Centre for Energy Research

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Nelson Mandela Metropolitan University

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Effect of spectral changes on device and performance parameters of a mc-Si solar cell under spot illumination

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Outline

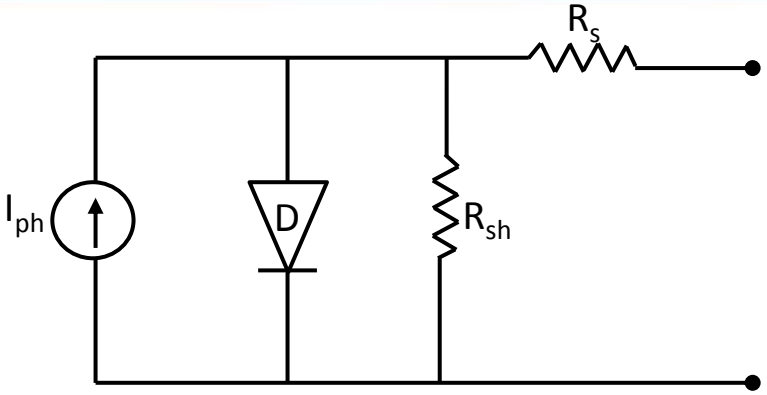
- Introduction
  - LBIC mapping technique
- Experimental set up
- Results
  - Photo-response mapping
  - Parameter extraction
- Conclusion
- Acknowledgement

Introduction

- mc-Si contribute more than 50% of total Si for PV applications
- Produced mainly from low grade feedstock
  - ✓ High concentration of impurities and active defects
- Steady state I-V characteristics of p-n junction Si solar cell often described using equivalent circuit models
  - ✓ Single or double diode models

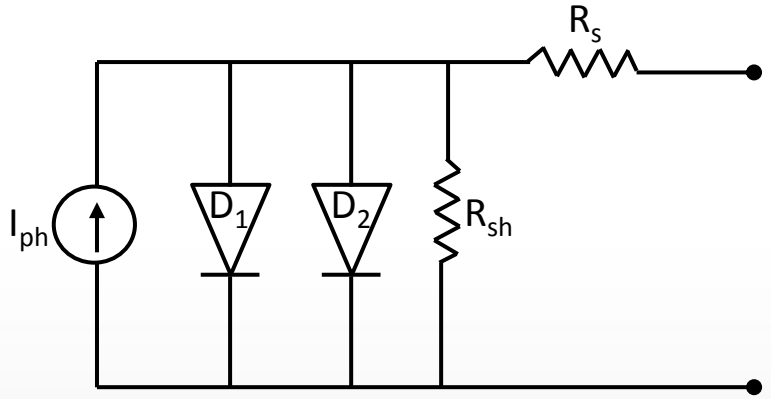
Introduction- Cell models

Single diode model



$$I = I_{ph} - I_0 \left\{ \exp\left[q\left(\frac{V + IR_s}{nkT} \right) \right] - 1 \right\} - \frac{V + IR_s}{R_{sh}}$$

Double diode model



$$I = I_{ph} - I_{01} \left\{ \exp\left[q\left(\frac{V + IR_s}{n_1 kT} \right) \right] - 1 \right\} - I_{02} \left\{ \exp\left[q\left(\frac{V + IR_s}{n_2 kT} \right) \right] - 1 \right\} - \frac{V + IR_s}{R_{sh}}$$

