Pt-nanowire thin film catalyst electrode for PEFCs

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Outlines

- Hydrogen and fuel cell research in Birmingham
- Pt-nanowire thin film catalyst electrodes
- Active screen plasma treatment to GDL support
- Summary and future work

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Graphene oxides & Catalyst supports

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Nanoparticles for Fuel cells

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Platinum recovery

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Economics

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Energy Policy, Techno-economics

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Non-technical Barriers to Energy Transition

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Hydrogen Production via Photocatalysis

Mathematics

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Prof, D Needham

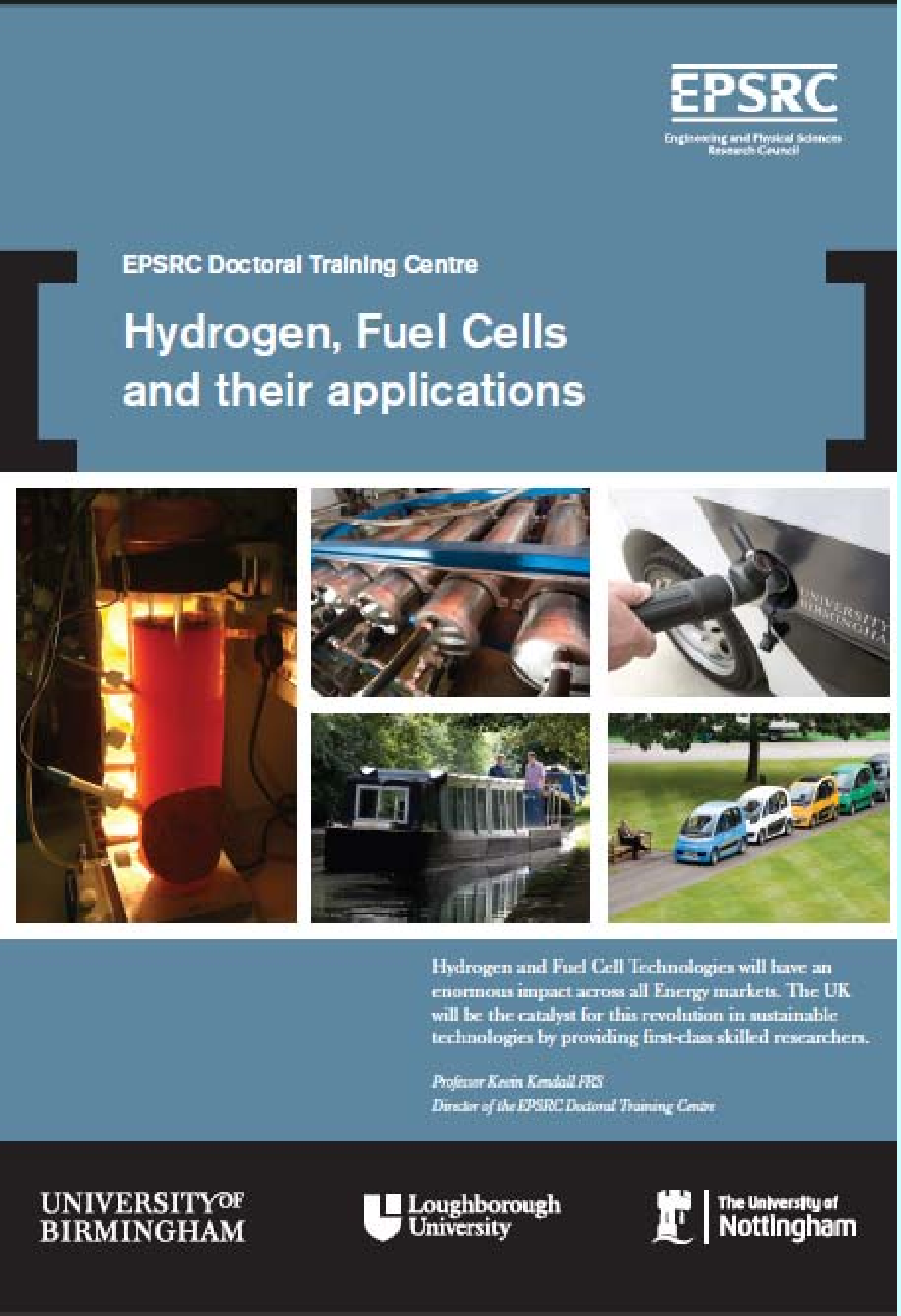
Dr Jamal Uddin

Dr D. Leppinen
Modelling of SOFC & PEMFC

Research Councils UK Energy For a Low Carbon Future

Birmingham Science City ideasforlife

www. hydrogen.bham.ac.uk
www.fuelcells.bham.ac.uk



£5.5M–UoB/LU/UoN

- 9 year programme
- 50 PhD students to be recruited
- 4 year PhD
- 120 credits (modules) + dissertation
- PhD projects covering Hydrogen generation, Hydrogen storage, Fuel Cell, Materials and system integration

For further details, please contact
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Polymer electrolyte fuel cells (PEFCs)

Hydrogen House: BAXI-CHP

Hybrid hydrogen-powered fuel cell cars: MicroCab

A clean power generator with high energy efficiency;

