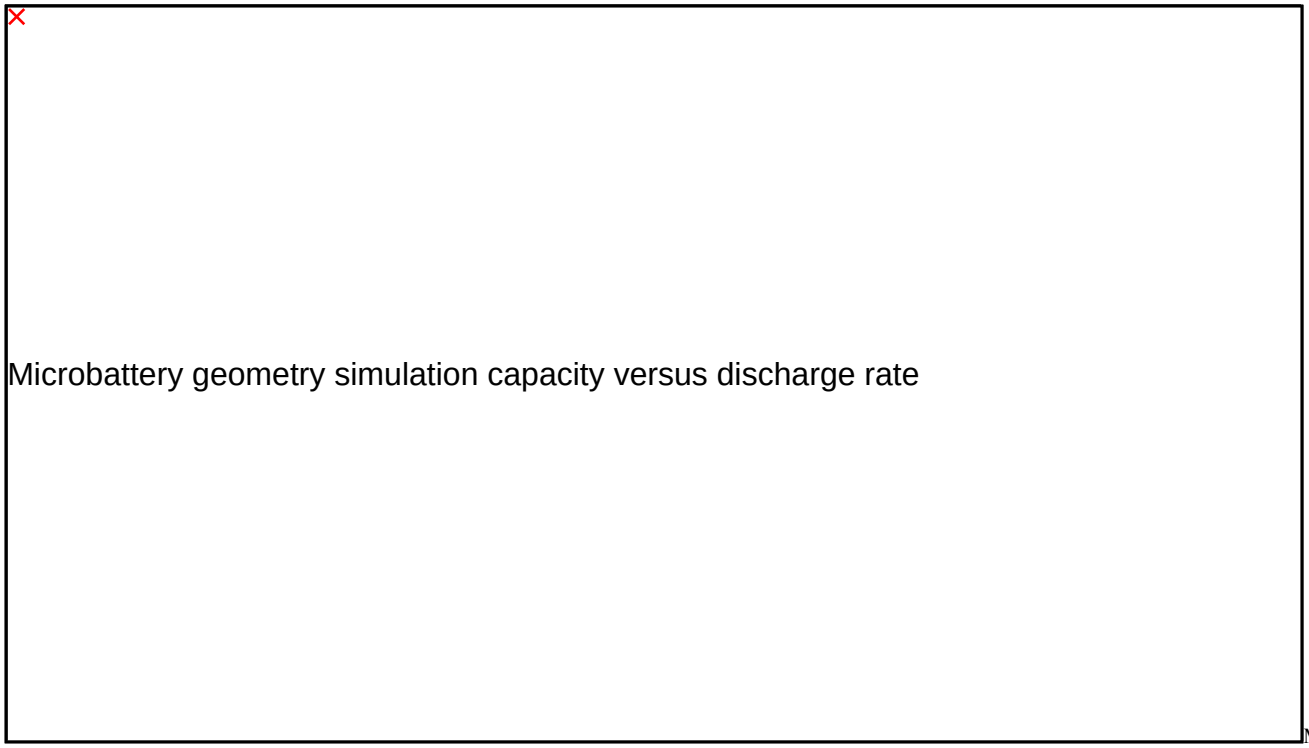
# Electrochemical Materials for Energy Storage