Introduction- cont'd

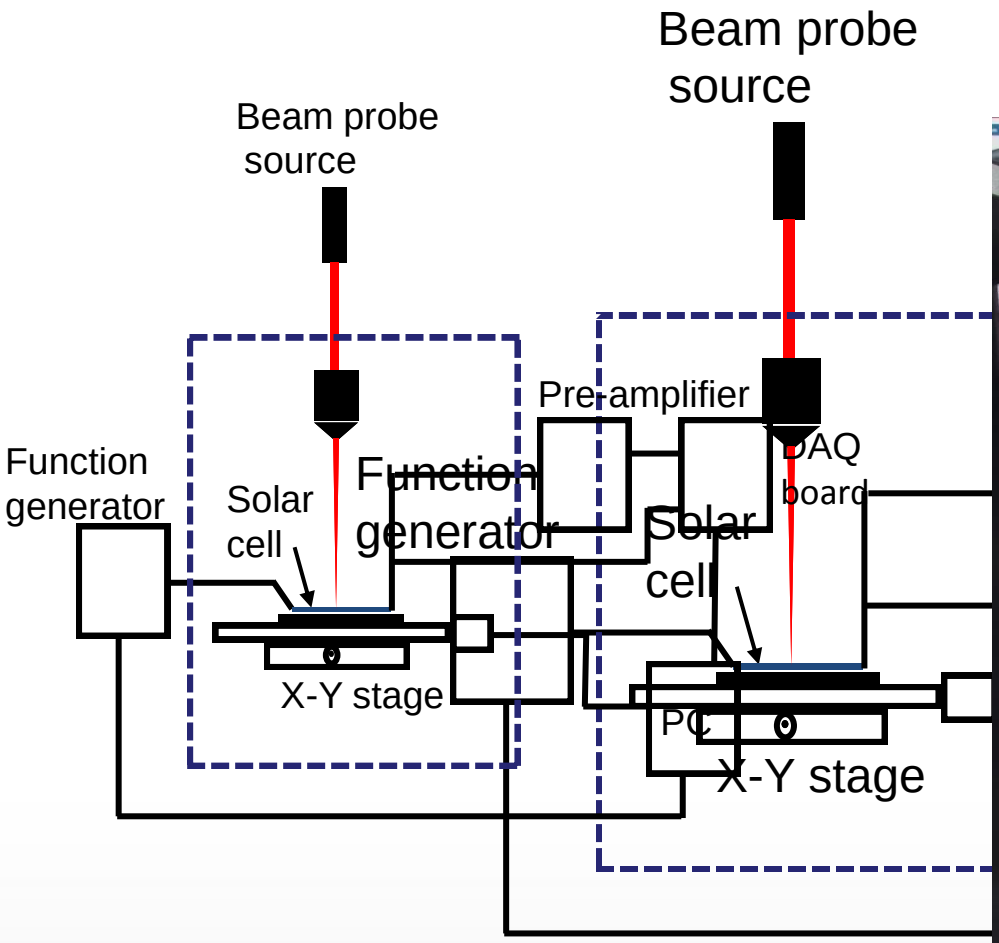
- Device parameters control I-V characteristics
  - ✓ Determine performance of solar cell device
- PV characterisation involves extraction of I-V parameters
  - ✓ Device and performance parameters extracted at specific conditions
  - ✓ Under outdoor conditions, solar cells exposed to varying conditions
- Why PV characterisation?
  - ✓ Evaluation of performance
  - ✓ Quality control of devices

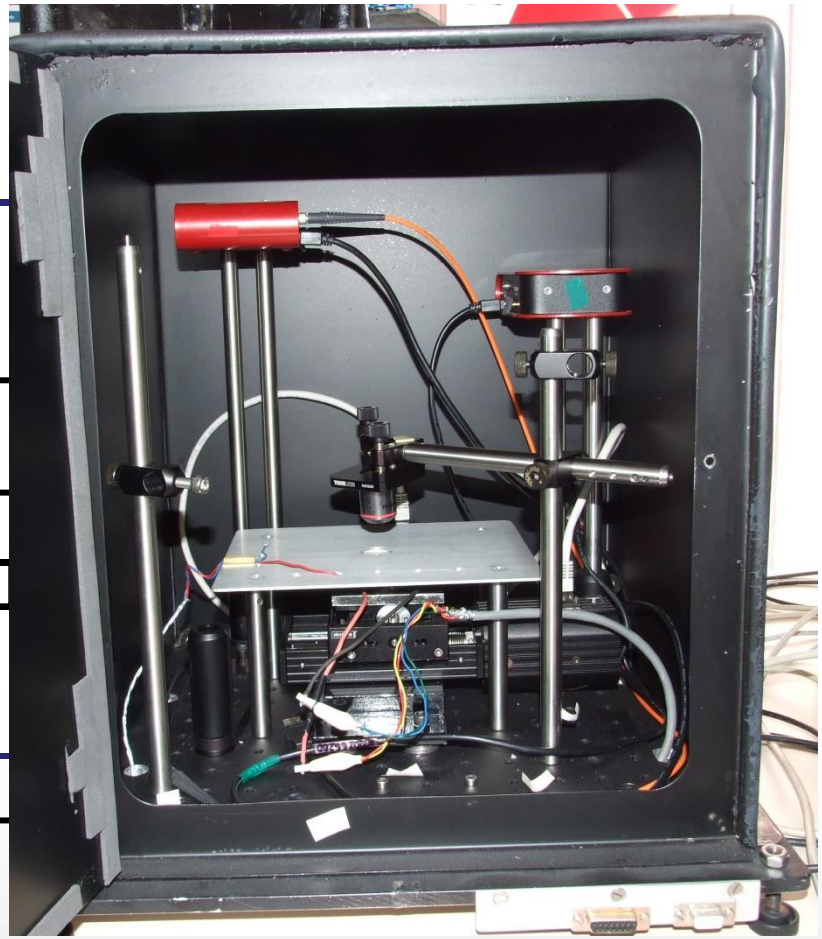
Introduction: LBIC

- Light beam Induced Current (LBIC)- a non destructive mapping technique
  - ✓ Beam scanned across cell surface in a raster pattern to generate localised current