Barriers: High cost; poor durability and reliability

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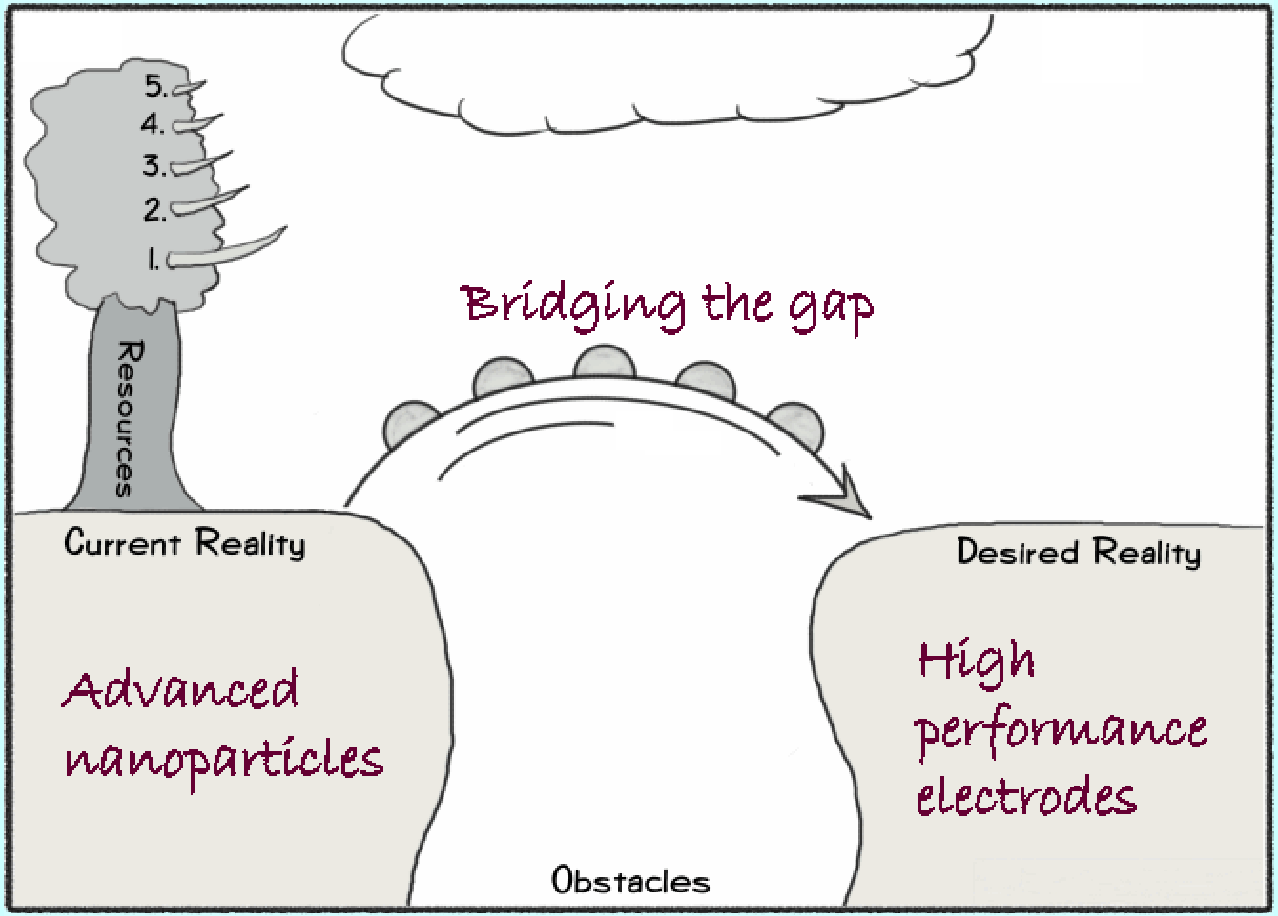
Challenges to PEFCs



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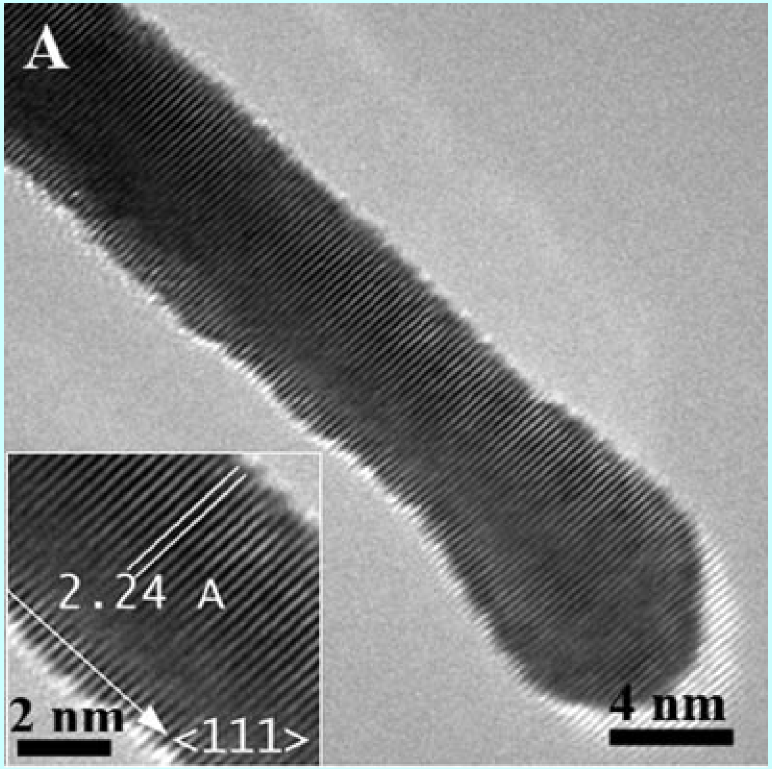
Pt nanowires

One-dimensional (1-D) nanostructures:

- □ Anisotropy
- □ Unique structure
- □ Surface properties



SH Sun et al. *Angew Chem Int Ed* 2010

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Pt-NW electrodes

Electrode structure:

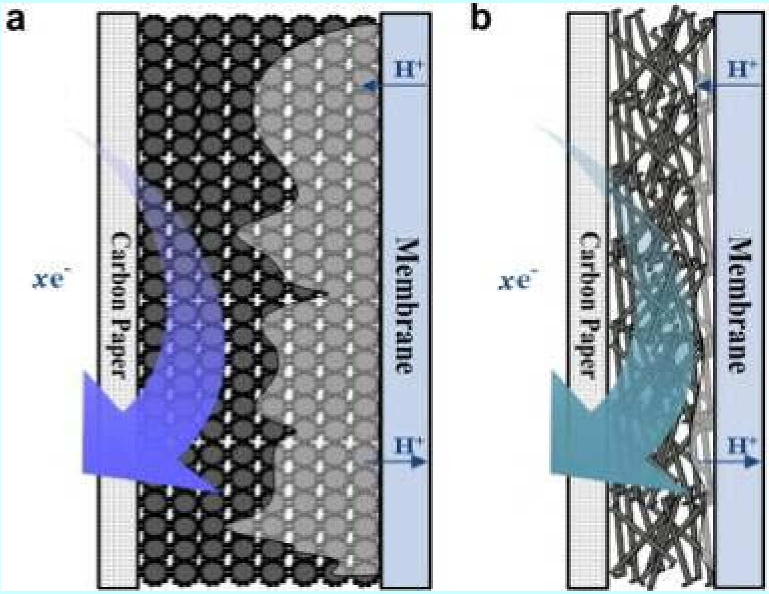
Facile pathways for charge transfer

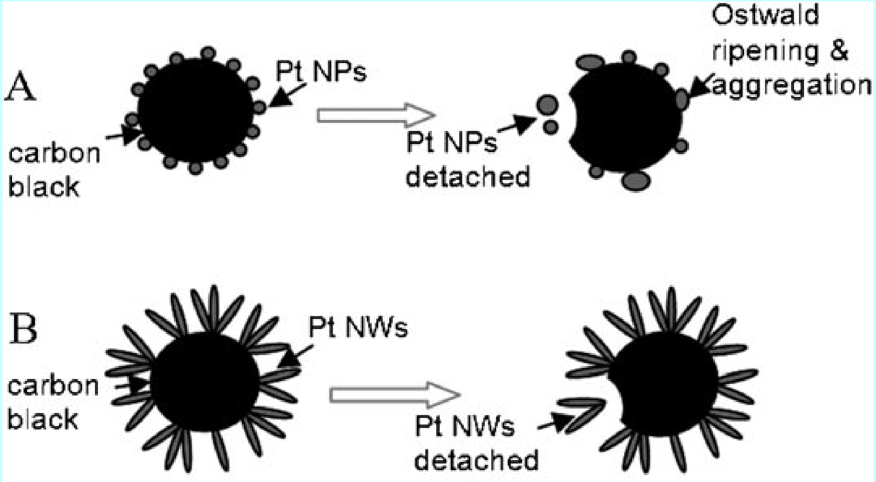
Reducing embedded sites

Facilitating effective mass transfer

Stability :

Mitigates Ostwald ripening and aggregation





YS Kim et al. *Electrochem Commun* 2008
S Du. *Int J Low Carbon Tech* 2012

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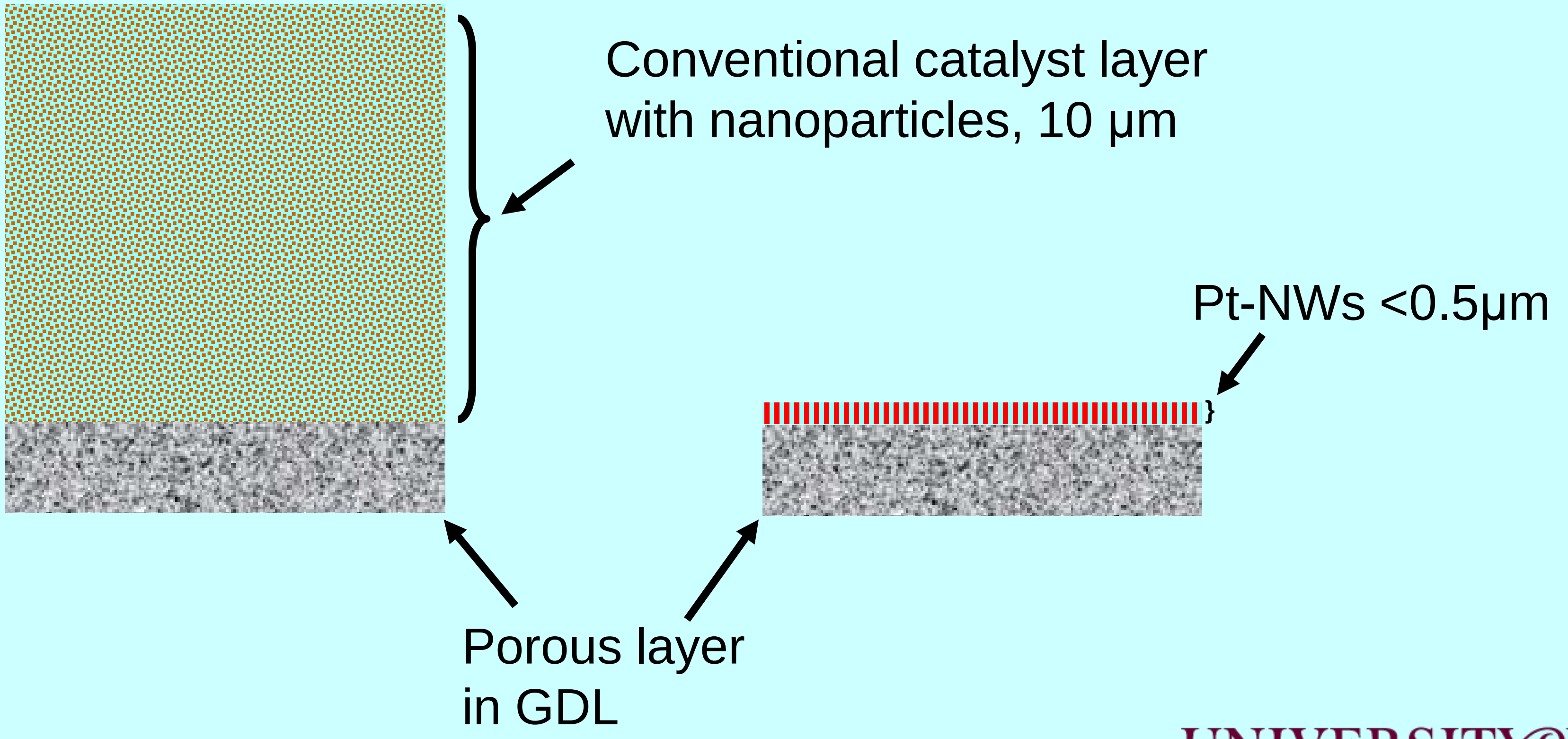
Disadvantages of Pt-NW electrodes