### Microbatteries

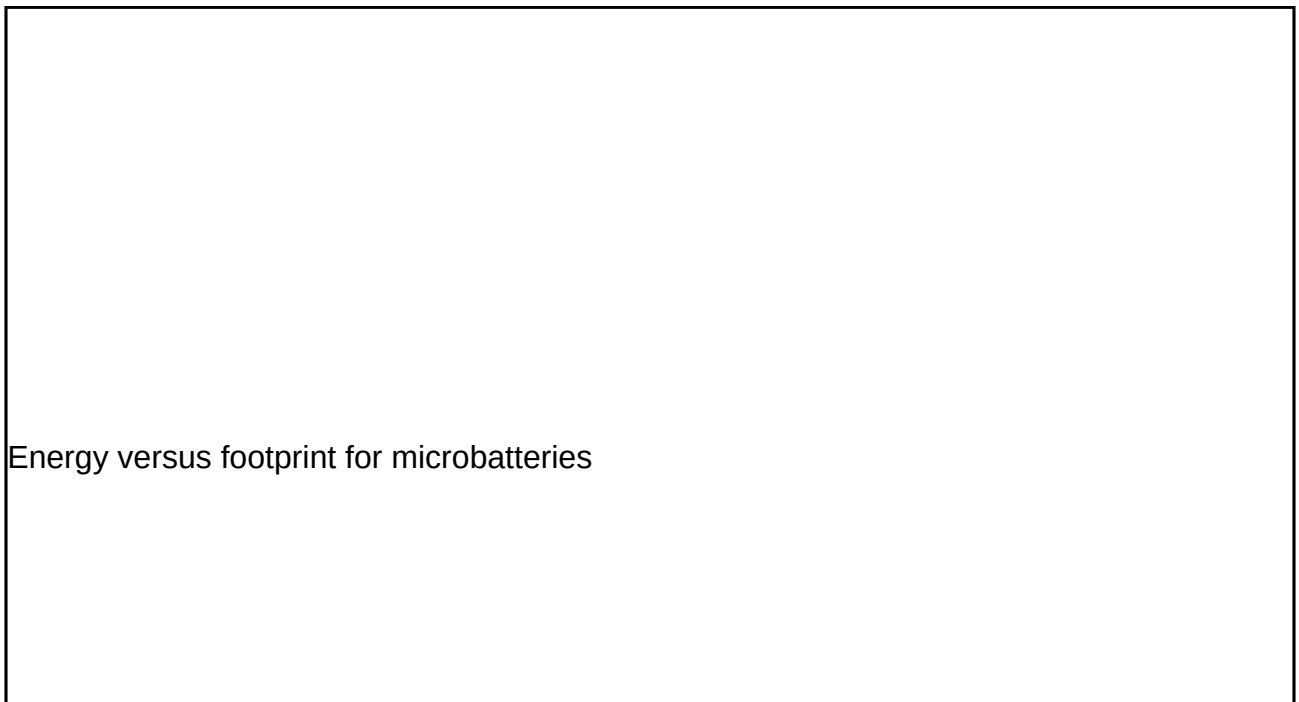
**Portable electronic devices rely on batteries for energy storage and operation. Planar (or 2D) lithium batteries have met the needs of this industry for the past 25 years. For extended operation, higher power and shorter charging times new materials and architectures are required. Similarly smaller or distributed sensors for the developing 'Internet of Things' also require enhanced energy storage in a decreased volume or area. Ultimately we believe this requires a hybrid energy harvesting and storage solution with minimal stored capacity loss during thousands of cycles.**

