UK-Korea: Innovative concepts from Electrodes to Stacks
H2FC Supergen, University St Andrews, 1-2 September

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Innovative Concepts from Electrodes to Stack

• Three year Project (1 Feb 15 - 31 Jan 18)
• £1M (80% FEC)

UK: UCL (Prof. D Brett), Loughborough (Dr R. Chen), Imperial

Korea: KIER (Prof. C.S. Kim); Hanbat (Dr K.Y. Kim); Soongsil (Dr K.W. Park)

• Consortium agreement
• Kick-off meeting Imperial 24/7/2015
Innovative Concepts from Electrodes to Stack
Roles of participants

Catalyst and Support
- Imperial College
- Soongsil University
- Johnson Matthey
- RTX Corp

Transport layer
- KIER
- Imperial College
- NPL

MEA
- Imperial
- Johnson Matthey
- KIER

Metal Foam Bipolar Plate
- UCL
- KIER
- Hyundai Hysco

CFD of Heat and Mass Transport in Metal foam
- Loughborough, Hanbat National Univ.

Graphite Bipolar Plate
- Hankook Tire

Imaging and diagnostics
- UCL, KIER

Stack clamping and Construction
- Loughborough, KIER
- Hyundai Hysco
- Intelligent Energy

Evaluation of Stack
- Loughborough
- Arcola
- KIER

Better durability
Higher catalytic performance

Improved mass and heat transport

Reduced stack volume and mass
Catalyst and support

~40-60 nm

Range of different metal phosphides produced
- A number appear more corrosion resistant than carbon
- Surprising ORR activity in acid (all are active in alkaline)
- All are active for hydrogen evolution
- Some are active for oxygen evolution

Corrosion in 0.1M HClO₄ at 1.2V

Oxygen reduction in 0.1M HClO₄

ORR in 0.1M KOH
Transport layer

Replace carbon transport layer with thinner metal layer to enhance mass transport and electrical/heat conductivity and PD_{Volumetric}

- For certain values there is an improvement over current GDLs
- Various anti corrosion layers tested
MEA – parametric studies to optimise performance

Effect of catalyst layer coating method

Microstructural changes by coating method

Decal
- Dense structure
- Low contact resistance
- High conductivity

Spray
- Porous structure
- Low mass transport resistance

Two catalyst layer

- Dense CL microstructure on membrane side
- Porous CL microstructure on GDL side

→ High conductivity + Low mass transport resistance

Different ionomers
Asahi-Kasei vs. 3M
Metal Foam Bipolar Plate

Utilising a metal foam gives better pressure distribution.
Determine optimum position of inlet and outlets for porous flow fields
- How to provide the most uniform distribution
Stack clamping and construction

- **Endplate**
- **Bi-polar plate**
- **Gasket**
- **MEA**

**Graph:**
- Contact pressure [Pa]
- Normalized cell position (0.5 at centre)

- 2cm thick endplate, mean variation 15.1%
- 3cm thick endplate, mean variation 4.93%
- 4cm thick endplate, mean variation 2.25%

**Designs:**
- **8 Bolt design**
  - 12mm solid endplates
- **Wire clamping design**
  - 5mm solid, 12mm rib
Imaging and diagnostics

POROSITY (%) vs COMPRESSION %

AVERAGE TORTUOSITY vs COMPRESSION %
Meetings – Korea - November 2015

Korea 11/2015 – Jeju Island (Linked to AFORE meeting)

- KIER Jeju Global Research Center on Jeju island
- KIER main research Fuel cell labs at Daejon
- KIER fuel cell test facility and type approval laboratory (Buan)
Meetings – UK - December 2015

- Linked to Supergen meeting
- Dr Chang Soo Kim gave keynote on R&D status of Korean fuel cell
- Visits to University labs and collaborators
  - Johnson Matthey
  - NPL
  - Intelligent Energy
Meetings – Korea – May 2016

• Linked to EMN conference which followed the meeting
Research Exchanges

Dr Kieran Fahy (Imperial) and Dr Ashley Fly (Loughborough) to KIER
• 25th April to 30th May
• Learn how to make CCMs
• Computational work on flow field design and wire clamping

Forthcoming trip of Soongsil researchers to Imperial to learn diagnostic techniques (5 September 2016)