Low-cost transparent solar cells: Potential of TiO_2 nanotubes in the improvement of these next generation solar cells

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Energy and Processes
Materials Science and Manufacturing

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Outline of Presentation

- Background to Photovoltaics
- Dye-sensitised Solar Cell R&D at CSIR
- TiO_2 Nanotube Synthesis
- Manufacturing of Dye-sensitised Solar Cells with TiO_2 Nanotubes
- Device Performance
- Future Work/The Way Forward

Background to Photovoltaics

- Photovoltaics (PV) - Direct conversion of sunlight into electrical energy through a solar cell
- Conversion results from the physical photo (or photovoltaic) effect, originally discovered by French physicist Edmund Becquerel in 1839
- Bequerel's findings first utilised in 1954 - first solar cell was developed from crystalline silicon in the USA
- Initially used only for satellite application as a clean source of energy
- First oil crisis in 1973: Realisation that earths' fossil resources are finite and cause for concern
- Increased research into PV techonologies

Satellite with PV power supply

Source: ESA

Car park installation (Courtesy: SEI, Italy)

Background to Photovoltaics

Two Major Types of Solar Cells

Solid State Solar Cells

Versus

Dye-sensitised Solar Cells

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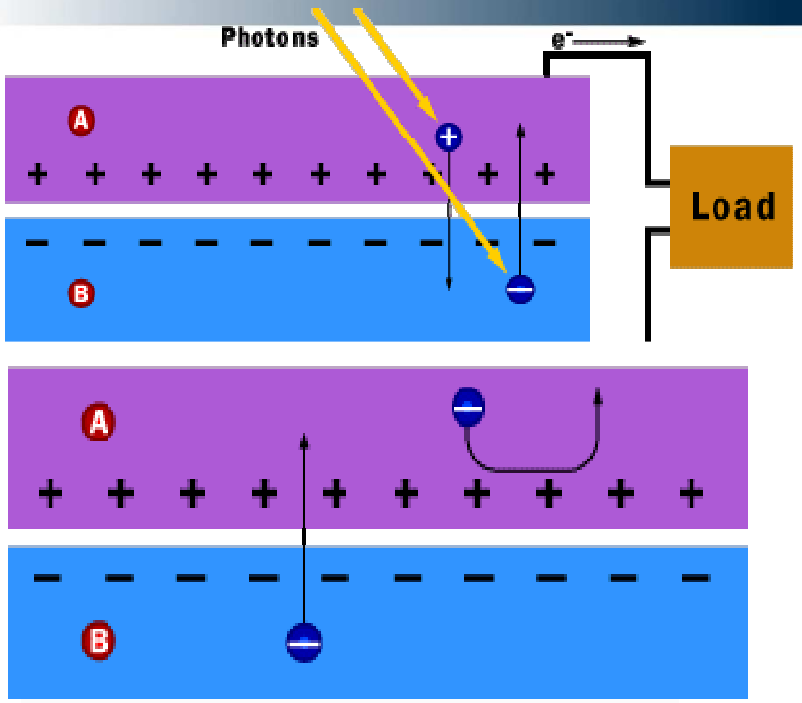
Background to Photovoltaics

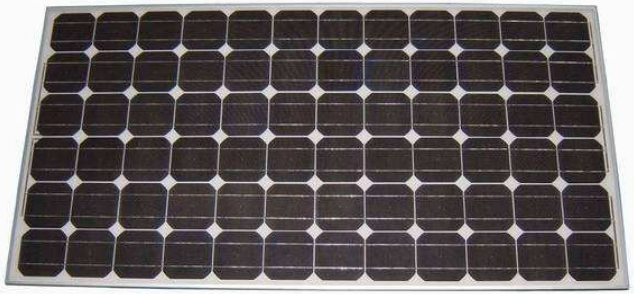
Basic Operation of a Traditional Solar Cell

Step 1: Photons (packets of sunlight) hit cell → are absorbed by semiconducting materials, e.g. silicon

Step 2: Electrons (negatively charged) knocked loose from their atoms → allowing them to flow through the material to produce electricity

Step 3: Complementary positive charges created (called “holes”) flow in the direction opposite of the electrons

