Energy & Light Symposium
21st October 2021

HENRY ROYCE INSTITUTE | UNIVERSITY OF CAMBRIDGE

"Energy & Light"

A presentation of academic and industrial research on the Royce Institute "Ambient Cluster"

We warmly welcome you to our Cluster Tool Symposium 2021 at the Cavendish Laboratory in Cambridge. This one-day symposium will showcase recent results from the growth, characterisation, testing and packaging of novel devices, and will explore potential new ideas and research directions for the Cluster Tool.

The Cluster Tool itself comprises of a series of dry inert ambient gloveboxes housing a range of equipment including a battery fabrication module (PLD, evaporator and DC/RF sputterer under Ar and capable of handling Li), two large thermal evaporators, two spin coaters, ALD, an aerosol jet and screen printer, slot die coater and an encapsulation device. The Cluster Tool was funded by a grant from the EPSRC supported Royce Institute for Advanced Materials. For the full list of Cluster Tool equipment and for information on other Royce facilities at Cambridge see: https://www.maxwell.cam.ac.uk/programmes/henry-royce-institute

Much of the academic work on the tool is undertaken as part of the Royce Institute's Atoms to Devices (A2D) theme. For more information see: https://www.royce.ac.uk/research-areas/atoms-to-devices/

The Royce Institute also financially supports a range of Student, Research and SME access to the Cluster Tool and other Royce equipment at Cambridge and other partner Universities across the UK. To find out more about funding opportunities from Royce please contact Dr Andrew Dobrzański, Royce@Cambridge Manager at ad2021@cam.ac.uk and see the Royce website for further information: https://www.royce.ac.uk/collaborate/funding/

Key Contacts

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Departmental Access Restrictions

Please note that the Cambridge University Department of Physics (Cavendish Laboratory) is current restricting access to the department under the following regulations:

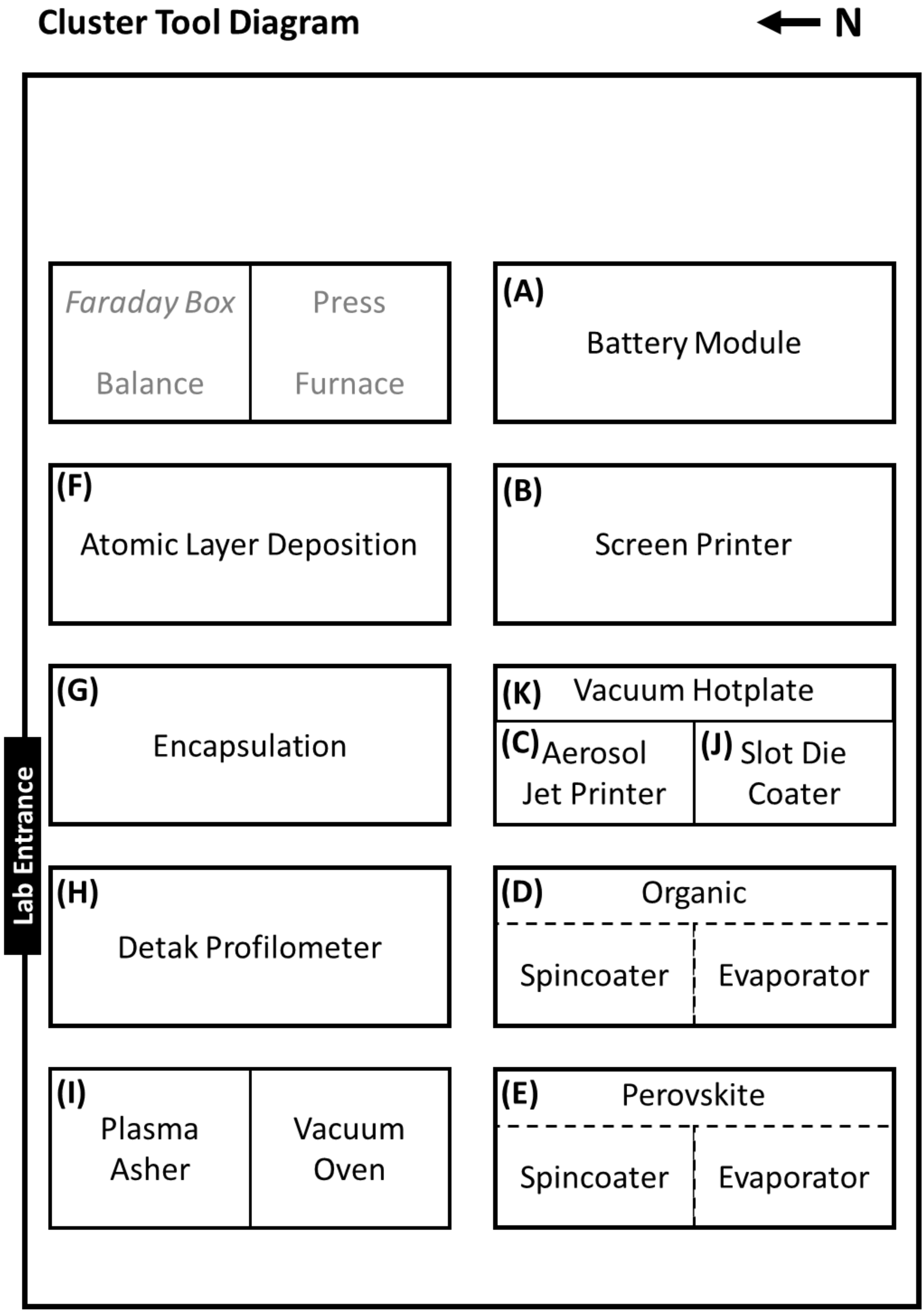
- In a room more than $24m^2$ (i.e. 5mx5m) you are not required to wear a mask IF you keep 2m apart from others.
- If 2m distancing is not possible, you must wear a mask/facecovering unless exempt (as a minimum, a 1-ply cloth mask. You should not wear a valved mask). Do not work closer than 1m and avoid face-to-face working.
- Masks are required in all public areas and small rooms.
- Eating areas: As you will not be wearing a mask, keep away from others. Keep your mask on till you sit down in these areas.
- You will already have been registered with Departmental Security prior to your visit and will be accompanied during events within the Maxwell Centre and the Cavendish.