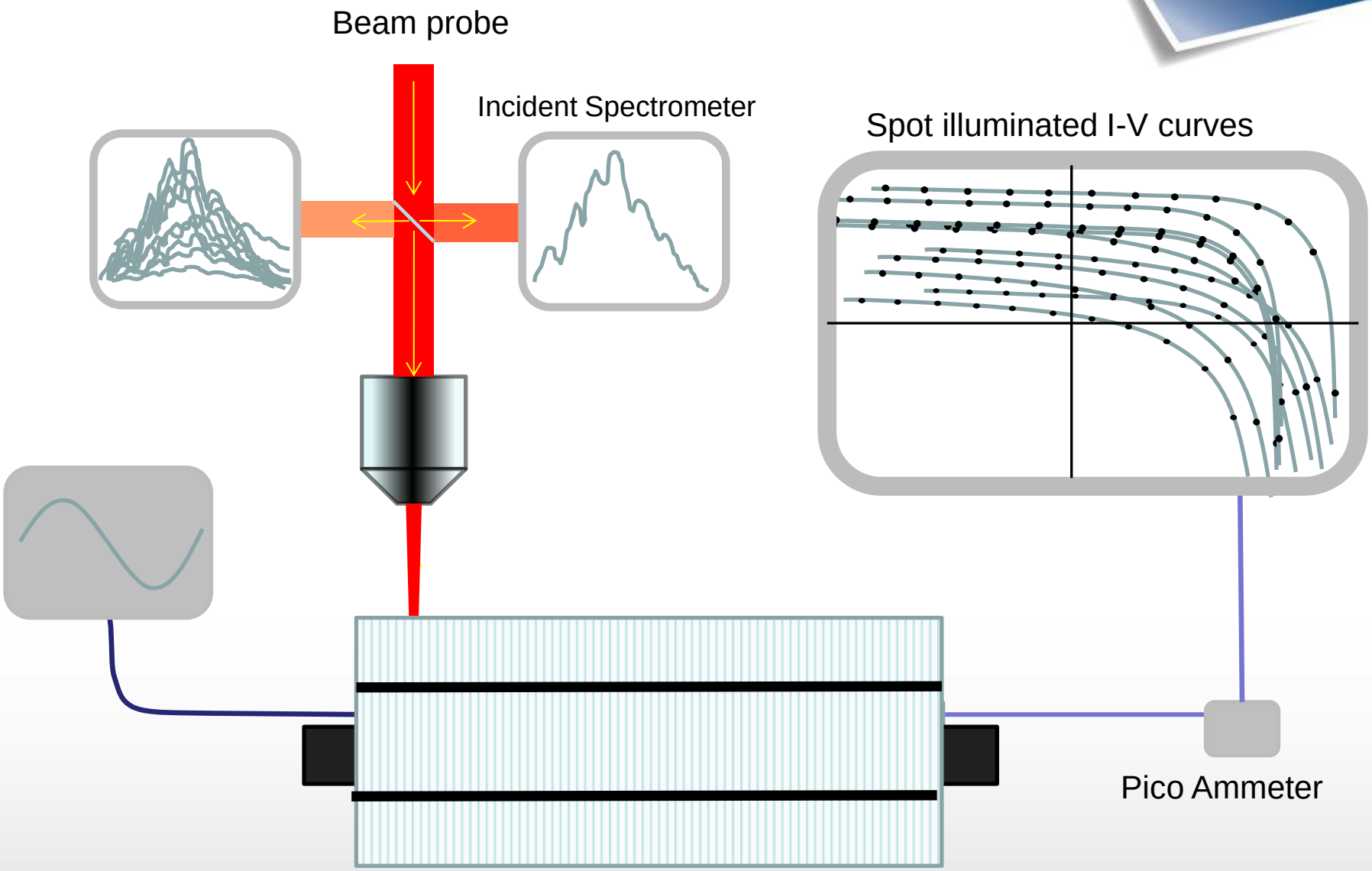
- Photo-response mapping
  - ✓ Carrier generation uniformity
  - ✓ Presence and strength of current reducing features
- Carrier generation depth
  - ✓ Defect detection within device cross-section
- Point by point I-V curves
  - ✓ Parameter maps