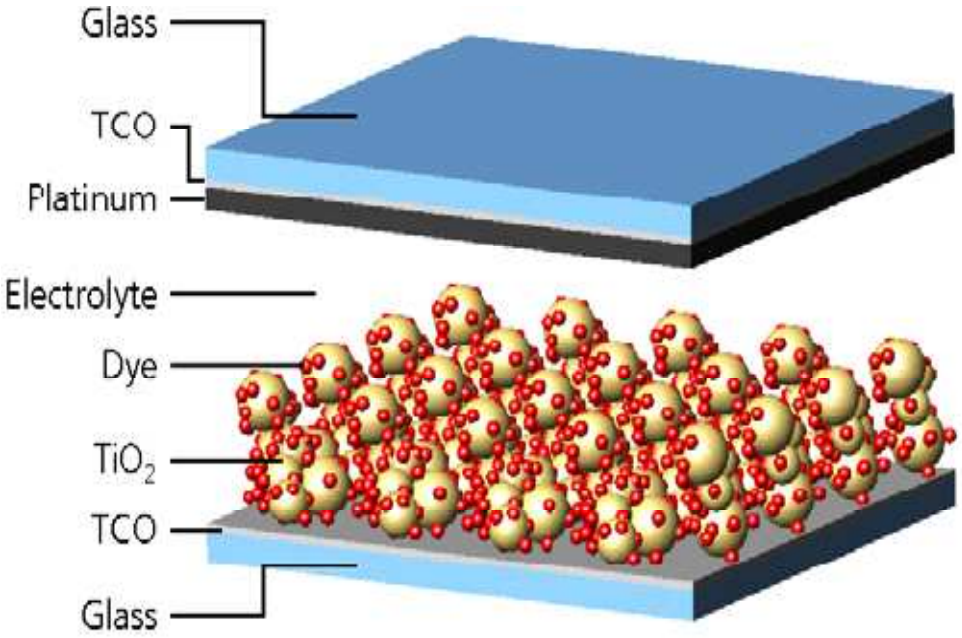


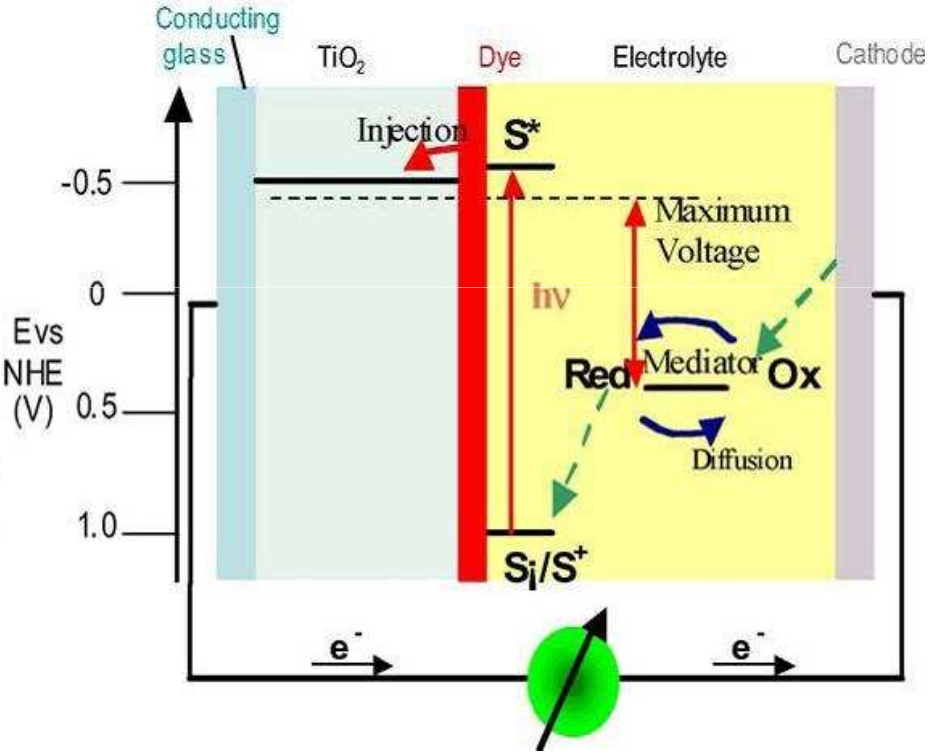


NB: Array (panel) of solar cells converts solar energy into a usable amount of direct current (DC) electricity

