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Mass-selected nanoparticles as model catalysts for electrochemical energy conversion

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Hydrogen could provide the cornerstone for a future sustainable society free of fossil fuels. However, the production of hydrogen in electrolysers is limited by the oxygen evolution reaction at its anode. Likewise, the utilization of hydrogen in fuel cells is limited by the backwards reaction, oxygen reduction. In order to minimize the efficiency losses incurred by these reactions, high loadings of catalysts based on precious metals are employed at the oxygen electrode. It turns out that several years' supply of Pt, Ru or Ir would be needed to scale up these technologies to the terawatt level, i.e., to a scale where they would make an impact to the global energy landscape. Consequently, it is essential to establish the extent to which the mass activity of these catalysts, i.e., the current density per unit mass, can be maximized. In this contribution, we study the catalytic performance of well-defined, size-selected nanoparticles of RuO_x for oxygen evolution and Pt, Pt_xY and Pt_xGd for oxygen reduction. They are produced using the magnetron sputtering method, and size-selected using a time-of-flight filter. By resorting to a physical method, we can elucidate intrinsic relationship between particle size and catalytic activity, without the inherent artefacts that are introduced from chemical synthesis. We complement electrochemical tests of catalytic performance with a number of different characterization techniques, including electrochemical scanning tunneling microscopy, X-ray photoelectron spectroscopy, transmission electron microscopy and X-ray absorption spectroscopy. For both reactions, the catalysts exhibit substantial activity enhancements over the current state-of-the-art.

Biography

Ifan E L Stephens obtained his PhD from the University of Cambridge. Since 2008 he has been employed at the DTU Physics, Denmark, first as a Postdoctoral Researcher, and since 2011 as an Assistant Professor. He has published 26 papers in peer-reviewed journals, including *Nature Chemistry, Nature Materials, Angewandte Chemie, JACS and Energy* and *Environmental Science*. His research is concerned with electrocatalysis for fuel cells and sustainable fuel production. He is particularly interested in the interplay between electrochemical experiments, first principle calculations, and surface science methods in the search for new catalyst materials.

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