Experimental set up

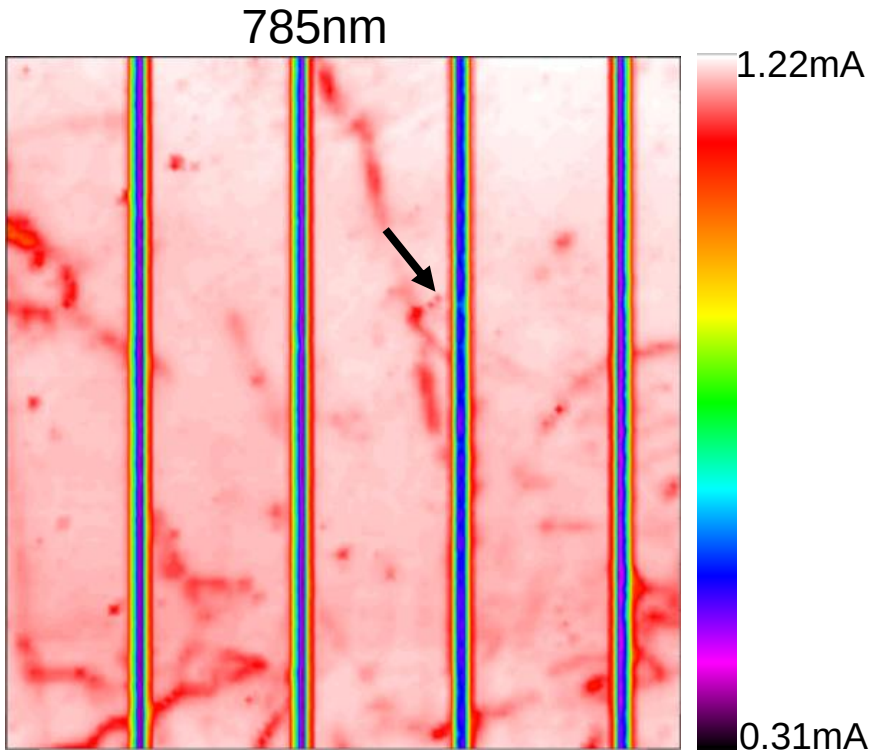




Data structure



Results: Photo-response