SUMMARY OF FINDINGS

STRIVE Fellowship

(2007-ET-FS-6-M5)

ENVIRONMENTAL TECHNOLOGIES:

Potential for a Zero Carbon Emission Micro Fuel Cell

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As the impact of the overdependence on fossil fuels becomes more apparent on gradual climate changes and the deterioration of the environment, the search for clean, efficient and safer energy sources is becoming increasingly important. The impetus for this project came from the need to develop low-carbon or decarbonised energy sources. This study unveils nanoporous gold as a remarkably efficient anode catalyst for a direct borohydride fuel cell.

Background

Identifying innovative energy solutions plays a vital role in responding to environmental-protection challenges and societal needs. Fuel cells can play a key part in delivering on the objectives of Ireland's 'smart green' economy through the generation of cleaner and more efficient power that places less stress on the environment owing to a decrease in emissions related to energy production.

Key Points

- This STRIVE project focused specifically on exploiting the properties of nanoporous gold, in particular, its large specific surface area combined with a high density of defect sites to develop an anode catalyst for a direct borohydride fuel cell that has high catalytic activity for oxidation of borohydride and low activity for its competing hydrolysis.

- The advantages of a borohydride fuel cell include the high energy density of borohydride coupled to the emission of carbon-free byproducts. Borohydride is non-toxic and easy to store, and transport and its byproducts can be regenerated into borohydride.
- Nanoporous gold electrodes were fabricated in a range of film and wire array formats by selectively dealloying silver from silver–gold alloys. Borohydride oxidation was studied by cyclic voltammetry at the nanoporous gold electrodes. These criteria point to nanoporous gold being a highly favourable and efficient catalyst for borohydride oxidation.
- In addition, facile and efficient oxidation of two other high-energy density fuels (ammonia borane and dimethylamine borane) at nanoporous gold that do not emit carbon byproducts was demonstrated.
- Nanoporous gold presents an attractive alternative to gold nanoparticle-based catalysts for fuel cells in that it does not require a carbon support, thereby removing the stability issues associated with carbon-supported gold nanoparticle systems.
- A prototype miniature direct borohydride fuel cell 1cm^2 in size (shown in Figure 1) was constructed using printed circuit board plates with manganese dioxide as cathode and NPG as anode.

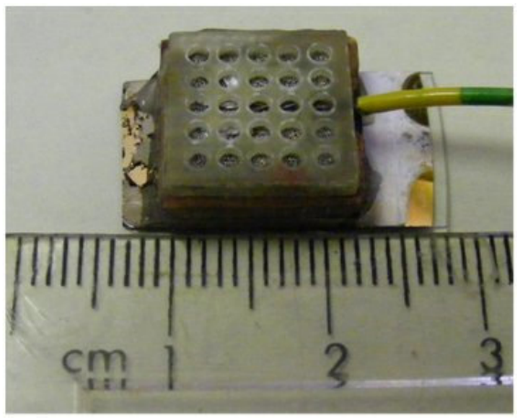

Figure 1 Side view of Direct Borohydride Fuel Cell

- Identifying innovative energy solutions plays a vital role in responding to environmental-protection challenges and societal needs.
- In summary, the facile and efficient oxidation of borohydride, a high-energy density fuel which does not emit carbon by-products was demonstrated at a nanoporous gold catalyst. This finding points to the future integration of this catalyst in the anode compartment of a direct borohydride fuel cell. The efficient oxidation of zero carbon

fuel sources warrants further investigation in order to realise the full potential of decarbonised energy technologies.

For Further Information

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The State of knowledge report 'Zero Carbon emission micro fuel cell design', Lorraine Nagle and James Rohan is published by the Environmental Protection Agency and is available from http://erc.epa.ie/safer/iso19115/displayISO19115.jsp?isoID=144

The report ENVIRONMENTAL TECHNOLOGIES: Potential for a Zero Carbon Emission Micro Fuel Cell (STRIVE 70) was funded by the Environmental Protection Agency and is available from http://www.epa.ie/downloads/pubs/research

Publications resulting from this project:

'Nanoporous Gold anode catalyst for Direct Borohydride Fuel Cell', Lorraine Nagle and James Rohan, *International Journal of Hydrogen Energy*, 36, 10319 (2011).

'Direct Oxidation of Ammonia Borane at Nanoporous Gold', Lorraine Nagle and James Rohan, *J. Electrochem Soc*.,158(7) B772-B778 (2011).

'Direct Oxidation of Ammonia Borane as an Alternative Fuel at Nanoporous Gold', Lorraine Nagle and James Rohan, *ECS Transactions*, 25 (41), 13 (2010).

'Nanoporous Gold Catalyst for Direct Borohydride Fuel Cell', Lorraine Nagle and James Rohan. Book of abstracts for the 14th *International Conference on Solid Films and Surfaces*, 344, 2008.