- Unusual shapes and bulky specific volumes:

- Difficult to fabricate into fuel cell electrodes

  Common obstacles:
  - Loose structures in coated layers
  - Thick catalyst layers
  - High electrode resistance
  - Poor cell performance

Pt-nanowire (Pt-NW) thin film catalyst electrode



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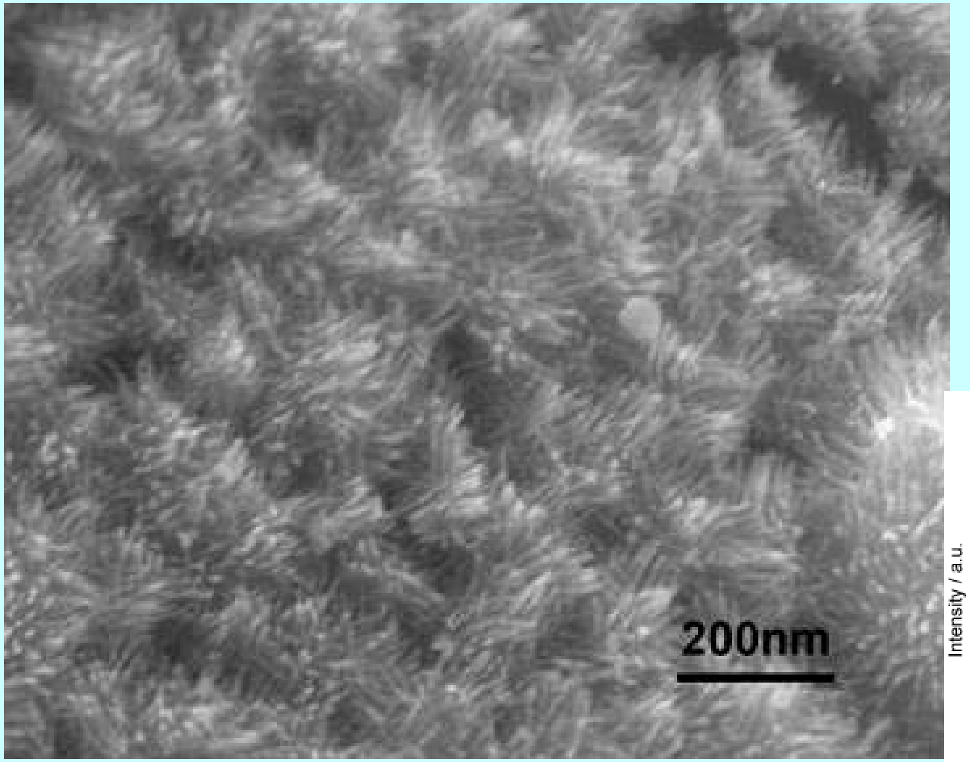
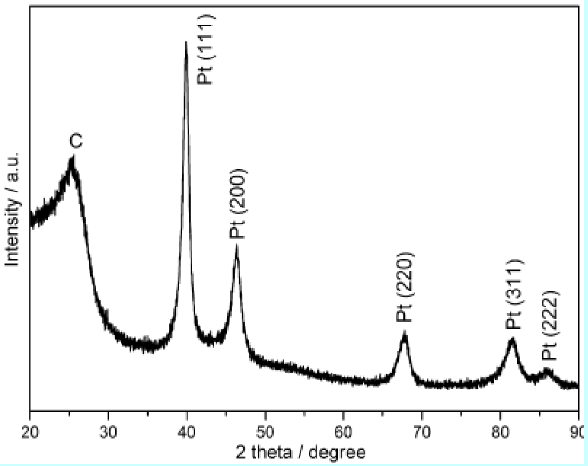
Pt-nanowire thin film catalyst electrode



Thickness < 0.5µm

Simple single-step method:

- Aqueous solution
- Room temperature
- No free nanoparticles



S Du, *et al*. *J Power Sources* 2010; *Int J Hydrogen Energy* 2011

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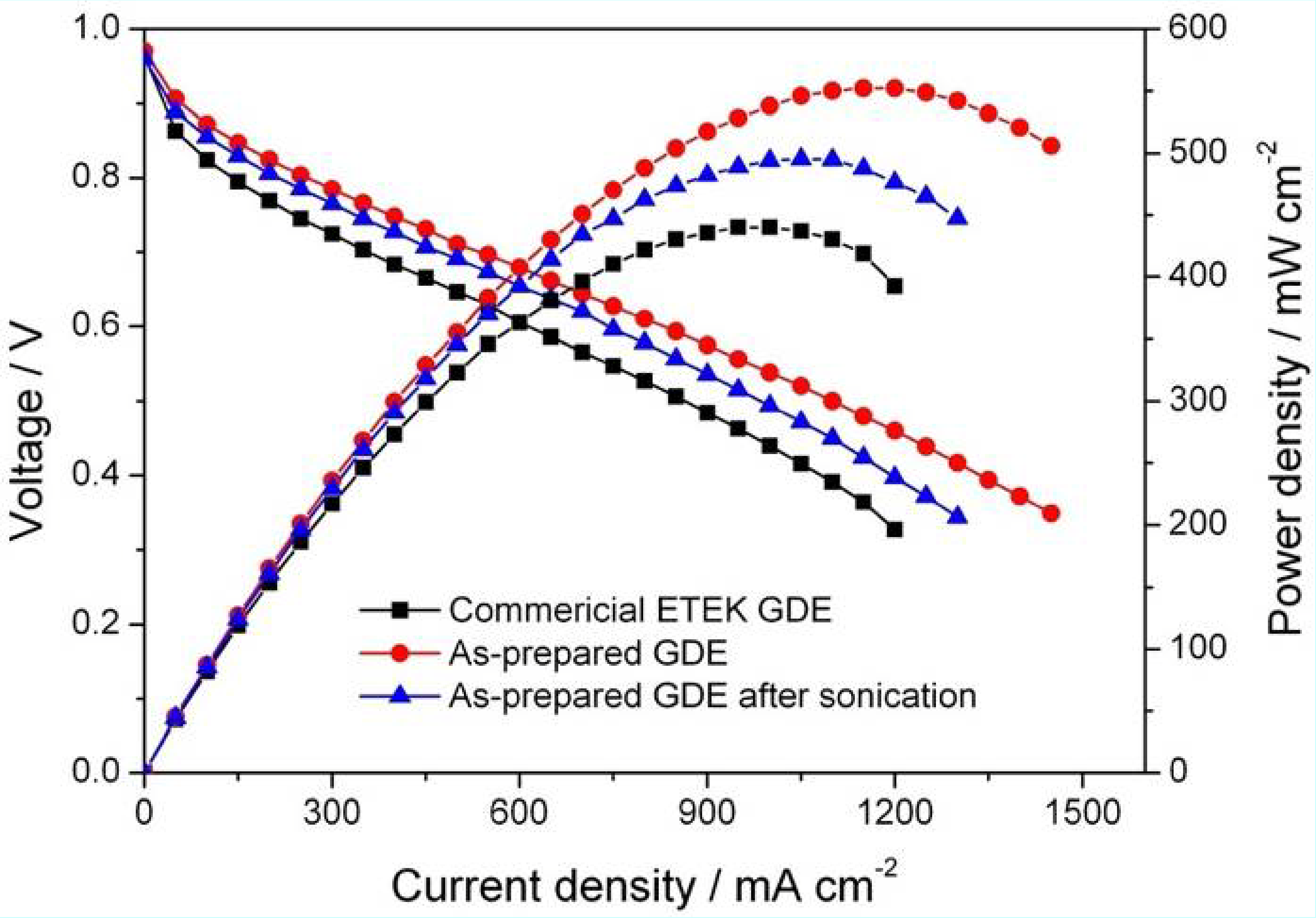
Power performance as cathode in PEMFC



FCT50-S: 25 cm^2 PEMFC, 65^{o}C, H_2/Air 1.5 bar, 100% RH

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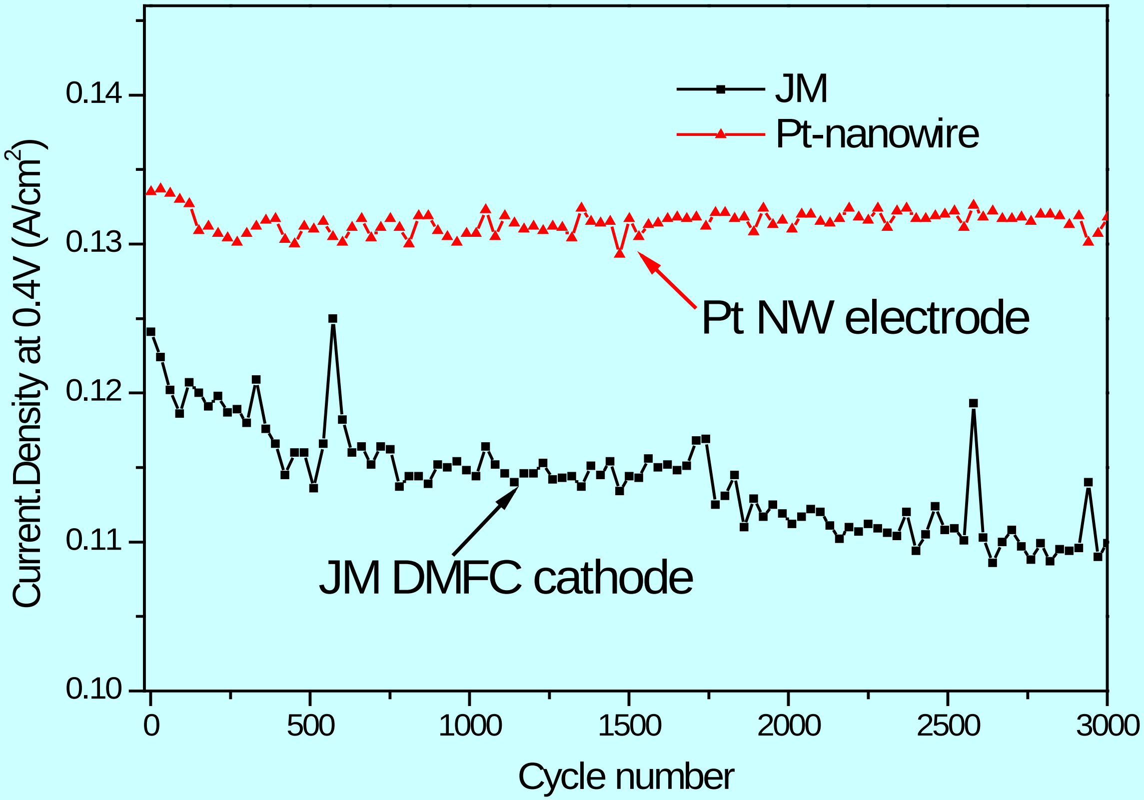
Pt-NW thin film catalyst cathode in DMFC