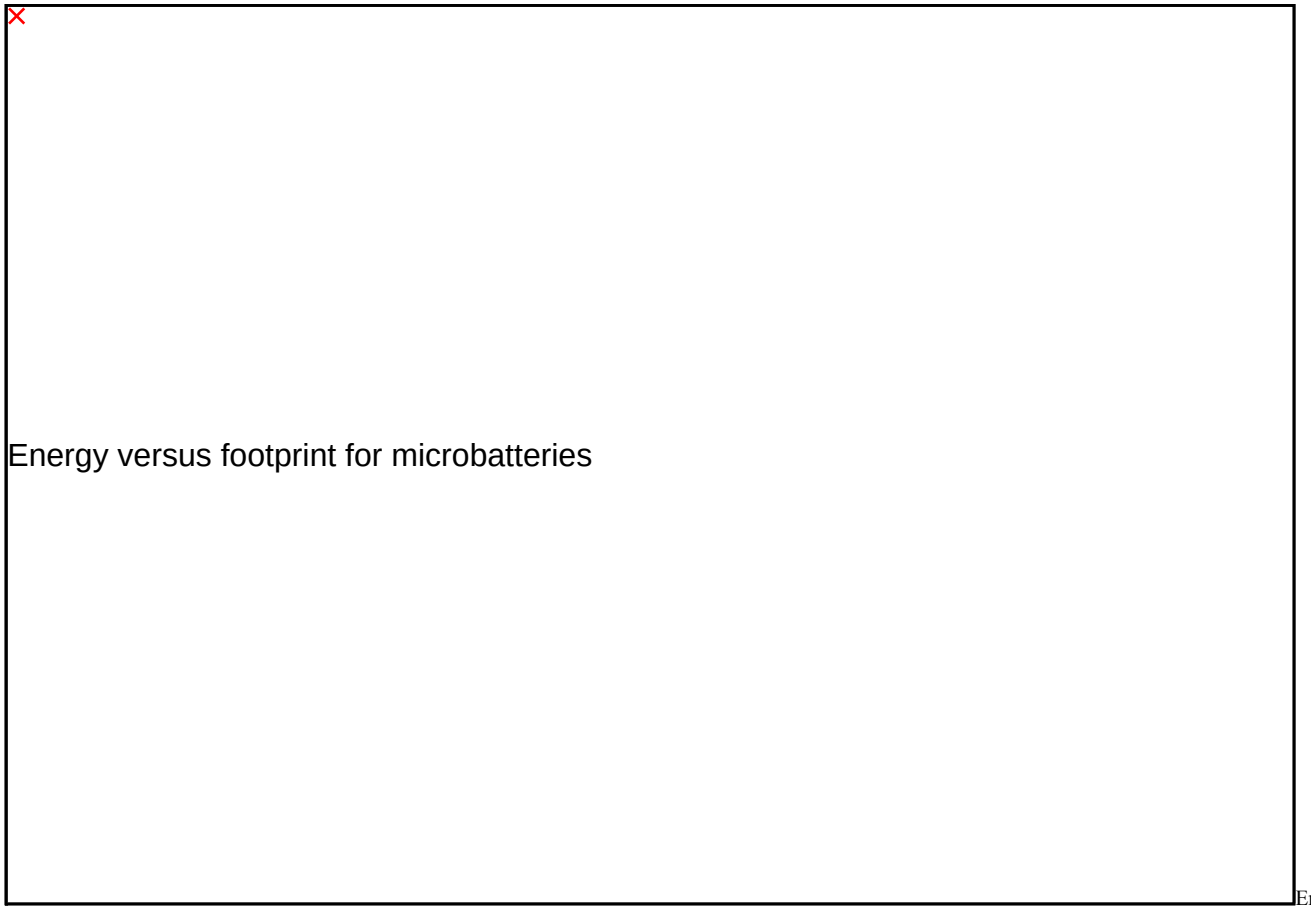


Microbattery geometry simulation capacity versus discharge rate

We are investigating novel materials and architectures for better batteries. We are analysing the influence of 3D structures to increase the energy provided without increasing the battery size or area. In current thin-film microbatteries the active material layer thickness is limited to micron scale dimensions in a large footprint 2D geometry due to the low conductivity and slow transport of ions in the solid state materials. We are utilising nanoscale materials over high conductivity supports such as copper to enhance the charge and discharge rate and overall stability of the active battery material. Nanotube based core-shell architectures also alleviate the effect of volume expansion, enhancing mechanical stability at the nanoscale in addition to the improved electronic and ionic characteristics.

We have utilised advanced device simulations to guide the experimental processing of materials at the modelled dimension and in the correct format to predict and design the structures necessary to achieve the best energy density 3D microbattery materials. We are developing processes for the most energy dense and high rate capable lithium ion battery materials for enhanced cycle life in typical battery electrolytes.





Energy versus footprint for microbatteries

We are investigating routes for the integration of the high energy density materials that can withstand microelectronics based processing temperature regimes. The projects are targeting a further integration of microelectronics and energy devices for enhanced products of relevance to electronics, healthcare and energy companies in Ireland.

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## Related Publications

- Core-shell Nanoarchitectures for Lithium-Ion Energy Storage Applications
  **MRS Advances** volume **1** issue **15** pages **1055 to 1060** (2016)
  Authors: Tomas M. Clancy, James F. Rohan

- Nanotubes of Core/Shell Cu/Cu[sub 2]O as Anode Materials for Li-Ion Rechargeable Batteries
  **Journal of The Electrochemical Society** volume **157** issue **6** page **A682** (2010)
  Authors: Maksudul Hasan, Tamjid Chowdhury, James F. Rohan

- Energy Storage: Battery Materials and Architectures at the Nanoscale
  **ICT - Energy - Concepts Towards Zero - Power Information and Communication Technology** (2014)
  Authors: James F., Maksudul Hasan, Sanjay Patil, Declan P., Toms Clancy

- Fabrication of three-dimensional substrates for Li microbatteries on Si
  **Applied Surface Science** volume **256** issue **3** pages **S61 to S64** (2009)
  Authors: Arockia Vimal Jeyaseelan, James F. Rohan