Background to Photovoltaics

Basic Operation of a Dye-sensitised Solar Cell





Background to Photovoltaics

Dye-sensitised Solar Cells

- **Relatively inexpensive**
  - Made in non-vacuum setting
  - Simple manufacturing process with inexpensive materials
- **Short return on investment**
  - Takes approx 3 months to produce energy savings equivalent to cost of production
  - Lightweight, semi-transparent and robust
- **Performance less affected by environmental conditions, e.g. light intensity**
  - Been shown that DSCs outperform traditional Si solar cells by 20% over 6 month period

Traditional Solar Cells

- **Expensive**
  - High vacuum and heat systems required to manufacture device quality materials
- **Long return on investment**
  - Takes approx 4 years to produce energy savings equivalent to cost of production
  - Heavy, big and rigid
- **Performs poor in low sunlight**
  - Known that solid state cells perform poor in days of low sunlight, through the night

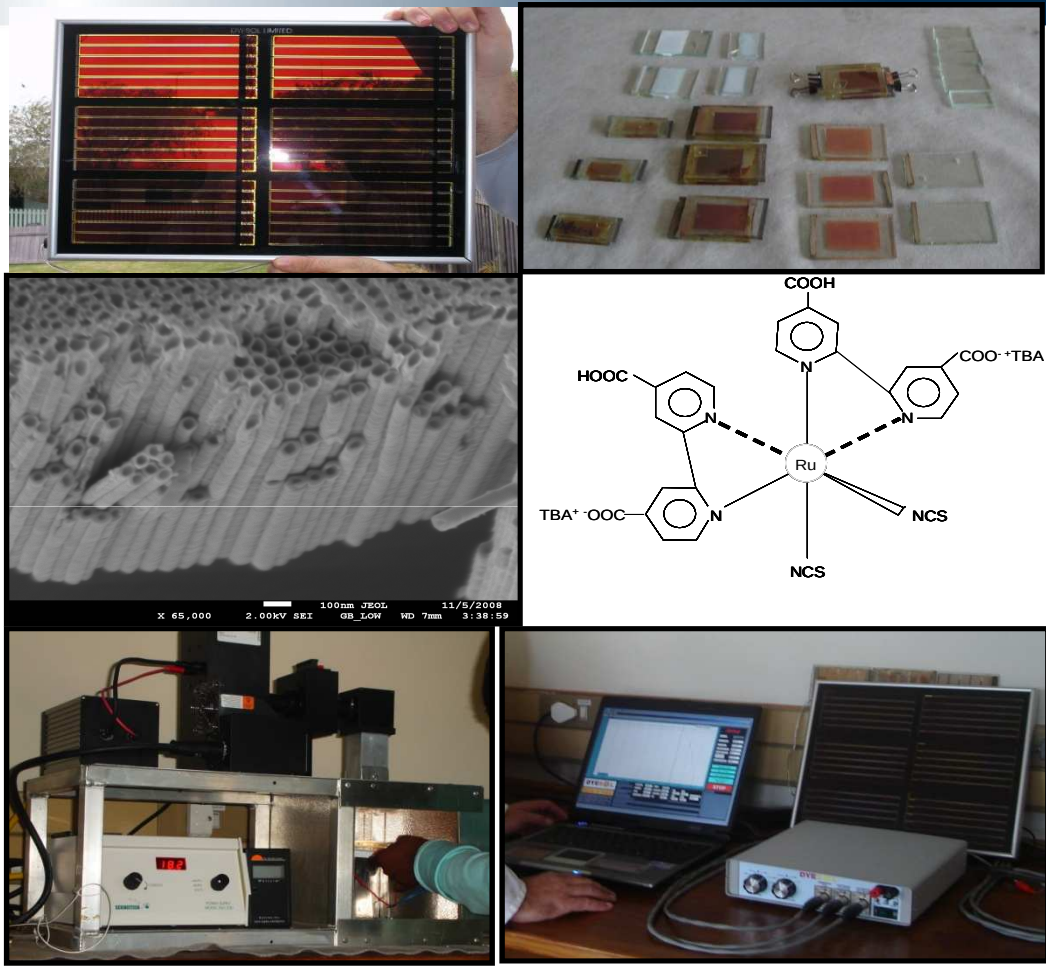
Dye-sensitised Solar Cell R&D at CSIR

Major Research Focus Areas

Studies on the improvement in cell efficiency – synthesis and application of TiO_2 NTs, novel dyes, core-shell materials

Studies on the effects of reverse bias potentials on the performance of DSCs

Outdoor testing of DSC cells vs. a-Si and c-Si cells



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TiO_2 Nanotube Synthesis

Why TiO_2 Nanotubes?

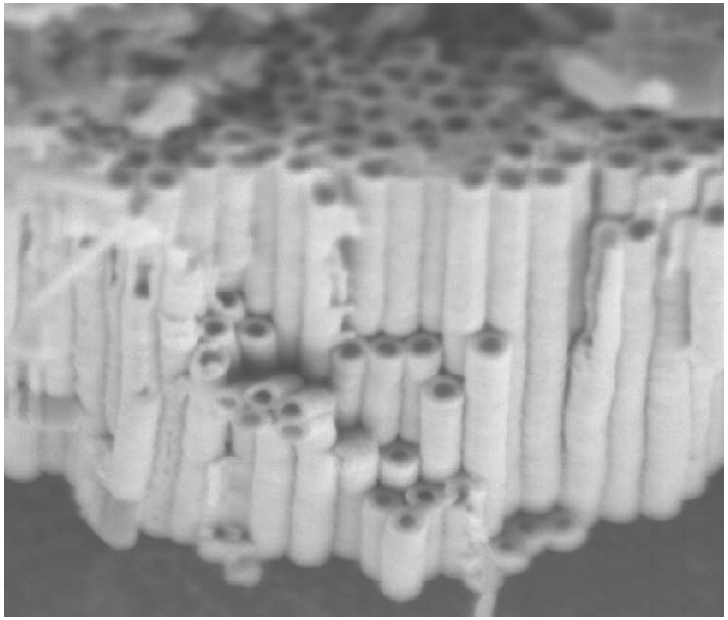
Provides a one-dimensional transport route for electrons in the cell

