Centre for Sustainable Chemical Technologies

UNIVERSITY OF BATH

Centre for Sustainable Chemical Technologies; University of Bath

Project Title:	Hierarchically designed piezoelectric energy harvesting materials for application in flexible systems
Lead Supervisor and co-supervisors:	Dr Hamideh Khanbareh Prof Chris Bowen
Industrial Partner:	Silent Sensors Ltd.

Project Summary

High-strain environment of automotive tyres provides deformation energy that can be harvested using piezoelectric materials for powering wireless sensors, thereby reducing their reliance on batteries which will simplify sensor maintenance and management, and thereby improve safety and reduce waste associated with disposable batteries.

The aim of this project is to create novel piezo-composite materials with enhanced performance, including high piezoelectric activity, thermal stability and endurance, to effectively harvest mechanical energy in flexible systems such as car tyres. This innovative project will involve collaboration with Silent Sensors Ltd, an Internet of Things (IoT) company with a focus on intelligent tyres.

Present piezo-ceramic materials and devices are brittle and cannot be operated reliably under the high strain conditions in a car tyre unless elaborate stress transfer mechanisms are employed, which increase complexity and cost. While piezo-polymer devices provide toughness and flexibility, they do not satisfy the operating thermal requirements (up to 100°C) for use in such an environment. However, functionally optimised piezo-ceramic-polymer composite films that combine piezoelectric ceramics and a thermally resistant polymer matrix can be designed to fulfil the requirements by making appropriate choices of the constituent phases and microstructure. Furthermore, these composites are suitable for low-cost mass production and easy integration into high strain systems.

The project is funded by Silent Sensors Ltd, a unique Internet of Things company focused on tyre management and in-tyre sensor platforms for fuel efficiency and accident reduction. They will bring practical understanding of integration of the energy harvesting devices to monitor tyres whilst on the road using services made of RFID tags and data delivery through the Cloud to in-field Apps. This will increase the performance and reduce the total cost of operations.

The CSCT is looking for a highly motivated candidate to:

- Design and fabricate next generation of flexible, stretchable piezoelectric materials Characterise electro-mechanical properties using dielectric spectroscopy, impedance spectroscopy as well as direct piezoelectric measurement of charge and voltage output.
- Thermo-mechanical properties will be tested using TGA, DSC and DMTA. Microstructure of the composites will be analysed using SEM.
- Map the effect of porosity, and develop a model to predict the effective electromechanical properties of composites
- Optimise the energy harvesting FOM based on properties of the constituent materials
- Characterise different electrode materials

- Mount the manufactured flexible piezo energy harvesters inside a car-tyre and evaluate the signal
- Develop a self-powered system based on the existing TPMS devices

Sustainability issues addressed

By designing novel piezo-composite materials with enhanced performance to effectively harvest mechanical energy in flexible systems such as car tyres, this project aims to enable the use of wireless sensors rather than disposable batteries on intelligent tyres and therefore reduce waste.