ELEC3202: Green Electronics
Coursework Assignments

Dr Stuart Boden
Two coursework assignments for ELEC3202

1. Photovoltaics Characterization Lab (10%)

   Submission deadline:
   4 pm on Thursday 15th March 2018

2. PC1D Solar Cell Simulation Exercise (20%)

   Submission deadline:
   4 pm on Thursday 19th April 2018

Submit both assignments electronically via handin.ecs.soton.ac.uk

Full details are available on the module notes page:
https://secure.ecs.soton.ac.uk/notes/elec3202/
Global production technology trends

About 75* GWp PV module production in 2016

Thin film
Mono-Si
Multi-Si

From the Fraunhofer ISE Photovoltaic Report, 12th July 2017
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Photovoltaics Characterization Lab

Learning Outcomes

Having successfully completed the lab, you will be able to:

1. Measure the quantum efficiency (QE) characteristics of solar cells.

2. Describe what limits QE in different parts of the spectrum

3. Measure and analyze the reflectance spectra of silicon samples that have undergone various surface treatments to reduce reflectance.
Standard commercial Si cells: Screen printed contacts, acid texture, SiN$_x$ thin film coating

http://pveducation.org/pvcdrom/manufacturing/screen-printed
Photovoltaics Characterization Lab

• 1.5 hours preparation (background reading)- not assessed
• 1.5 hour lab session in 53/4016 (Nano Group Measurement Lab)
• Three tasks to complete in the lab:
  – Task L1: EQE measurement of commercial solar cell
  – Task L2: Reflectance of commercial solar cell
  – Task L3: Reflectance measurements on silicon treated with various antireflective coatings.
• Working in small groups (timetable will be posted online soon)
• A step-by-step guide to the operation of the Bentham PVE300 system for the measurement of QE and reflectance will be given to you in the lab. In addition, the lab demonstrator will be on hand to guide you through the safe operation of the equipment. You should aim as a to collect a full set of results (complete tasks L1, L2 and L3) during the lab session.
• Each of you should take a copy of the results away to complete the write up INDIVIDUALLY (Tasks R1 and R2).
Photovoltaics Characterization Lab

• Analysis and write-up tasks are described in the Lab specification document:
  – Task R1: EQE and IQE of commercial solar cell
  – Task R2: Antireflective treatments for silicon solar cells
• You should individually complete the tasks, presenting your work in a report that should be submitted electronically via handin.ecs.soton.ac.uk by 4pm on Thursday 15th March 2018.
• The report should be no longer than 7 pages.
• Normal penalties for late submission apply.
• This assignment will contribute 10% of the marks for ELEC3202.
• A detailed marking scheme is included in the lab specification document.
• You should expect to spend up to 12 hours on this assignment (including lab and prep time).
• All the lab sessions will take place in 53/4016 (Nano Group Measurement Lab).
• Please turn up on time to your allocated session.
<table>
<thead>
<tr>
<th>Hazard</th>
<th>Who is at Risk</th>
<th>Existing Controls</th>
<th>Risk Evaluation</th>
<th>Risk</th>
<th>Type of Further Action Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tripping over bags/coats</td>
<td>Users of the equipment</td>
<td>Users advised to keep the lab tidy and store bags/coats under the tables</td>
<td>Low</td>
<td></td>
<td>Optional</td>
</tr>
<tr>
<td>placed on floor</td>
<td>and other users of the room</td>
<td>Users advised to not to run in the lab</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Damage to eyes due to exposure UV light from monochromator.</td>
<td>Users of the equipment</td>
<td>All sweeps of monochromator into the UV range will be carried out with the enclosure doors closed</td>
<td>Low</td>
<td></td>
<td>Optional</td>
</tr>
<tr>
<td>Burn hazards from light sources becoming hot</td>
<td>Users of the equipment</td>
<td>Students warned not to touch light sources Safety labels in place warning of hazard</td>
<td>Low</td>
<td></td>
<td>Optional</td>
</tr>
<tr>
<td>Work with mains voltage</td>
<td>Users of equipment</td>
<td>Equipment is safety tested (PAT). Visual inspection for damage to equipment, lead and plug Users of equipment are instructed in its use.</td>
<td>Low</td>
<td></td>
<td>Optional</td>
</tr>
<tr>
<td>electrical equipment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Summary of key safety instructions:

1. Place all coats and bags under the tables to prevent them from becoming a trip hazard.

2. Follow the instructions given by the demonstrator.

3. The light sources can get hot during operation so avoid touching them.
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PC1D Simulation Exercise

• Numerical simulation forms an important part of the development process for solar cells.
• Simulation allows the optimal device designs to be identified before the fabrication steps are planned.
• This reduces the number of potentially expensive and time consuming fabrication runs required in development.
• It can also be used to identify problems with a fabricated device and suggest solutions
• PC1D is a freely-available quasi-one-dimensional finite-element program for modelling semiconductor devices that is used frequently in university research groups and industrial R&D labs around the world.

PC1D Simulation Exercise

Learning Outcomes

Having successfully completed this coursework assignment, you will be able to:

1. Use PC1D to generate dark I-V, illuminated I-V and quantum efficiency data for a modelled single crystal silicon solar cell.
2. Calculate some key performance indicators from your simulated data.
3. Use numerical simulations to investigate the how varying the device design affects the performance of the device.
4. Combine PC1D simulations with data from other sources to optimize aspects of the solar cell design.

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PC1D Simulation Exercise

https://sourceforge.net/p/pc1d/code/HEAD/tree/downloads/

• Download and install a copy of PC1D
• Work through the “Getting Started” section of the assignment document to familiarize yourself with the operation of PC1D.
• Then work through the tasks in the “Simulation Tasks” section of the assignment document.
• You should present your work on these tasks in a report that should be submitted electronically via handin.ecs.soton.ac.uk by 4 pm on Thursday 19th April 2018.
• The report should be no longer than 10 pages.
PC1D Simulation Exercise

Simulation Tasks:

- **Task 1**: Dark and illuminated I-V characteristics
- **Task 2**: Varying illumination intensity
- **Task 3**: Quantum efficiency
- **Task 4**: Front surface optimization

- Task 4 involves using some online calculators to create data to import into PC1D. These are available at [www.pvlighthouse.com.au](http://www.pvlighthouse.com.au), a great resource for PV simulation tools. You can also find the help files for PC1D here.
- A list of references is given in the assignment documentation to help with your further reading.

- Normal penalties for late submission apply.
- This assignment will contribute 20% of the marks for ELEC3202.
- A detailed marking scheme is included in the lab specification document.
- You should expect to spend up to 30 hours on this assignment.
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