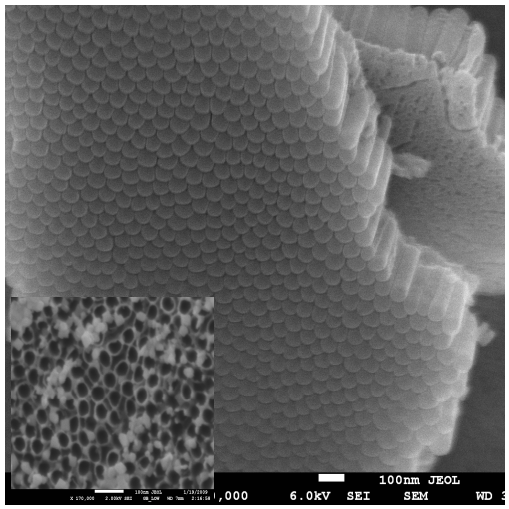
Reduces electron-hole recombination

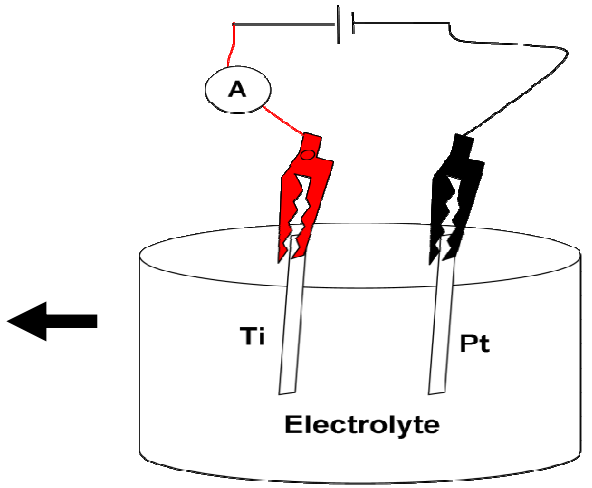
Synthesis of films of TiO_2 nanotubes

Simple anodisation technique

Parameters investigated – voltage, electrolyte composition, time







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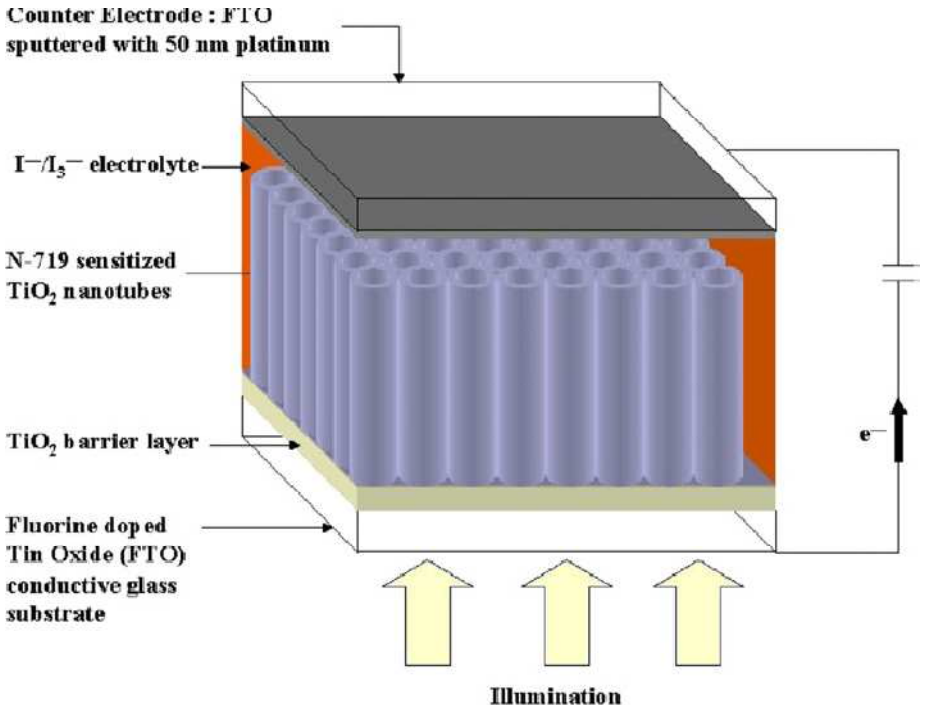
Manufacturing of Dye-sensitised Solar Cells with TiO_2 Nanotubes



