Department of Mechanical Engineering
Faculty of Engineering

You are cordially invited to our:
Department Seminar

Topic:	**Using the dipole of a material to enhance energy conversion – from sun to fuel and vibration to power**
Speaker:	**Dr Steve Dunn** School of Engineering and Materials Queen Mary University of London
Date:	**21 May 2014, Wednesday**
Time:	**10.00am to 11.00am**
Venue:	**EA-06-04** *(map of NUS can be found at http://map.nus.edu.sg/)*
Host:	**A/Prof Zeng Kaiyang**

Abstract

From acoustic enhancement of photovoltaic devices to the spatial separation of redox chemistry polar materials are having an ever increasing influence on energy conversion technologies. In this talk I will discuss some of our work on photocatalysis using ferroelectric materials and the influence of vibration (sound and impact) on energy harvesting and energy conversion. The underlying theme is that a polar material can be used to influence band structure and with that enhance the overall performance of energy conversion.

Specifically I will discuss the photocatalytic decolourisation of azo dyes such as Rhodamine B and Acid Black 1 using ferroelectric powders, such as $LiNbO_3$, $BaTiO_3$ and doped or plasmonic enhanced powders, as photocatalysts. For photocatalytic experiments we focus on using simulated solar illumination as the photo stimulant. We show that the rate of decolourisation can be attributed to the majority carrier and also show that the surface depolarization field associated with a ferroelectric material alters the surface chemistry. This is due to changes in the Stern and inner Helmholtz plane through to the interaction of catalyst surface charge and the polar nature of solvated species. The spatial separation of REDOX reactions in ferroelectric powders positively influences the proportion of reactions being driven to completion, enabling a high rate of decolourisation despite the wide band gap of the catalyst, which ranges from 3.2eV for $BaTiO_3$ to 3.7eV for $LiNbO_3$. Our results also indicate that the band structure of lithium niobate enables single carrier oxidation of CO_2 to occur through an altered reaction mechanism when compared to a typical system such as TiO_2. This as yet untapped reaction mechanism further enhances the rate of photochemical reactions. Our results give further evidence that ferroelectric materials provide an interesting alternative to non-ferroelectric materials as photocatalysts.

Relating the polar nature of a ferroelectric to that of piezoelectric I will expand to show how the understanding of the ferroelectric band structure can be used to further enhance vibration energy conversion. Taking two case studies from our work – vibrational enhancement of photovoltaic devices and vibration energy harvesting – the talk will draw to close when I show how careful device design can improve the ECE of a photovoltaic by around 50% when driven by musical sound and some of the improvements we have made to ZnO energy harvesting devices. A comparison between passivated and non-passivated ZnO energy harvesting devices shows that the passivated device generated an open-circuit voltage of 212 mV and short circuit current of 1 mA/cm^2 which was around twice the value of non-passivated device (90 mV and 0.66 mA/cm^2). When tested across a range of load resistances, the maximum power density was also found to have almost doubled from 36.00 $\mu W/cm^2$ across a 1.38 kΩ load for the non-passivated device to 64.40 $\mu W/cm^2$ (1.67 kΩ) for the passivated device. I will show that the voltage and voltage-driven current density of the passivated ZnO device improved due to three-fold increase in carrier life time.

References

Shoaee S, Briscoe J, Durrant J. R. and Dunn S , Acoustic enhancement of ZnO nanorod:polymer photovoltaic device performance, Advanced Materials vol. 26, (2) 263-268 (2014)

Bowen CR, Kim HA, Weaver PM and Dunn S, Piezoelectric and ferroelectric materials and structures for energy harvesting applications. Energy and Environmental Science vol. 7, (1) 25-44 (2014)

Briscoe J, Cui Y and Dunn S, Effect of ferroelectricity on solar light driven photocatalytic activity of $BaTiO_3$ – influence on the carrier separation and Stern layer formation, Chemistry of Materials, 25 (21), pp 4215–4223 (2013)

Briscoe J, Jalali N, Woolliams P, Stewart M., Cain M., Weaver, PM and Dunn S, Measurement techniques for piezoelectric nanogenerators, Energy and Environmental Science, DOI: 10.1039/c3ee41889h (2013)

About the Speaker

Dr Steven Dunn is Reader in Nanoscale Materials at Queen Mary University of London, where he has been a staff member since September 2009. Dr Dunn completed his PhD at Cambridge University before moving to Cranfield University working with Professor R Whatmore and initiating his independent research career in 2003. He now has extensive experience managing a range of projects from large multi partner European Union programmes to more intimate business to business projects and has developed an extensive network of contacts both nationally and internationally. Dr Dunn has generated over £4.5m of income since January 2011 which has been focused on developing materials and devices that are nanostructured, or have enhanced functionality due to size constraints. This income supports a team of 11 researchers who range in skills from materials development and analysis to device fabrication. Since 2012 Dr Dunn has published over 15 papers in journals such as Advanced Materials, Energy and Environmental Science and Nature Communications, with a recent Advanced Materials publication being the 5th most reported in the press for Advanced Materials. He has provided many keynote presentations as well as consultancy to clients based across Europe, America, China and Singapore. He is a Fellow of the Institute of Mining Minerals and Materials, and Institute of Nanotechnology.

Admission is free. All are welcome to attend.