Centre for **Sustainable & Circular** Technologies

MONASH University

UNIVERSITY OF BATH

Bath Monash Global PhD Programme in Sustainable & Circular Technologies

Project Title:	Lead-free pyroelectric materials for a new form of water treatment by harvesting low grade waste heat
Supervisors at Bath:	Prof. Chris Bowen (lead); Prof Frank Marken; Prof. Toby Jenkins
Supervisors at Monash:	Dr. Alison Funston; Dr. Jie Zhang
Home Institution:	University of Bath
Indicative period at Host Institution:	2.5 years at Bath; 12 months at Monash with exact dates to be confirmed

Project Summary

Pyroelectrics are a class of materials that convert thermal fluctuations into electric charge as a result of a change in their polarisation with temperature. Applications have focused on their use for infrared detection and thermal imaging. However, in recent years a new avenue for ferroelectric materials has emerged in applications related to electrochemical catalysis based on the pyroelectric effect. This new approach in controlling electrochemical applications involves exploiting the pyroelectric charge generated during changes in the natural ambient temperature to drive electrochemical reactions. This PhD will explore potential applications related to degradation of water pollutants, and water disinfection and by using low grade waste heat (<100°C) to provide the necessary temperature fluctuations.

The PhD combines skills from Bath (pyroelectrics, electrochemistry and disinfection) and Monash (plasmonics and electrochemistry) and will:

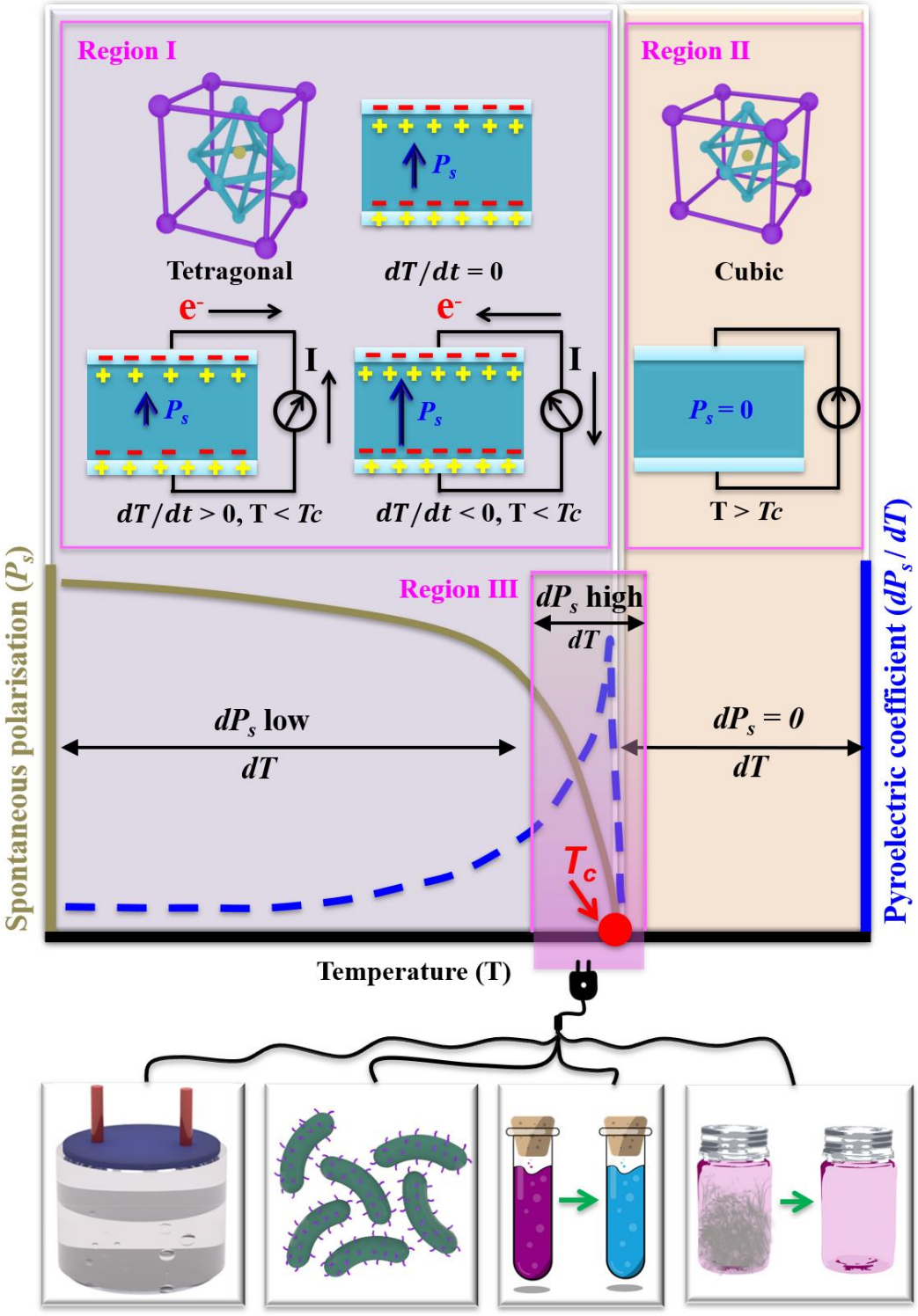
(i) Explore the potential to maximise performance using low Curie temperature (T_c) materials (< 100 °C) as a result of the large changes in polarisation due to a transition from a low temperature ferroelectric state to high temperature paraelectric state (Schematic 1). To date, limited attention has been paid to the application of the low T_c pyroelectrics, especially the use of lead-free ferroelectrics which exhibit a low T_c.

(ii) Create fine scale nano-sized powders to offer an opportunity to maximise the surface area and total surface charge when the pyroelectric particulates are in direct contact with the electrolyte.

(iii) Examine the performance and electrochemical mechanisms for disinfection of bacteria and removal of pollutants by reduction-oxidation reactions.

(iv) Further increase performance by the creation of pyroelectric particulates combined with plasmonic particles to improve photo-thermal heating.

The work aligns within the sustainable and circular technologies since it aims to reuse low grade waste heat or light for sustainable clean water and addresses key research challenges that span the chemistry/materials engineering interface. Bath will provide expertise in pyroelectric materials manufacture (Bowen), electrochemical mechanisms (Marken) and water disinfection (Jenkins) and Monash will provide expertise in plasmonics (Funston) and advanced dynamic electrochemical techniques for characterization (Zhang) of the pyroelectric enhanced reactions.



Schematic 1 The pyroelectric effect coupled with electrochemical reactions. Note the regions I (T<T_c, ferroelectric and tetragonal), II (T>T_c, paraelectric and cubic) and III (T ~ T_c, in the vicinity of the phase transition). Lower images indicate potential applications.

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 23rd February 2020

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.