Programme:

11:00 - Registration (Maxwell Centre) and Tea/Coffee (Cavendish)	
11:45-13:15 - Session 1 (Small Lecture Theatre, Cavendish Laboratory)	
11:45-12:00	Prof Henning Sirringhaus Welcome and Overview of the Royce@Cambridge Cluster Tool
12:00-12:15	Dr Bart Roose All-perovskite tandem solar cells: The importance of interlayer design
12:15-12:30	Dr Juliane Borchert Co-evaporated 2D perovskites - progress, challenges, and applications
12:30-12:45	Yu-Hsien Chiang Evaporated perovskite solar cells
12:45-13:00	Alessandro Mirabelli Instability in Blue Perovskite LEDs
13:00-13:15	Dr Miguel Anaya Halide perovskite X-ray detectors
13:15-14:00 - Lunch (Cavendish Outside Area)	
14:00-15:15 – Session 2 (Small Lecture Theatre, Cavendish Laboratory)	
14:00-14:15	Dr Farheen Sayed, *Grey Group* Pulsed Laser Deposition of battery materials / solid state battery materials
14:15-14:30	Adam Lovett Vertically aligned nanocomposites for solid state battery applications
14:30-14:45	Dr Xiaolong Chen, 3D-printed hierarchical pillar array electrodes for high performance semi-artificial photosynthesis
14:45-15:00	Dimitrios Simatos Water stability of electrolyte-gated organic field-effect transistors
15:00-15:15	Martyn Rush (Industry visitor) OPV for BIPV
15:15-16:00 - Tea/Coffee and Wrap-Up with Equipment Tours (Cavendish Outside Area/ Maxwell Centre)	

Layout of the Cambridge-Royce Cluster Tool

Cluster Tool Diagram



Speaker Abstracts and Biographies

Prof. Henning Sirringhaus
Introduction to the Cambridge-Royce Cluster Tool

Biography
Prof. Henning Sirringhaus, FRS, is the Hitachi Professor of Electron Device Physics and a Royal Society Research Professor at the Cavendish Laboratory, University of Cambridge. He works on the charge transport, photo- and device physics of conjugated polymer and molecular semiconductors as well as hybrid organic-inorganic semiconductors and their application in electronics and thermoelectrics.

Abstract
The ambient processing cluster tool at the Maxwell Centre of the University of Cambridge is a user facility that forms part of the Henry Royce Institute. It provides an integrated, inert atmosphere glovebox environment for the deposition and processing of a broad range of organic, inorganic and hybrid organic-inorganic functional materials and allows combining powerful vacuum deposition methods, such as thermal evaporation, atomic layer deposition and pulsed laser deposition with printing-based methods such as aerosol printing and slot-die coating as well as processes for thin film metrology and device encapsulation. In this introductory talk we will provide an overview over the tools capabilities and how to access them.