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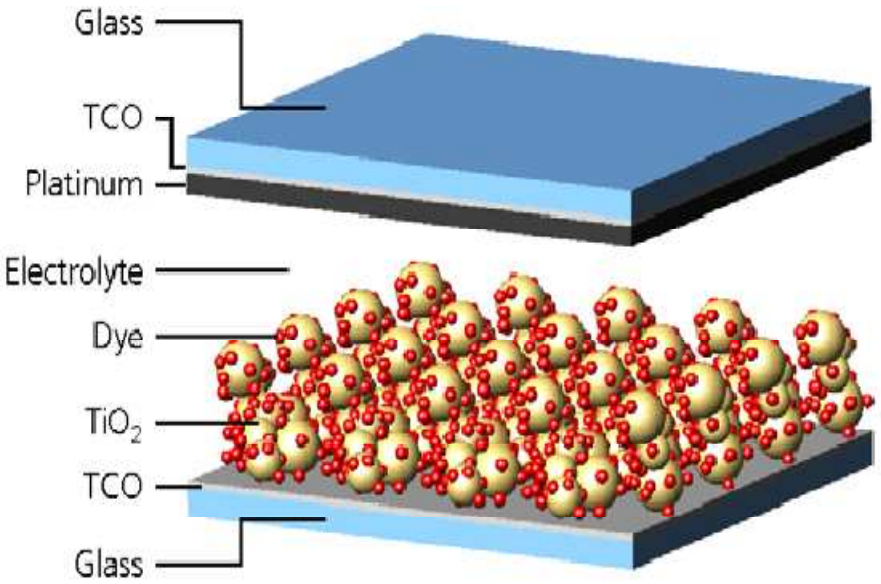
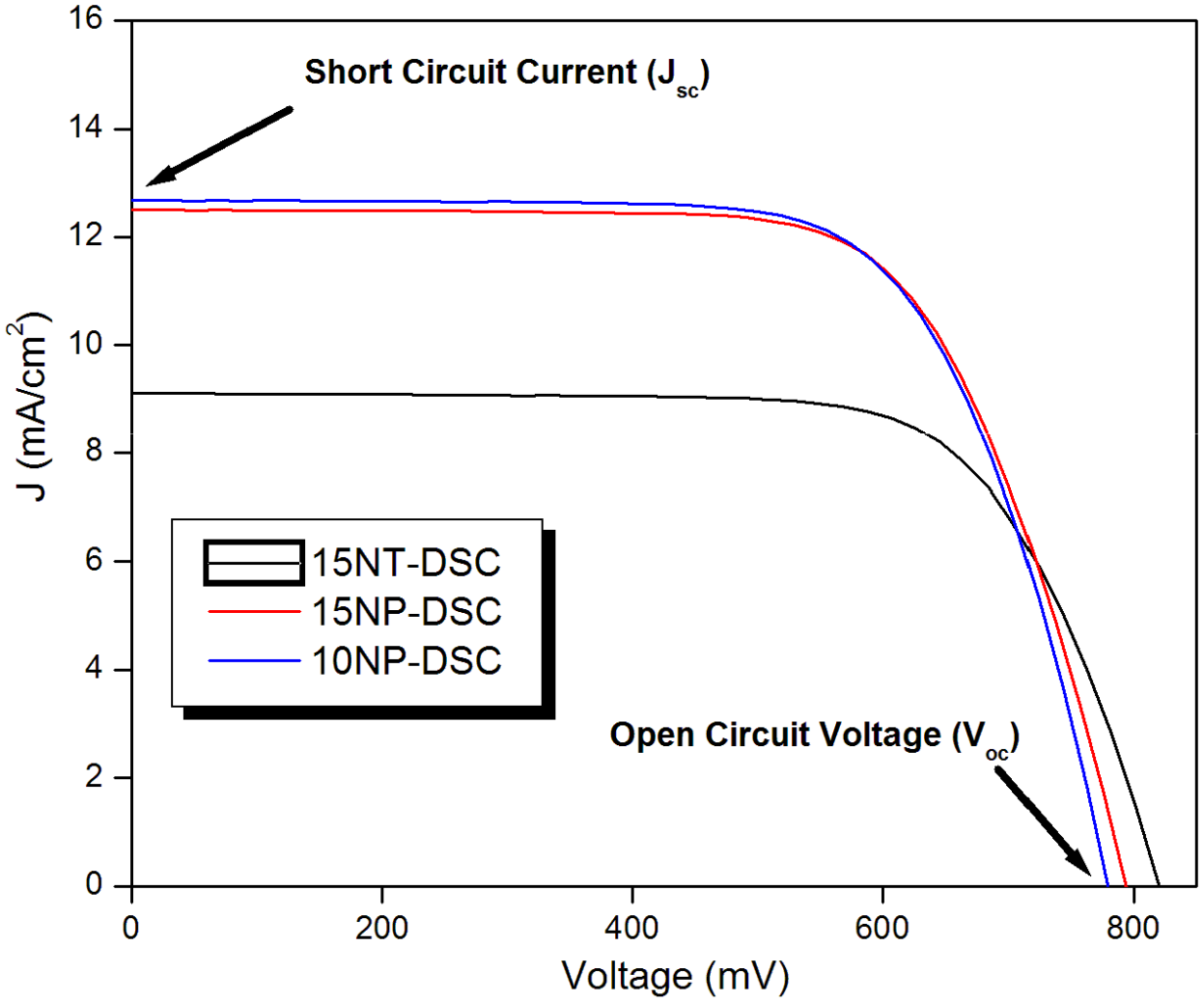