mapping



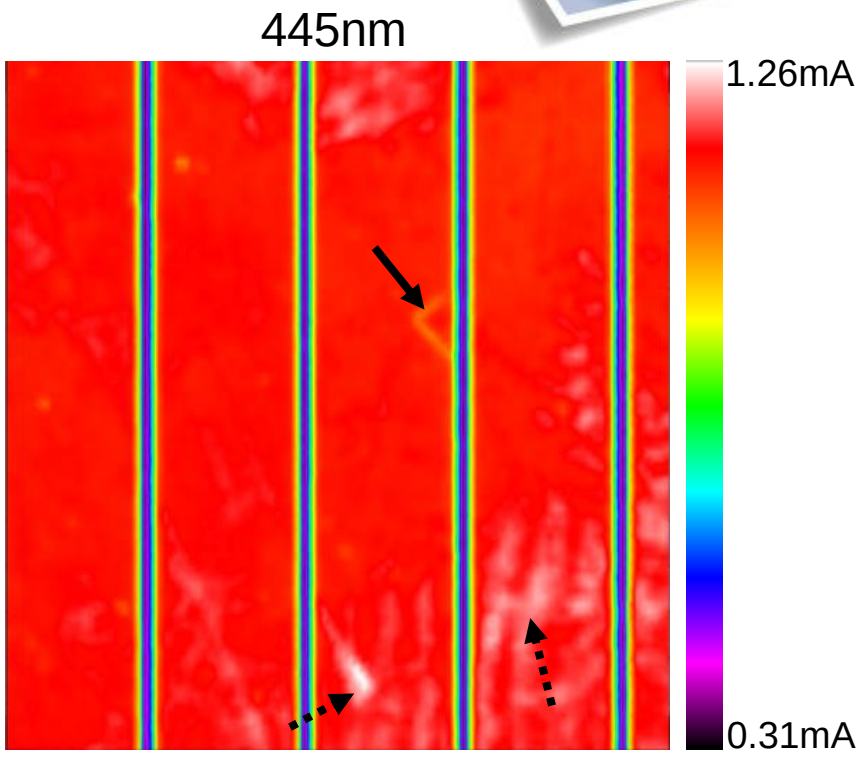
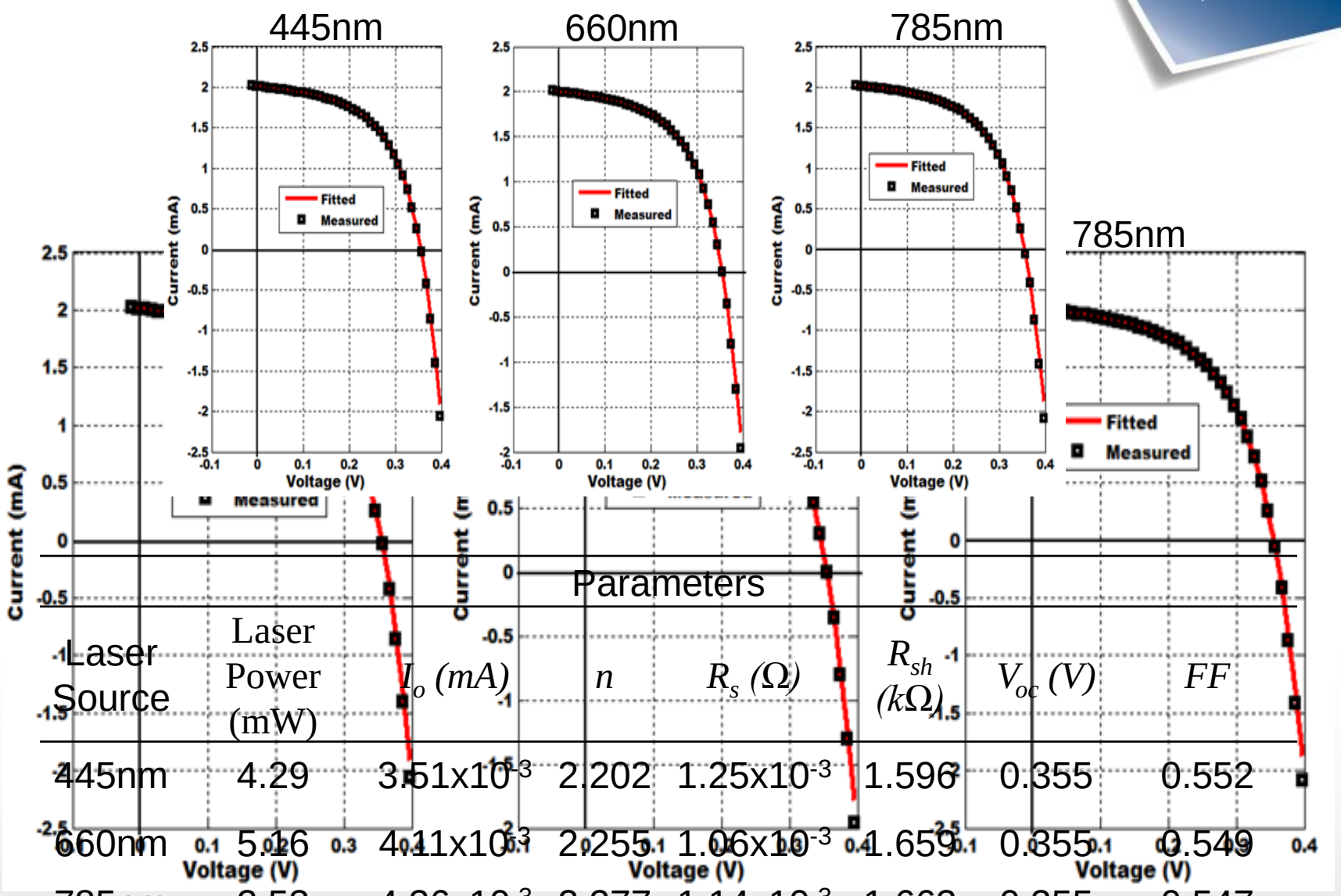


