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

Development of beta-voltaic batteries for space applications

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 project developing novel beta-voltaic batteries for space and other unique applications (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: Priority will be given for those who graduated from a Masters by research program, focusing on photovoltaic devices.

Supervision will be done by Associate Professor Ziv Hameiri (SPREE), (ziv.hameiri@unsw.edu.au).

Project details: Development of beta-voltaic batteries for space and other unique applications

Low-power, wireless electronic devices are gaining significant importance these days. As it is expected that their importance will increase even further in the next decade, energising these devices is becoming a critical need. Despite the ubiquitous use of electrochemical batteries, they all suffer from limited longevity and must be frequently charged and replaced. Electrochemical batteries also suffer from low energy density and high sensitivity to environmental conditions. At high temperatures, electrochemical batteries often undergo self-discharge and permanent loss of capacity, while at low temperatures they exhibit lower voltage and capacity. Possible leaked electrolyte creates corrosion of nearby electronics and is a potential safety hazard in the form of burns and poisoning. Instabilities leading to shorting in lithium batteries can result in fire or explosion. Hence, **a new type of battery must be developed to overcome these limitations and beta-voltaic (BV) battery is a strong candidate**.

Beta-voltaic devices that use a radioisotope beta-emitter and a semiconductor (absorber) to produce electricity, can address these limitations. In these batteries, the energy is by emission of beta-particles in long-lived radioactivity. The beta-particles (high-energy electrons) produce a cascade of electron-hole (e-h) pairs in the semiconductor. Hence, in principle, BV batteries operate as PV cells and can be modelled using a similar equivalent circuit.

The main advantages of BV batteries compared to electrochemical batteries are: (a) depending on the half-life of the beta source, **BV batteries can operate for many years** (>50 years); (b) they have a **very high energy density** (c) BV batteries can work at **extreme temperatures** (-55°C to 150°C); and (d) beta-sources can be applied as thin films, allowing **direct integration** of the energy source into the device with only minimal additional volume requirement, and hence, the battery becomes a micropart of the system.

Beta-voltaic batteries are already used for critical applications where electrochemical batteries have severe limitations. They are well suited for long-life applications with low power requirements. For example, BV devices have been applied to space missions and to power pacemakers. Recent developments in sensors, electronic devices and medical implants significantly expand the possibilities for BV usage. However, common BV devices suffer from low efficiency and fast degradation in their electrical performance, preventing them from reaching their full potential. **This project aims to develop a new type of BV batteries**.