Dr. Bart Roose
All-Perovskite Tandem Solar Cells: The importance of Interlayer Design

Biography
Dr Bart Roose obtained his PhD from the Adolphe Merkle Institute (Fribourg, Switzerland), studying metal oxide contacts for perovskite solar cells. He then took up a Newton International Fellowship at the Cavendish Laboratory (Cambridge, UK) to study aging and degradation mechanisms of lead halide perovskites. He is currently leading the photovoltaic research activities in the Optoelectronic Materials and Device Spectroscopy Group at the Department of Chemical Engineering & Biotechnology (Cambridge, UK), focusing on all-perovskite tandem solar cells. His research interests are dynamic processes, sustainability and novel applications of emerging photovoltaic technologies.

Abstract
Over the last decade, lead halide perovskite solar cells have become one of the most promising emerging photovoltaic technologies. By compositional engineering, a wide range of bandgaps can be obtained, making lead halide perovskites ideal materials for tandem solar cells. A tandem solar cell is made by stacking two perovskite solar cells with a different bandgap on top of each other. This makes it possible to harvest a broader range of wavelengths and achieve higher power conversion efficiencies. This talk will highlight the intricate role of the interlayer that connects the two subcells.

Dr. Juliane Borchert
Co-evaporated 2D perovskites - progress, challenges, and applications

Biography
Juliane Borchert is a postdoctoral research associate at the University of Cambridge and at AMOLF, Amsterdam. Her research focuses on the fabrication, optimisation, and understanding of evaporated perovskite thin-films for solar cells and other optoelectronic devices. She combines the varied methods and expertise available at the Cavendish and at AMOLF to understand and improve perovskite materials for the solar cells of the future. Previously she was a EPSRC Doctoral Prize Research Associate at the University of Oxford, where she also completed her PhD. Her PhD research was conducted as part of the EPSRC Center for Doctoral Training in New and Sustainable Photovoltaics, under the supervision of Prof. Michael Johnston and Prof. Henry Snaith. In the past, she studied physics at the Freie Universität Berlin, the Martin-Luther Universität Halle-Wittenberg, and Rijksuniversiteit Groningen.

Abstract
Metal halide perovskites are a highly promising class of semiconductors for the fabrication of cheap and efficient optoelectronic devices such as solar cells, LED's, and photodetectors. Intense research effort has resulted in efficiencies for lab scale perovskite solar cells of over 25%. Co-evaporation is a promising deposition technique for the upscaling of perovskites because it is additive, results in very uniform films, and does not require toxic solvents.

Recently two-dimensional organic metal halide materials which are similar to the well-known 3D perovskites have attracted a lot of attention. These 2D materials are promising as stabilisation and passivation layers used together with 3D perovskites or for use on their own as active materials in LEDs and solar cells. In this talk I will present recent work on co-evaporated 2D perovskites.

Yu-Hsien Chiang
Evaporated perovskite films for solar cells application

Biography
Yu-Hsien Chiang obtained his Bachelor's and Master degrees in chemistry at National Chung Cheng University and National Cheng Kung University (NCKU), Taiwan. During his master's degree, his research was focusing surface chemistry with an ultra-vacuum system. After his Master's degree, he joined the Department of Optoelectronics at NCKU as a research assistant, working on the new charge transport materials and chemical vapour deposition for perovskite solar cells. In 2018, He joined StranksLab as a PhD student in the Department of Physics at the University of Cambridge. His PhD is focusing on vacuum-deposited perovskite films for (multijunction) solar cells application and surface passivation to improve device performance and stability.

Abstract
Halide perovskite solar cells have attracted numerous attention due to their promising optoelectronic properties. To date, most of the research has been focused on the spin-coating method for the preparation of perovskite film and devices. However, it is unclear whether solution processing will yield sufficient spatial performance uniformity for large-scale photovoltaic modules or compatibility with deposition of multilayered tandem solar cell stacks. In this talk, we will focus on how to use multisource evaporation for different perovskite compositions to achieve high-quality morphological, structural, and optoelectronic properties. Our results demonstrate the promising device performance of single-junction and tandem perovskite solar cells.

