CAM-IES: Centre for Advanced Materials for Integrated Energy Systems

£2.4M funding for an EPSRC Networking Centre + £1.4M Matching from Industry
Joint Centre involving Cambridge, Newcastle, Queen Mary and UCL. 400k earmarked for networking activities

Start Date: 1 December 2016

Objectives:

- To create a UK-based community of researchers focused on materials for Integrated Energy Systems.
- Facilitate access to experimental facilities for interested users, in particular unique tools for energy materials characterization and deposition that are currently being set-up in Cambridge as part of the Sir Henry Royce Institute.
- Develop advanced materials for energy storage, specifically **solid-state batteries, coatings for high voltage electrode battery materials, and flow batteries, and solid-oxide fuel cells, CO_2 gas separation membranes, hybrid thin film photovoltaics** and **large-area thermoelectrics**
- Help identify new research directions, working closely with industry

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CAM-IES: Centre for Advanced Materials for Integrated Energy Systems – PIs and project leads

Chemistry:	**Prof Clare P. Grey (Director and PI; WP3)**
CAM COIs: Dept. of Materials Science:	**Prof Judith Driscoll (WP1)**
	Dr. Sohini Kar-Narayan
Cavendish Laboratory:	**Dr Siân Dutton**
	Prof Sir Richard Friend (WP6)
	Prof Henning Sirringhaus (Co Director; WP5)
Dept. of Engineering:	**Dr Stephan Hofmann**
Newcastle University:	**Prof Ian S. Metcalfe (Co Director; WP2)**
QMU:	**Prof William Gillin**
	Dr Christian Nielsen
UCL:	**Dr Hugo Bronstein (WP4)**
	Prof Franco Cacialli
Programme Manager:	**Lata Sahonta**

Project Partners

Applied Materials Inc
Deregallera Ltd
Shell
Eight19 Ltd
Sasol Technology Research Laboratory
American Institute of Physics
National Physical Laboratory NPL
Siemens plc
ARM Ltd
Cambridge Display Technology Ltd
Johnson Matthey
Tata Steel UK

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Challenges and Scientific Approach

From basic scientific understanding through to device optimisation there is insufficient attention paid to characterising, understanding and tackling interface issues in energy materials.

- What is the relationship between the nature of the interface and the ionic and electronic conductivity both in, and across, an interface?
- How important is strain and materials orientation in controlling ionic and electronic transport?
- How do ions/electrons move across interfaces and how perfect does the interface need to be?
- Can we design structures that are inherently stable towards ion migration/removal of an ion /expansion/contraction on extended operation, often under extreme conditions?
- How do we control electron and energy transfer at hybrid organic-inorganic heterointerfaces?
- Which two materials' surfaces should we interface to maximize performance?

Approach
(i) develop new strategies for growing new controlled model and complex interfaces,
(ii) pioneer new metrologies to characterize interfaces under operando conditions,
(iii) integrate the new materials into operating devices and optimize performance.

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- *Characterisation techniques*: Cross-fertilization from other communities - the battery community has developed techniques for characterising electrochemical processes at buried interfaces, such as NMR, PV researchers have advanced analogous techniques for electronic processes, such as time-resolved pump-probe spectroscopy..
- *Materials discovery:* focus not only on materials discovery but also on interfacing of nano-materials and on exploring integration of functional materials across traditional boundaries. E.g., organic materials that undergo two (or more) electron transfer steps, such as quinones, are widely studied by the organic optoelectronics community as charge transport materials; the knowledge gained will aid the design of novel organic materials for redox flow batteries.
- *Materials, device and system integration:* Opportunities exist to combine different functional materials into hybrid heterostructures, for integrating different energy devices together onto a common substrate and for sharing scientific knowledge between different energy communities to design better integrated energy systems.

Enabling Capabilities and Techniques

A major CAM-IES goal is to design and build new tools to control and characterize interfaces.

A wide spectrum of techniques for characterising both electrochemical and electronic processes at heterointerfaces is already available:
In-situ and in-operando characterisation techniques, such as in-situ X-ray diffraction and in-situ *NMR/magnetic resonance imaging (MRI)*
Pulsed isotope exchange, PIE

Theory and simulation: *ONETEP*, d-AIRSS, the *eigenvector-following (EF) technique*

10million capital investment in materials deposition and characterisation infrastructure as part of the Sir Henry Royce Institute.
"Ambient Processing Cluster Tool":
Pulsed laser deposition (PLD) facility with in situ X-ray and ultraviolet photoelectron spectroscopy (XPS/UPS) capability.
In-situ TEM:
Environmental XPS

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