# Creating value from technology

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Johnson Matthey Fuel Cells Ltd

# Outline

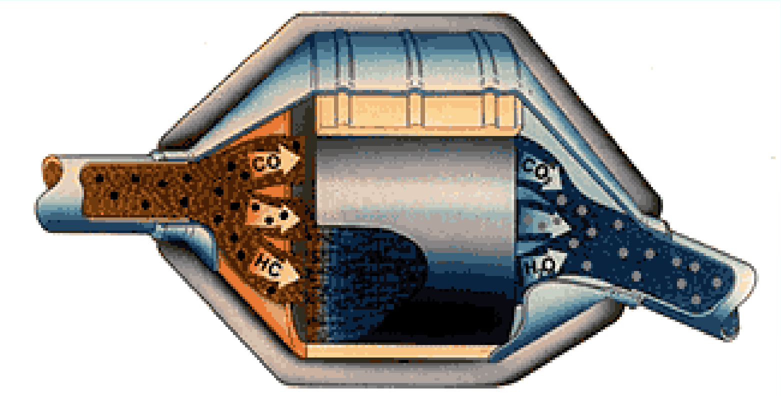
- An Overview of Johnson Matthey

- Proton Exchange Membrane (PEM) Fuel Cell
  - performance improvements
  - future challenges

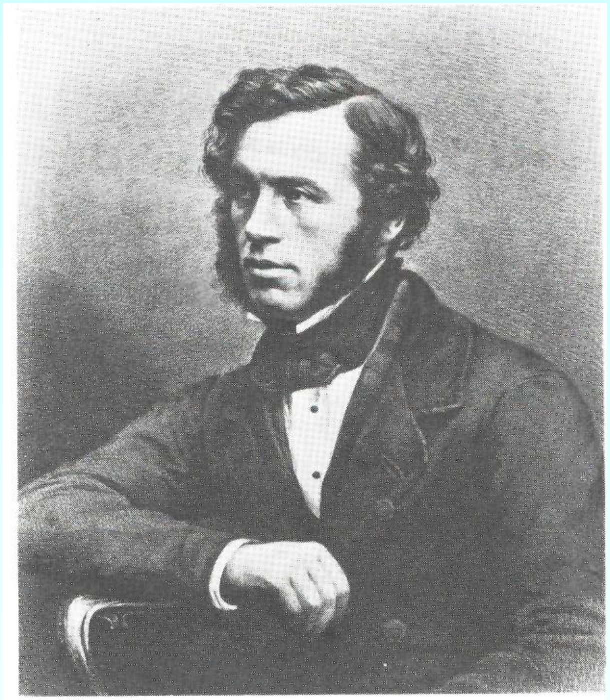
- On-board Hydrogen Storage
  - defining the problem
  - materials development

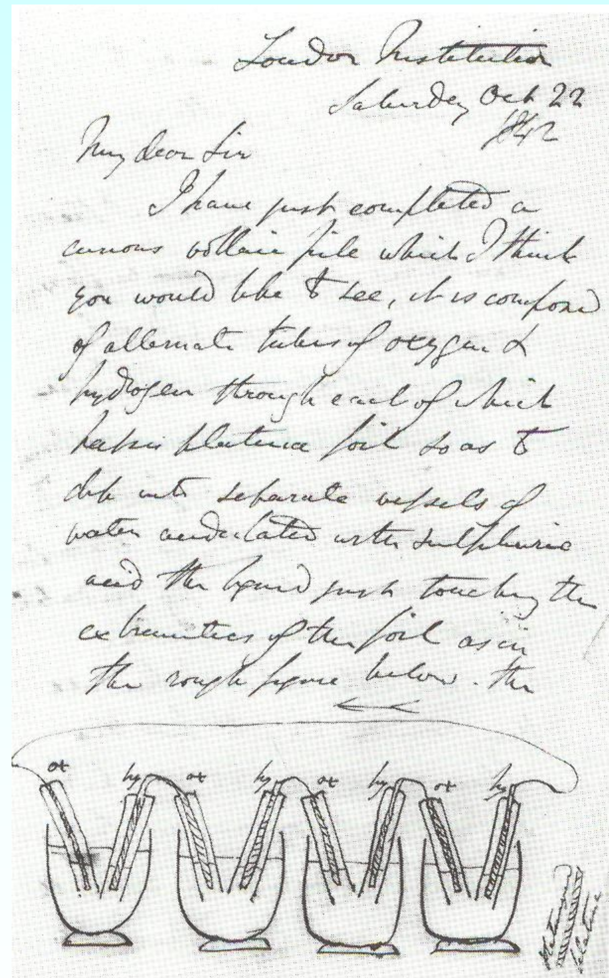
# Johnson Matthey plc

- Origins date back to 1817, incorporated 1896
- FTSE 100
- £204M profit before tax, 7600 employees
- Profits 44% NA, 39% Europe, 17% RoW
- Catalysis, precious metals, speciality materials