Alessandro Mirabelli
Instability in Blue Perovskite LEDs

Biography
Alessandro James Mirabelli completed his BS in Physics at the University of Bologna. He then pursued a master's degree in Material Physics at the same institute. For his thesis he went to King Abdullah University of Science and Technology in Saudi Arabia where he worked on bifacial perovskite silicon tandem solar cells in Professor Stefaan De Wolf's group. At Cambridge, under the guidance of Dr. Sam Stranks, he is now investigating blue perovskite LEDs with a focus of their issues such as degradation and stability.

Abstract
Halide perovskite have attracted much attention in the renewable and clean energy sector for both photovoltaic and lighting applications. Perovskite LEDs (PeLEDs) show very promising optoelectronic qualities such a narrow line emission and high brightness. While respectable efficiencies over 20% have been achieved for green and red PeLEDs, blue light emitting diodes are still struggling behind. Plagued by ion migration, color instability and short operational lifetime, this talk will highlight the current issues that are affecting blue PeLEDs.

Dr. Miguel Anaya
Halide Perovskite X-Ray Detector

Biography
Miguel Anaya is a Royal Academy of Engineering Research Fellow at the Department of Chemical Engineering and Biotechnology of the University of Cambridge, and Research Fellow at Darwin College, Cambridge. He completed his PhD at the Spanish National Research Council in 2018, with recognition from the Spanish Royal Society of Physics as the Best Thesis in Experimental Physics. He leads a subgroup at the StranksLab focusing on the modelling, fabrication and characterisation of perovskite-based devices.

Abstract
X-ray imaging is one of the most powerful diagnostic tools developed in the 20th century, allowing physicians to non-invasively see into the human body. However, X-rays are inherently carcinogenic and, in order to lower the radiation dose for patients undergoing X-ray imaging, more sensitive scintillator materials are required. Here, we will present a new generation of highly sensitive, flexible scintillators based on halide perovskite semiconductors.

Dr. Farheen Sayed

Interphases at solid-solid interface in thin film high voltage cathodes for Li-ion battery

Biography

Dr Farheen N Sayed is a solid-state chemist currently focusing on structure and electrochemistry of energy storage materials. Farheen obtained her PhD from Bhabha Atomic Research Centre - Mumbai University (India) in Solid-State Chemistry. After her thesis submission, she worked at the Tata Institute of Fundamental Research (TIFR Mumbai, India) as a research fellow. Subsequently, she joined Bhabha Atomic Research Centre as Junior Visiting Scientist, where she developed oxygen ion conductors for solid-state electrolytes application. In 2015 she received prestigious Nehru Fulbright Postdoctoral Fellowship to work with Prof P M Ajayan at Rice University (Texas, USA), where she started her journey in the field of materials for energy generation and storage (e.g. electrocatalysis, batteries and supercapacitors). Currently, Farheen is working at Yusuf Hamied Department of Chemistry, the University of Cambridge, with Prof Clare P Grey. As a CATMAT Faraday Institute PDRA, her research focuses on the synergy of solid-state chemistry and electrochemistry, focusing on the interphases at the solid-solid interface in batteries and the structural investigation of new cathode materials.

Abstract

Li-ion batteries (LIBs) have been around for a very long time. However, the increasing energy demand necessitates the further development of all the battery components (anode, cathode, and electrolyte). Cathodes have always been the major limiting factor in achieving higher energy density due to their low capacity and limited operating voltage. The utilisation of available high voltage cathodes is challenging since the structural stability of a cathode is compromised at a higher voltage in combination with other degradation mechanisms. One of the solutions to mitigate this issue is surface modification using artificial interfaces, i.e. coating materials. This presentation will discuss the thin-film fabrication of high voltage LIB cathode and coating materials, along with their electrochemistry and structure.

Adam Lovett

Vertically aligned nanocomposites for solid state battery applications

Biography

Adam J. Lovett graduated in Chemistry (MChem, First Class with Honours) from the University of Durham in 2018, specialising in materials science and physical chemistry. He wrote his Masters Theses under Prof. Ivana Evans on novel oxide ion conductors. In Cambridge, he is enrolled in a PhD programme in the Device Materials Group with Professor Judith Driscoll funded by an EPSRC studentship received for academic performance. His field of work focuses on PLD, phase analysis and electrochemical characterisation of vertically aligned nanocomposite (VAN) thin films for solid-state batteries and SOFC applications