75 ^{o}C, 3000 loading cycles: 0.2–0.7V, 50 mV s^{-1},
Anode: 1.0 mL min^{-1} 1N CH_3OH; Cathode: 100 sccm air

S. Du, et al. EFCF 2011 A0707

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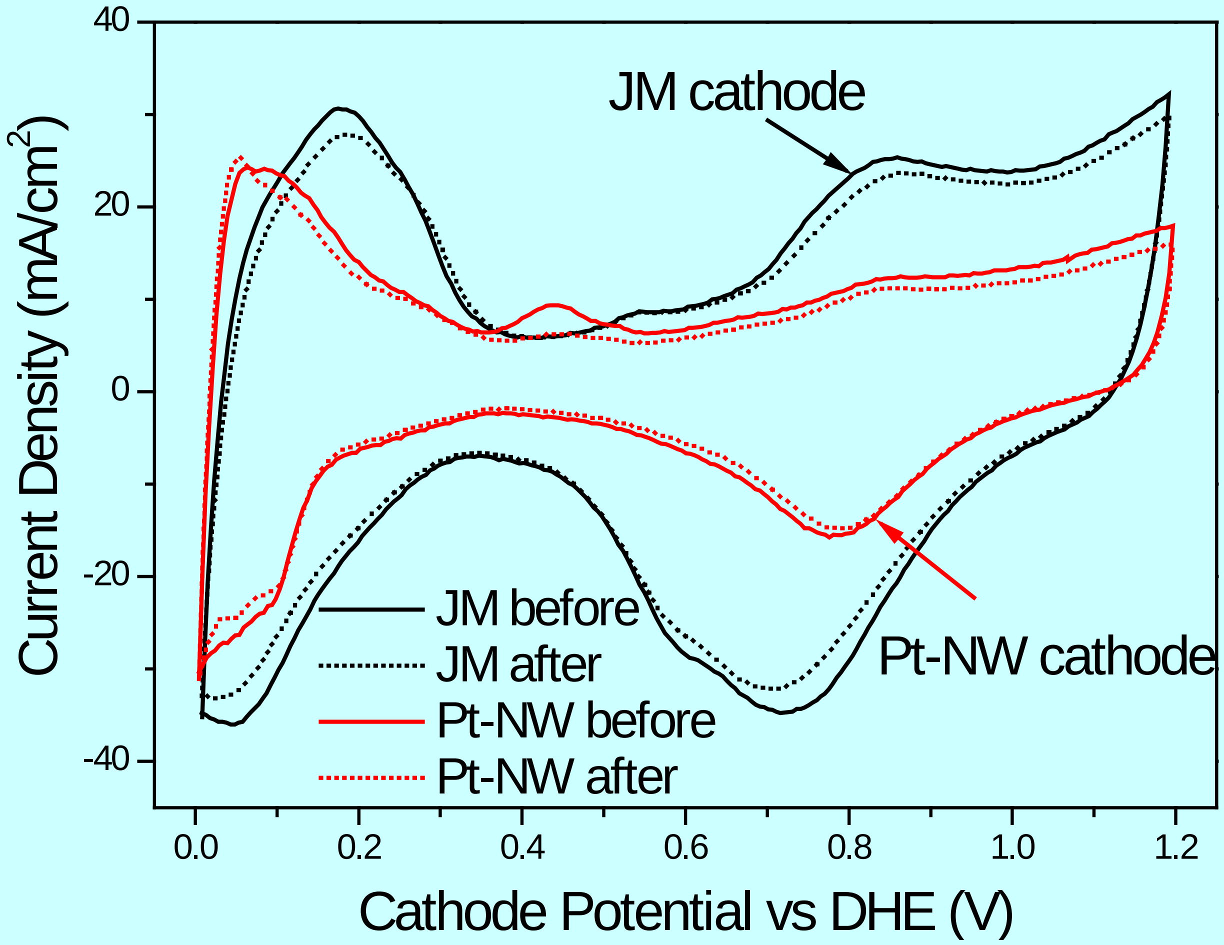
Cathode CV in DMFC



