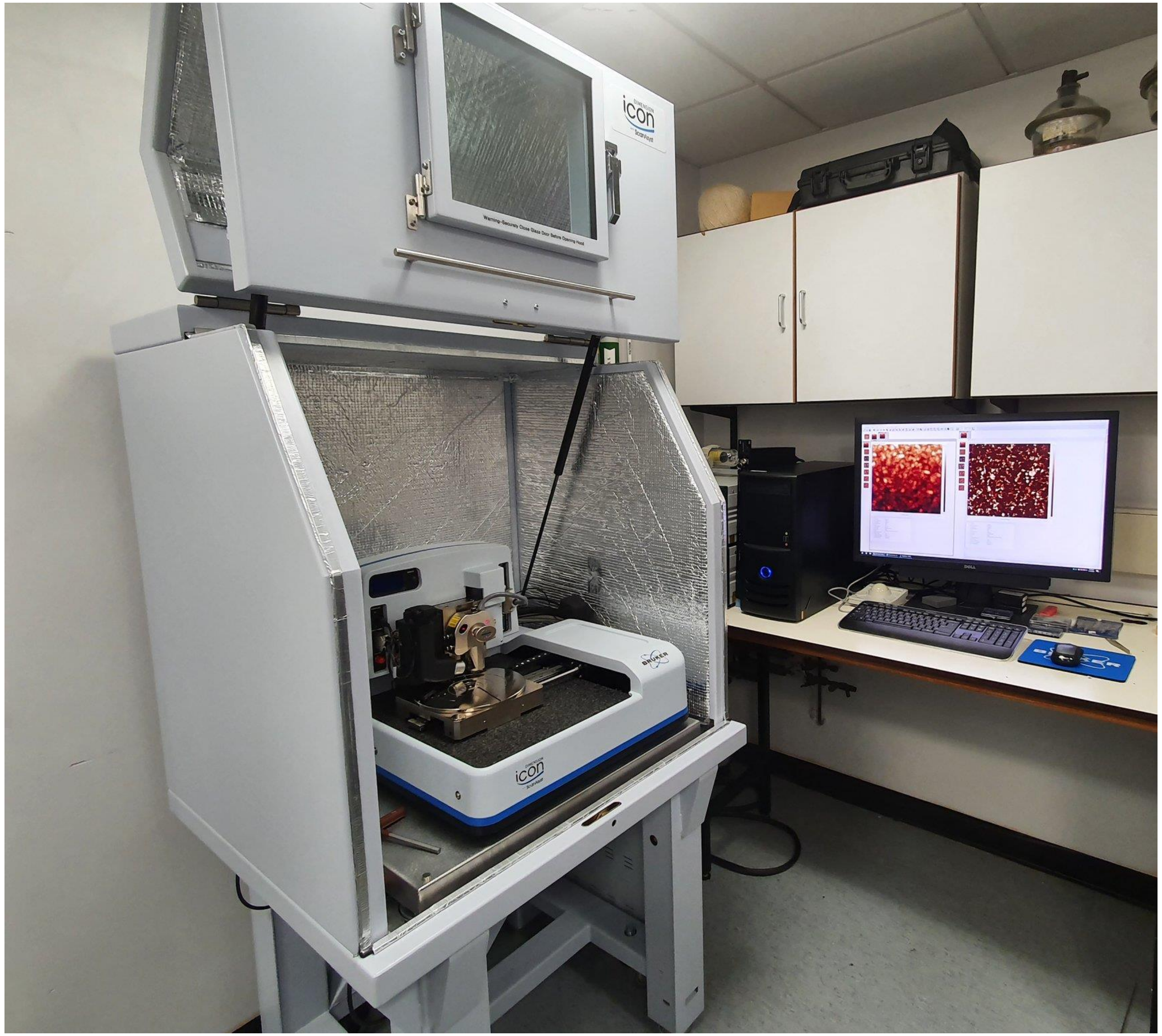
+8 V = ‘P_{down}’

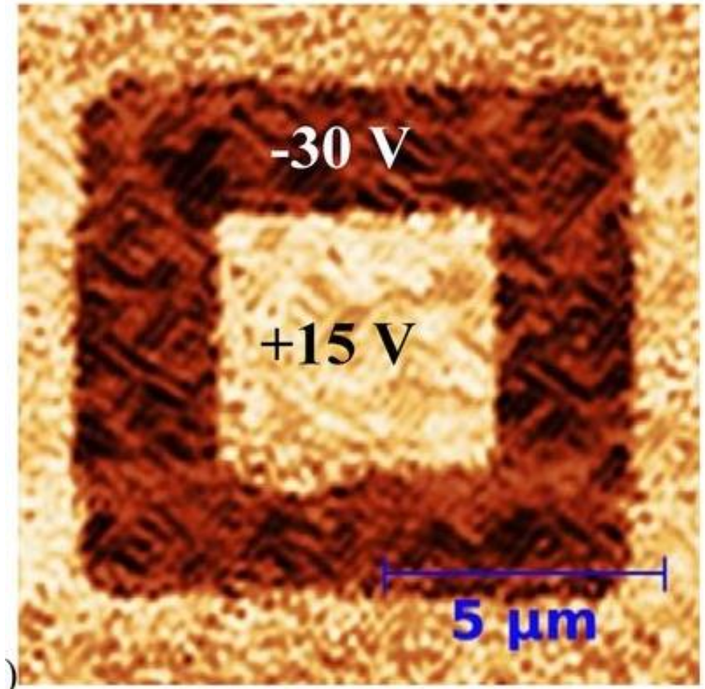






Atomic force microscope





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https://energyhouse2.salford.ac.uk/energy-house-labs/barratt-z-house/

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