Abstract

Vertically aligned nanocomposite (VAN) thin films have shown strong potential in oxide nanoionics but are yet to be explored in detail in solid-state battery systems. Their 3D architectures are attractive because they may allow enhancements in capacity, current and power densities. Also, owing to due to their large interfacial surface areas, VANs could serve as models to study interfaces

and solid-electrolyte interphase formation, which is challenging as they are buried and very small, making them difficult to probe. In this presentation, a summary of the VAN systems grown in the Ambient Cluster lab will be presented, including LixLay(Nb,Ti)O3-(Ti,Nb)O2-anatase electrolyte/anode system, which exhibits very high ionic conductivity, comparable with the best in class; and LiMn2O4-SrRuO3, a promising high 3D cathode-current collector system which has displayed the ability to cycle at very high C-rates with better capacity retention and much lower capacity fade than conventional planar LiMn2O4 thin films. The excellent performance of these systems could form the basis of a high-performance 3D nanoarchitectured solid-state battery utilising VAN films.

Dr Xiaolong Chen
3D-printed hierarchical pillar array electrodes for high performance semi-artificial photosynthesis

Biography
Xiaolong is a Postdoctoral Researcher in the Zhang Group based in the Yusuf Hamied Department of Chemistry which focuses on Bio-hybrid approaches for energy conversion

Abstract
The re-wiring of photosynthetic bio-machineries to electrodes is a forward-looking semi-artificial route for sustainable bio-electricity and fuel generation. Currently, it is unclear how the bio-material interface can be designed to meet the complex requirements for high bio-photoelectrochemical performance. Here, we developed an aerosol jet printing method for generating hierarchical electrode structures using indium tin oxide nanoparticles. We printed libraries of micropillar array electrodes varying in height and sub-micron surface features and studied the energy/electron transfer processes across the bio-electrode interfaces. When wired to the cyanobacterium Synechocysis sp. PCC 6803, micropillar array electrodes with micro-branches exhibited favourable biocatalyst loading, light utilisation and electron flux output, ultimately almost doubling the photocurrent of state-of-the-art porous structures of the same height. When the micropillars' heights were increased from 50 to 600 µm, milestone mediated photocurrent densities of 245 µA cm–2 (the closest thus far to theoretical predictions) and external quantum efficiencies of up to 29% could be reached. This study demonstrates how bioenergy from photosynthesis could be more efficiently harnessed in the future and provide new tools for 3D electrode design.

Dimitrios Simatos
Water stability of electrolyte-gated organic field-effect transistors

Biography
Dimitrios is a final year PhD student under the supervision of Prof. Henning Sirringhaus. He is working on stabilizing electrolyte-gated field effect transistors

Abstract
Organic materials (conjugated polymers and small molecules) seem ideal candidates for bioelectronics due to their softness, biocompatibility, stretchability, and their ability to conduct both electrons and ions. However, water constitutes a key factor in charge trapping and device degradation in organic materials, due to its strong dipole moment, high dielectric constant, and its

omnipresence in almost all processing, environmental, and operational conditions. Architectures such as electrolyte-gated field effect transistors (EG-OFETs), in which the organic material is in direct contact with the liquid, are considered to be especially hard to stabilize. In this talk I will present long-term water stability experiments on EG-OFETs, and demonstrate that cleanly fabricated EG-OFETs can remain stable within the course of an overnight measurement. This highlights the importance of clean fabrication, which is ensured by the stringent cleaning and processing protocols followed in the cluster tool.

