School of Photovoltaic and Renewable Energy Engineering
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PhD at the University of New South Wales, Sydney, Australia

Photoluminescence-based characterisation methods for perovskite and tandem solar cells

The **School of Photovoltaic and Renewable Energy Engineering** (SPREE) is one of the eight schools within the Faculty of Engineering at the **University of New South Wales** (**UNSW), Sydney, Australia**.

The school is widely considered as the **best in the world**. Building on its world-leading research, the **school attracts leading international researchers in the area of photovoltaic.** Our academic staff has been consistently ranked **amongst the leaders worldwide in the photovoltaic field** through international peer review. Our team has held the world record for silicon solar cell efficiencies for over twenty years and has been responsible for developing the most successfully commercialised photovoltaic technology internationally throughout the same period. The solar cell technology that is predicted to dominate the market in the next decade (the 'PERC') was invented and developed in our school.

We are looking for excellent students for a for a novel project involving new solar cell technology and advanced inspection tools (details below).

The PhD will be done in our state-of-the-art laboratories, including our industrial production line (**the only one in Australia**) and our advanced fabrication and characterization facilities. Our laboratories allow most of the fabrication processes of semiconductors, including diffusion (phosphorous and boron), oxidation, chemical vapor deposition, laser-based etching and doping, photolithography, metal and semiconductor evaporation, metal plating, screen printing, etc.

Suitable students will be awarded a full scholarship for 3.5 years (PhD duration in Australia is 3-3.5 years). The scholarship fully covers the university fees and provides an additional allowance to cover living costs:

Tuition fees: **$45,000** per year

Living allowance: **$27,000** per year

Conference allowance: **$3,000** per conference (to support attending a scientific international conference; at least two conferences during the PhD).

Requirements:

Undergraduate Degree: Bachelor's degree in a scientific or engineering discipline specialising in electrical and electronic, chemistry, material, or physics with a **graduation GPA above 8 out of 10 or equivalent**.

Master degree: Graduation from a Master by research program, focusing on perovskite, organic or dyes solar cells. At least one international journal publication in a relevant research area is required.

Supervision will be done by Associate Professor Ziv Hameiri, Dr Arman Mahboubi Soufiani and Associate Professor Xiaojing (Jeana) Hao. For more details please contact **Dr Ziv Hameiri** (ziv.hameiri@unsw.edu.au).

Project details:

Photoluminescence-based characterisation methods for perovskite and tandem solar cells

In the past few years, a new class of solar cell based on mixed organic-inorganic hybrid perovskite has stunned the photovoltaic community. Perovskites were first used as a PV absorber in 2006, achieving an efficiency of 2.2%. This efficiency has been rapidly increased to 24.4±0.8% by 2019. Within a couple of years perovskite solar cells achieved similar efficiency to those of much more mature thin-film solar cell technologies (such as CdTe and CIGS). Development of various fabrication methods and several device structures suggest that this efficiency is still far from its limit.

Despite the astonishing performance improvement in such a short time, perovskite-based solar cells suffer from some major problems. One key challenge for this technology is the stability of the devices; they tend to undergo degradation (sometimes within only a few hours), especially upon exposure to moisture. Another challenge associated with perovskite-based solar cells, which is common to all thin film solar cell approaches, is the cell uniformity. The latter determines the ability to scale-up the impressive efficiencies achieved on small devices to larger areas. To date, perovskite solar cells have been fabricated mostly on relatively small substrates (5–30 mm^2). However, commercial applications require a much larger substrate area (in the order of 156 mm × 156 mm). This scaling-up requires the ability to monitor the uniformity of the fabrication process. Lateral process variations can be expected particularly for solution spreading techniques that are often implemented in the fabrication of perovskite solar cells.

The rapid progress in the fabrication technology of perovskite solar cells has not been accompanied by the development of dedicated characterisation methods. The uniqueness of perovskite-based solar cells and the strong need for dedicated characterisation methods is obvious when considering the challenges researchers face to perform a simple current–voltage measurement for this type of device.

Note that the world record for silicon solar cell efficiency that had been held by UNSW over the last few decades was strongly supported by the availability of state-of-the-art characterisation tools and the resulting ability to analyse loss mechanisms. In order to further improve the efficiencies of perovskite-based solar cell, innovative analysis methods need to be developed.

Aims:

The aim of this project is to develop luminescence-based imaging methods to characterise spatially resolved recombination and degradation mechanisms within perovskite-based solar cells (both single and tandem cells).

Photoluminescence (PL) – the emission of light from a material after the absorption of photons – has been proven to be a very powerful monitoring tool for photovoltaic devices. PL *imaging* was developed at UNSW more than a decade ago. Since the first proof of concept studies in our laboratories, this technology has seen rapid adoption worldwide by researchers and companies and is now one of the most widely used techniques. For silicon devices, PL imaging is frequently used to monitor essential electrical parameters such as minority carrier lifetime, implied open-circuit voltage, diode saturation currents, series resistance, shunt resistance, and pseudo fill factor. The contactless nature of the measurement and the fact that it can be performed even on non-completed devices makes it an ideal tool to investigate various limiting processes within silicon and non-silicon solar cells. **UNSW has an internationally leading position in the growth of PL as an effective inspection tool for photovoltaic devices**.

The main project aims are to:

- Develop methods to extract essential solar cells parameters from luminescence images (both single and tandem cells).
- Investigate recombination mechanisms within perovskite-based solar cell using luminescence and identifying the main loss mechanisms that limit efficiency.
- Investigate the degradation processes associated with perovskite-based solar cell.
- Investigate the uniformity of various processing methods and assessing the losses associated with the non-uniformity.
- Saving the world!