Bath Monash Global PhD Programme in Sustainable & Circular Technologies

Project Title:	Carbon contact perovskite solar cells: toward high efficiency and stability
Supervisors at Bath: Supervisors at Monash:	Petra Cameron (Chemistry), Alison Walker (Physics) Phil Andrews (Chemistry), Vicki Blair (Chemistry), Udo Bach (Engineering)
Home Institution:	Bath
Indicative period at Host Institution (Monash):	Second year of PhD project

Project Summary (to include a brief description of the relevance to sustainable & circular technologies)

Lead Halide Perovskite solar cells have been intensively studied in the last ten years. Perovskite Solar Cells (PSC) show impressive efficiencies up to 25.6% and the stability has been improved to give measured lifetimes of between 1 and 2 years. Life cycle assessment suggests that PSC have the lowest CO_2 footprint per kWh_{DC} of electricity generated when compared to current commercial PV modules. This benefit is offset against higher toxicity should the Pb^{2+} ions escape to the environment [Prog Photovolt Res Appl.2002; 1-15]. If perovskite solar cells are to be successfully commercialized, then both the long-term stability and the potential toxicity need to be addressed.

This project will look at the development of stable, low-cost, and ideally lead-free perovskite solar cells with carbon contacts. We aim to understand and overcome the limitations of carbon contact cells and to trial our most promising cell configurations with new lead-free perovskite materials. Carbon contact PSC show substantial benefits compared to standard PSC. There are no precious metals or expensive conducting polymers and they can show impressive long-term stability. On the downside there is usually a significant (~200-300 mV) reduction in open circuit voltage when the hole conducting polymer and the gold are replaced with carbon. Interestingly we have shown that $CsPbBr_3$ solar cells are the exception to this. $CsPbBr_3$ is a yellow perovskite material with a band gap of 2.3 eV. The band gap limits the maximum efficiency we can get from the cells (our current state of the art is 9%) but in Bath we have shown open circuit voltages greater than 1.4V for both mesoporous and planar carbon cells. These results show that low open circuit voltages are not an automatic function of carbon PSC and we intend to use a range of characterization tools to better understand the voltage loss and to guide us when engineering lower band gap perovskite materials for high efficiency solar cells.

The Bath-Monash team have extensive complementary expertise in this area. Prof. Philip Andrews is an expert in green and sustainable chemistry and the team in Monash have developed innovative and scalable low temperature deposited carbon contacts to replace expensive gold in PSC [Adv.Mater. Technol.2022, 7, 2101148] as well as new lead-free photovoltaic materials [Adv. Energy Mater. 2022, 12, 2201482 and 2019, 9, 1803396]. Prof. Bach also has expertise in using machine learning and high through put combinational synthesis to prepare new perovskite materials and is actively searching for lead-free perovskites. In Bath, we have considerable expertise in making high voltage $CsPbBr_3$ planar and mesoporous carbon contact PSC [*Nature Communications,* 2019, 10, 2097]. This combination of skills puts us in an excellent position to co-supervise a truly collaborative research project that makes real progress in the area of low-cost, lead-free carbon contact cells.

Features of the programme

- PhD researchers will be registered at both institutions and will be awarded a joint PhD degree.
- PhD researchers will be jointly supervised by academics from both Monash and Bath Universities.
- All PhD researchers in the joint programme will also undertake a bespoke advanced training plan covering a range of topics focusing on sustainability.
- Applicants can apply to either Monash University or the University of Bath as their nominated home institution.
- PhD researchers will undertake a period of no less than 12 months at the partner institution.
- Up to four scholarships/studentships will be offered. Additional and suitably qualified applicants who can access a scholarship/studentship from other sources will be also considered. Evidence of funding must be provided.
- The scholarships/studentships include:
  - a *full tuition fee sponsorship* provided by Monash or Bath for the course duration (up to a maximum 42 months). Note, however, that studentships for Bath-based projects will provide cover for UK/EU tuition fees ONLY.
  - *a living allowance (stipend)* provided by Monash or Bath Universities.

Note: Overseas Student Health Cover (OSHC) must be paid by the student, unless covered by the university.

How to apply

You MUST express interest for three projects in order of preference. Please submit your application at the Home institution of your preferred project ('Home' institution details can be found in the project summary). However, please note that you are applying for a joint PhD programme and applications will be processed as such.

The deadline to submit applications is 30th January 2023

Monash University

Expressions of interest (EoI) can be lodged through https://www.monash.edu/science/bath-monash-program. The EoI should provide the following information:

CV including details of citizenship, your Official Academic Transcripts, key to grades/grading scale of your transcripts, evidence of English language proficiency (IELTS or TOEFL, for full requirements see: https://www.monash.edu/graduate-research/faqs-and-resources/content/chapter-two/2-2), and two referees and contact details (optional). You must provide a link to these documents in Section 8 using Google Drive (Instructions in Section 8).

University of Bath

Please submit your application through the following link: https://www.csct.ac.uk/bath-monash-global-phd-programme/

Please make sure to mention in the "finance" section of your application that you are applying for funding through the joint Bath/Monash PhD programme for your specified projects.

In the "research interests" section of your application, please name the three projects you are interested in and rank them in order of preference. Please also include the names of the Bath lead supervisors.