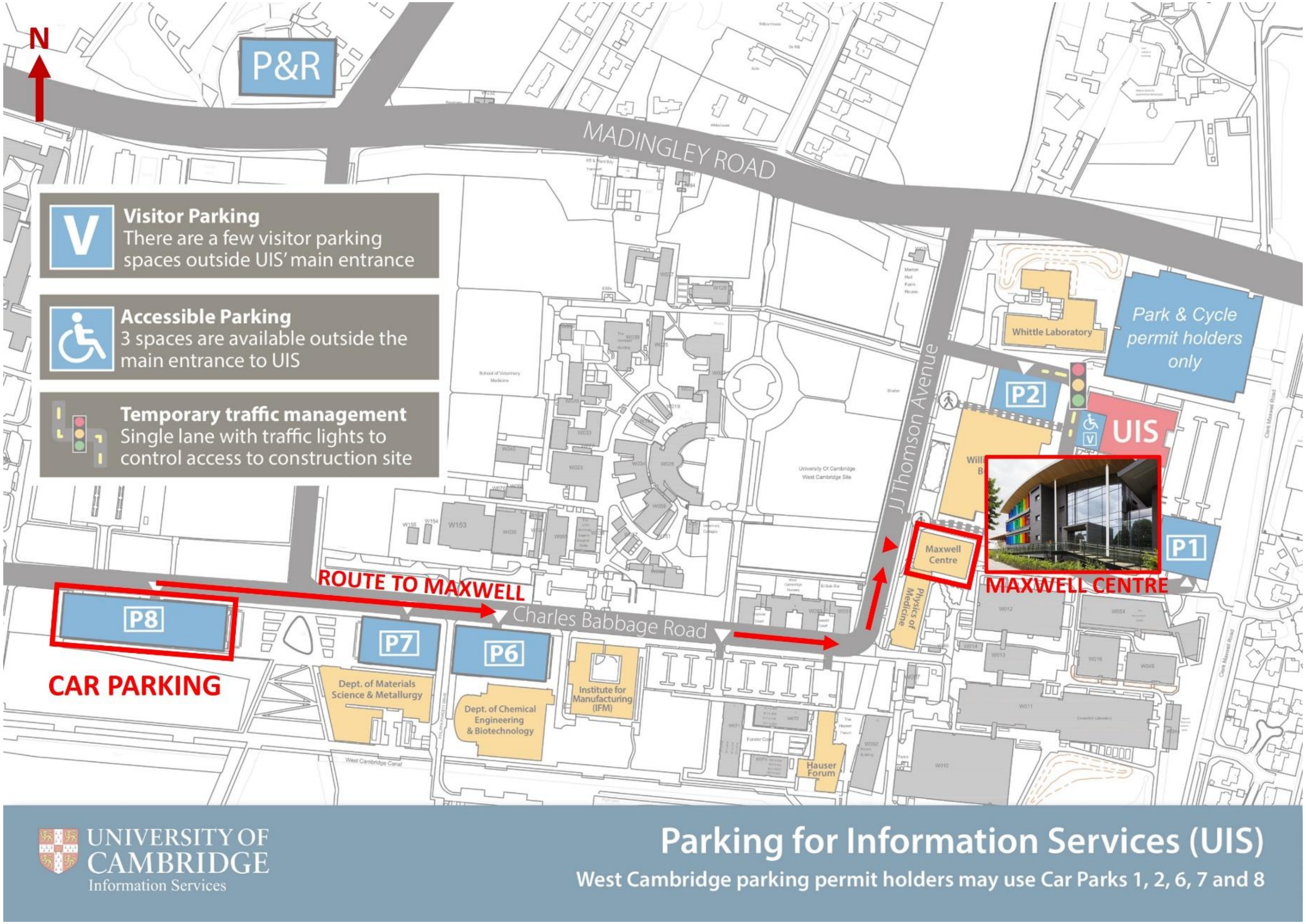
Martyn Rush
OPV for BIPV

Biography
Martyn Rush is currently the R&D Manager at Polysolar Ltd, a Cambridge based company specialising in Building Integrated Photovoltaics (BIPV). His main focus is to work with academic partners to better understand the effects of current PV technology on the building itself, beyond electrical power generation, as well as scouting for new technology opportunities in simplifying manufacture of BIPV. Before this he was at Eight19 Ltd as Material Development Manager, a broad role that saw him develop OPV, interlayer materials, processes, and novel architectures for roll-to-roll processable OPV on flexible substrates. He is a keen believer in democratising solar PV by changing focus from the highest efficiency to the most applicable solution, this includes materials usage, recyclability, and decentralised manufacture.

Abstract
Solar PV prices have dropped significantly over the last few years which has led to more opportunities for deployment beyond solar farms. PV attached, applied, or integrated into or onto buildings gives us a unique chance to generate power where it is used, thus protecting our natural environment from development through dual use of land and vertical installations. However, narrow focus on performance for extant and emerging technologies hinders universal adoption and a broader view of benefits are needed. We will look at PV in a different light through a brief assessment of all PV technologies (OPV included) beyond %PCE.

Parking Information and Location of the Maxwell Centre

Address: Maxwell Centre, University of Cambridge, CB3 0HE



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Peter Levermore	CEO		Peroled
Mike Clausen	Head of Technology		CPI
Dr. Mike Clark	Technology & Management Consultant		
Dr. Jeremy Burroughs	CTO		CDT
Karikath Varma	Academic Director		Pilikington (NSG)
Nicholas Kasch	Research Scientist		PowerRoll
Dr. Sumithra Santhanam	Lead Scientist		Echion Ltd
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Dimitrios Simatos	PhD student, Organic Bioelectronics	Dept. of Physics	Cambridge University
Dr Juliane Borchet	Optoelectronics	Dept. of Physics	Cambridge University
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