Photo-response depends on wavelength

- ✓ Due to differences in absorption coefficient

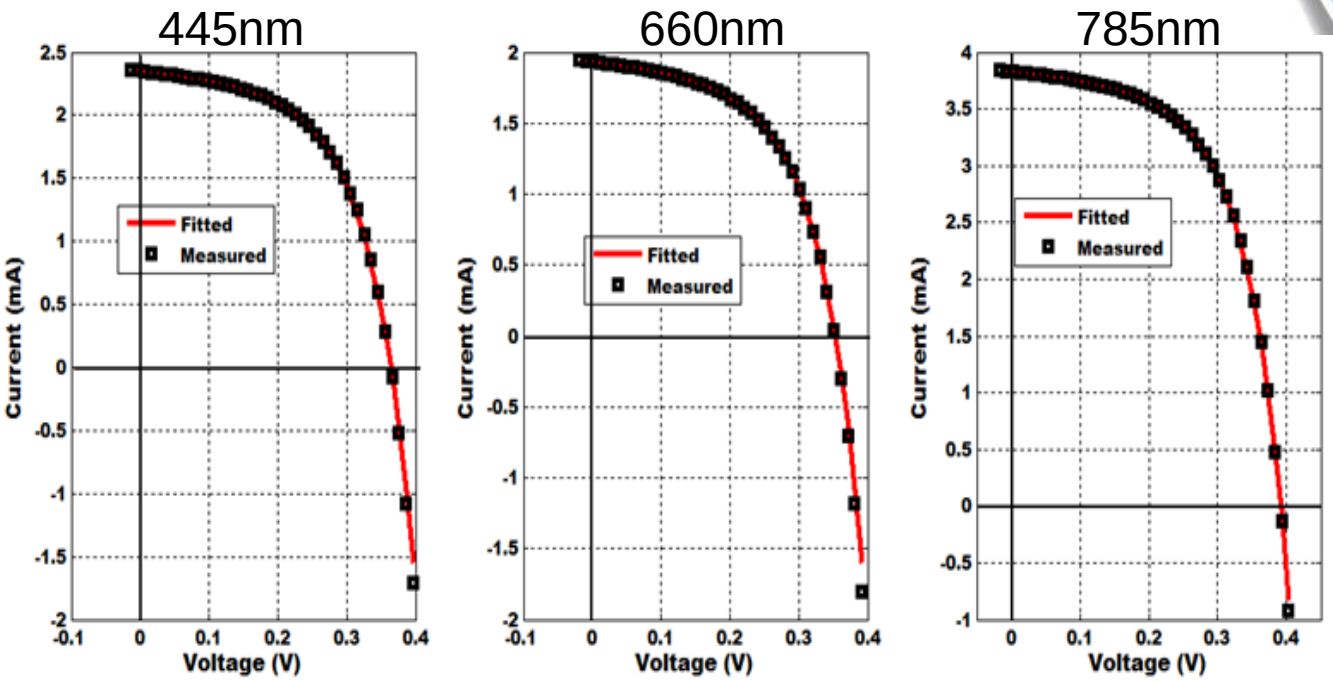
Effect of spectral change



Parameters

Laser Source	Laser Power (mW)	I_o (mA)	n	R_s (Ω)	R_{sh} (kΩ)	V_{oc} (V)	FF
445nm	4.29	3.51×10^{-3}	2.202	1.25×10^{-3}	1.596	0.355	0.552
660nm	5.16	4.11×10^{-3}	2.255	1.06×10^{-3}	1.659	0.355	0.549
785nm	2.53	4.36×10^{-3}	2.277	1.14×10^{-3}	1.663	0.355	0.547

Spectral change- cont'd



Parameters							
Laser Source	n	$I_o\ (mA)$	$R_{sh}\ (k\Omega)$	$R_s\ (\Omega)$	$I_{sc}\ (mA)$	$V_{oc}\ (V)$	FF
445nm	2.309	4.84×10^{-3}	1.683	9.50×10^{-4}	2.35	0.364	0.554
660nm	2.302	4.62×10^{-3}	1.694	1.35×10^{-3}	1.93	0.353	0.544
785nm	2.217	3.90×10^{-3}	1.584	4.36×10^{-3}	3.82	0.392	0.588

Conclusion

- Photo-response mapping of mc-Si
  - ✓ Photo-response maps obtained at two spectral conditions
  - ✓ Current reducing defects identified
- Parameter extraction carried out at different spectral conditions
  - ✓ Point I-V parameters extracted
  - ✓ Variation in extracted point I-V parameters observed
    - Changing recombination mechanisms

Acknowledgement

african laser centre

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our future through science

NLC Rental pool programme

Makerere University

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Thank you