Scan rate:
20 mV s^{-1}

Cell temperature:
75 ^oC

Anode:
non-humidified H_2
100 sccm
No back pressure

Cathode:
ultra-pure water
1.0 mL min^{-1}

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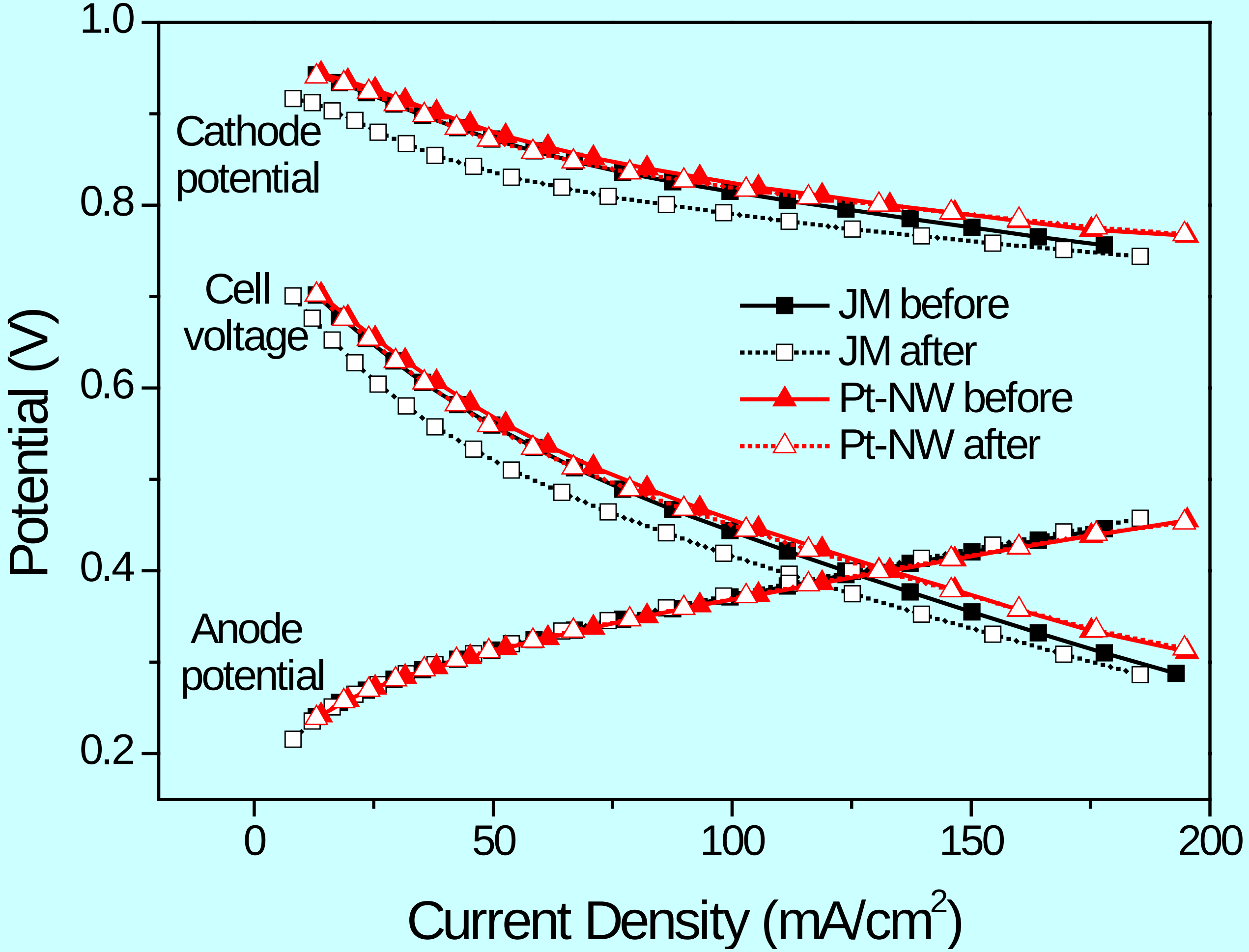
Durability test – Cathode polarization