Device Performance



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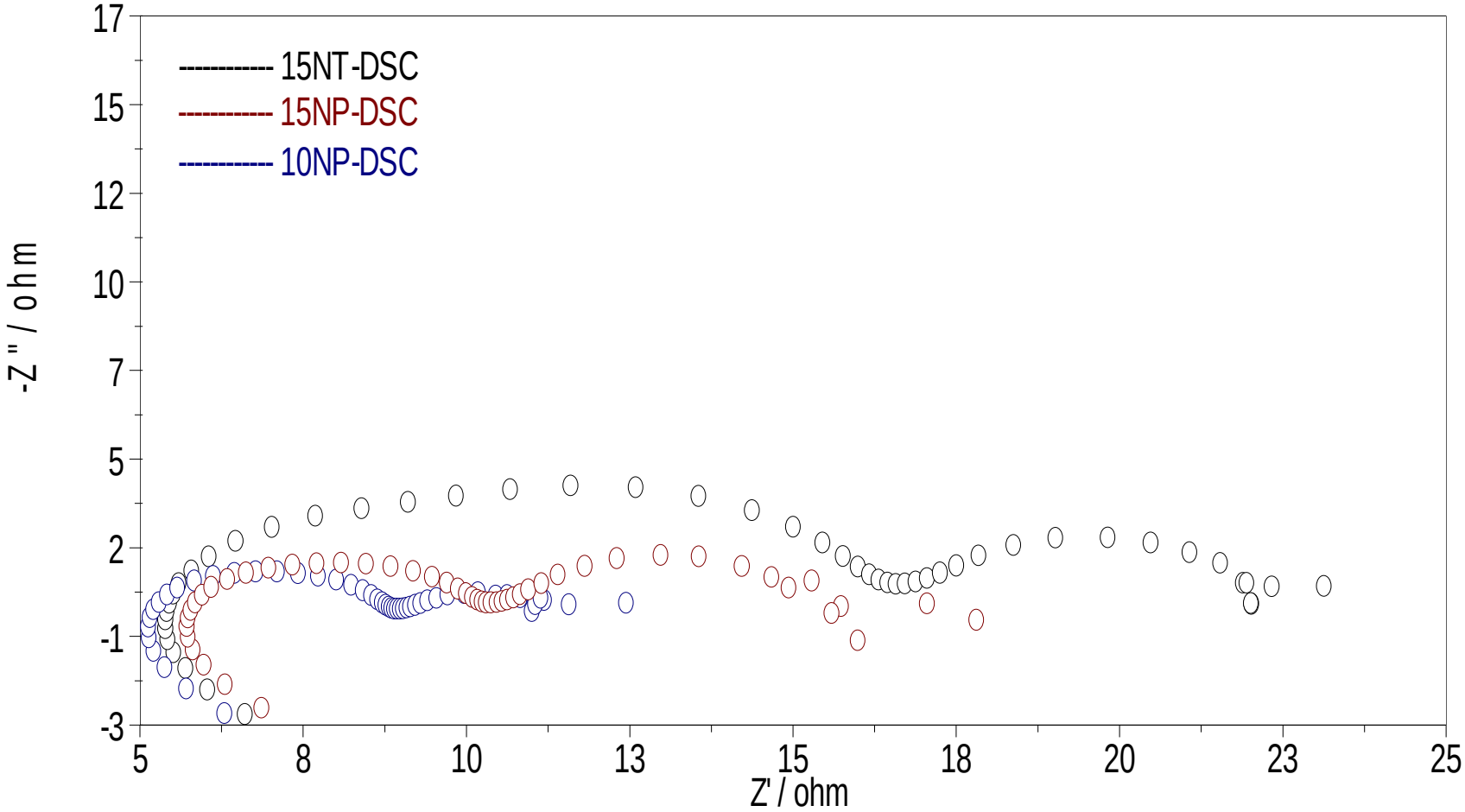

Future Work/Way Forward

Further synthesis and improvement in TiO_2 morphology

Further device characterisation

Thank You