Anode polarization:
Scan rate:
5 mV s^{-1}

Cell: 75 ^{o}C

Anode:
1 mol L^{-1} CH_3OH
1.0 mL min^{-1}

Cathode:
non-humidified H_2
100 sccm
No back pressure

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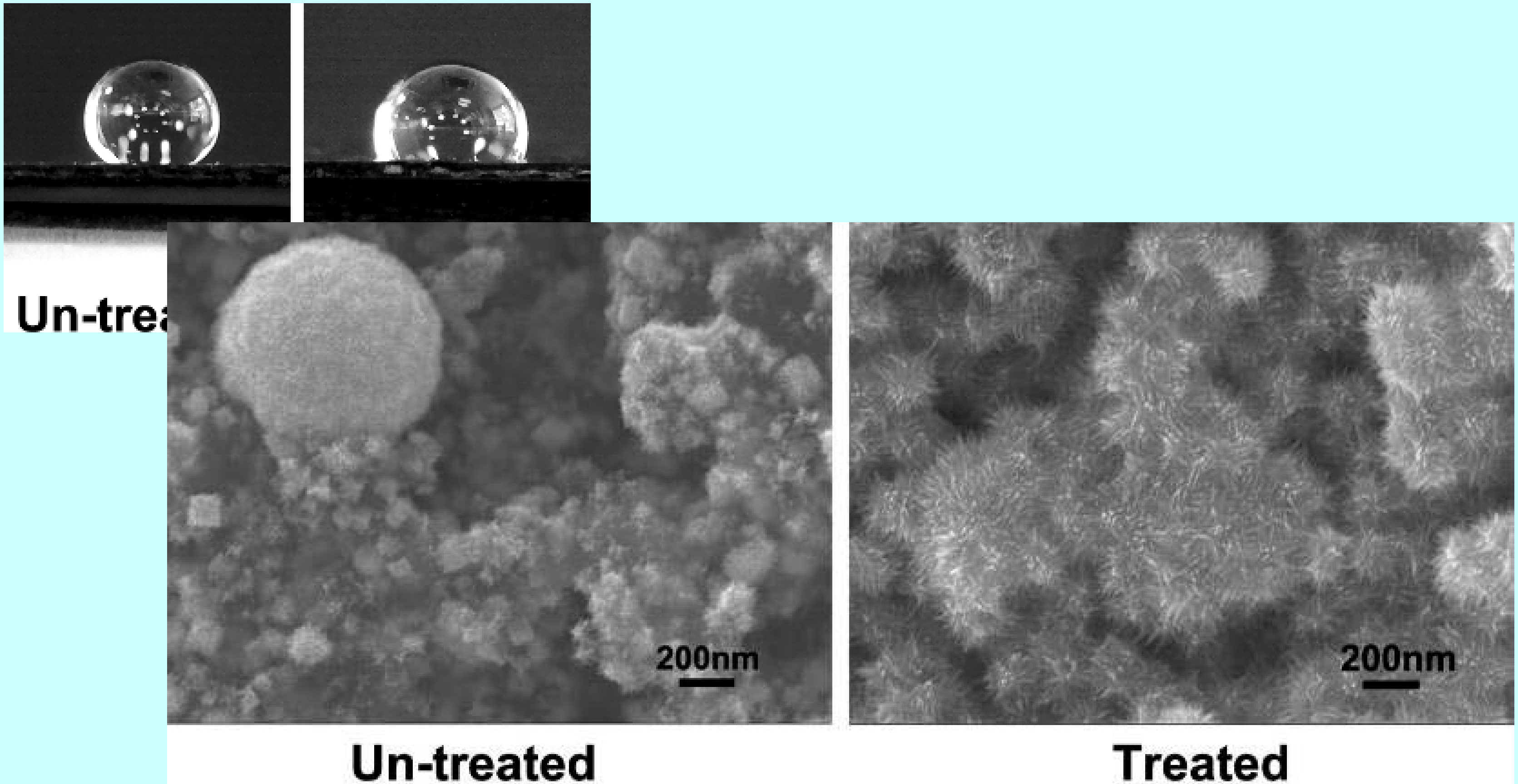
Plasma treatment to GDL substrates



S Du, H Dong. *GB1203409.6, 2012*

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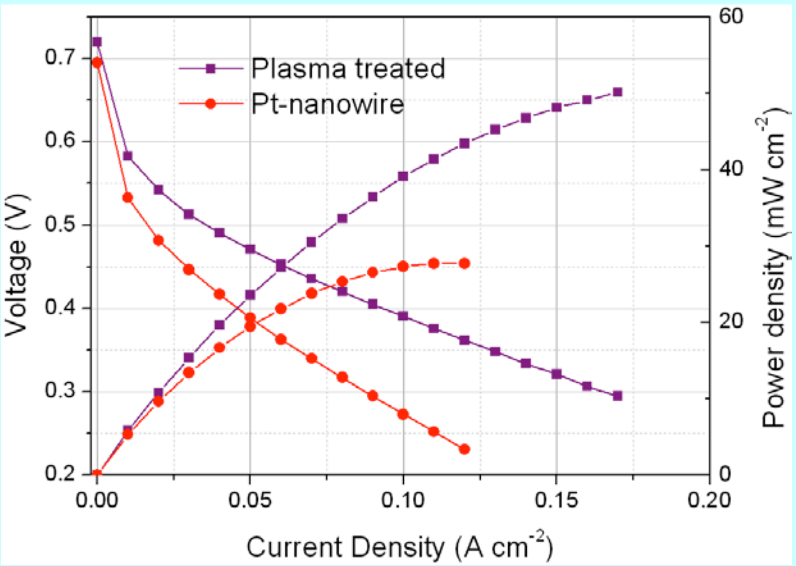
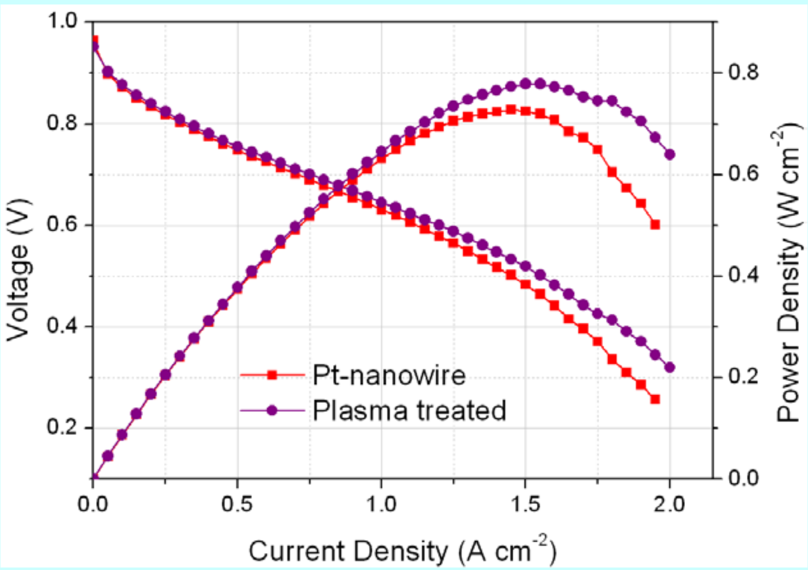
Impact of pre-GDL treatment





DMFC

PEMFC

S Du, H Dong. *GB1203409.6, 2012*

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Summary and future work

- A simple and effective method for preparing Pt-nanowire thin film catalyst electrode
- High reliability, better catalytic activity and improved durability
- Pre-GDL treatment enhanced performance

- Controlling Pt-nanowire distribution
- Ultra-thin Pt-nanowires for better performance

Acknowledgements

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Thank you
for your attention!