# The first fuel cell 1842




London Institution
Saturday Oct 22
1842

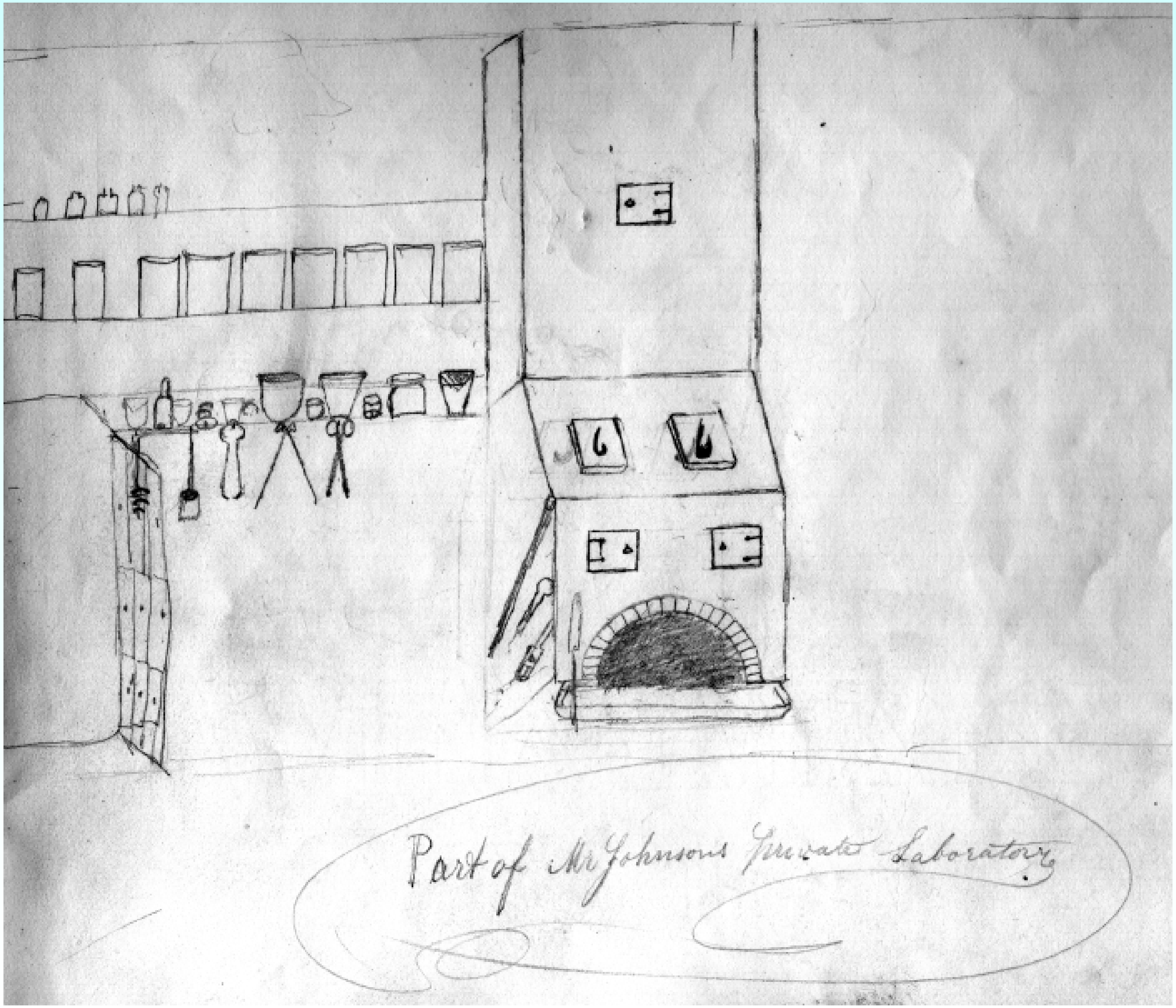
My dear Sir

I have just completed a curious voltaic pile which I think you would like to see, it is composed of alternate tubes of oxygen & hydrogen through each of which passes platina foil so as to dip into separate vessels of water acidulated with sulphuric acid the liquid just touching the extremities of the foil as in the rough figure below. The



Johnson Matthey supplied the platinum

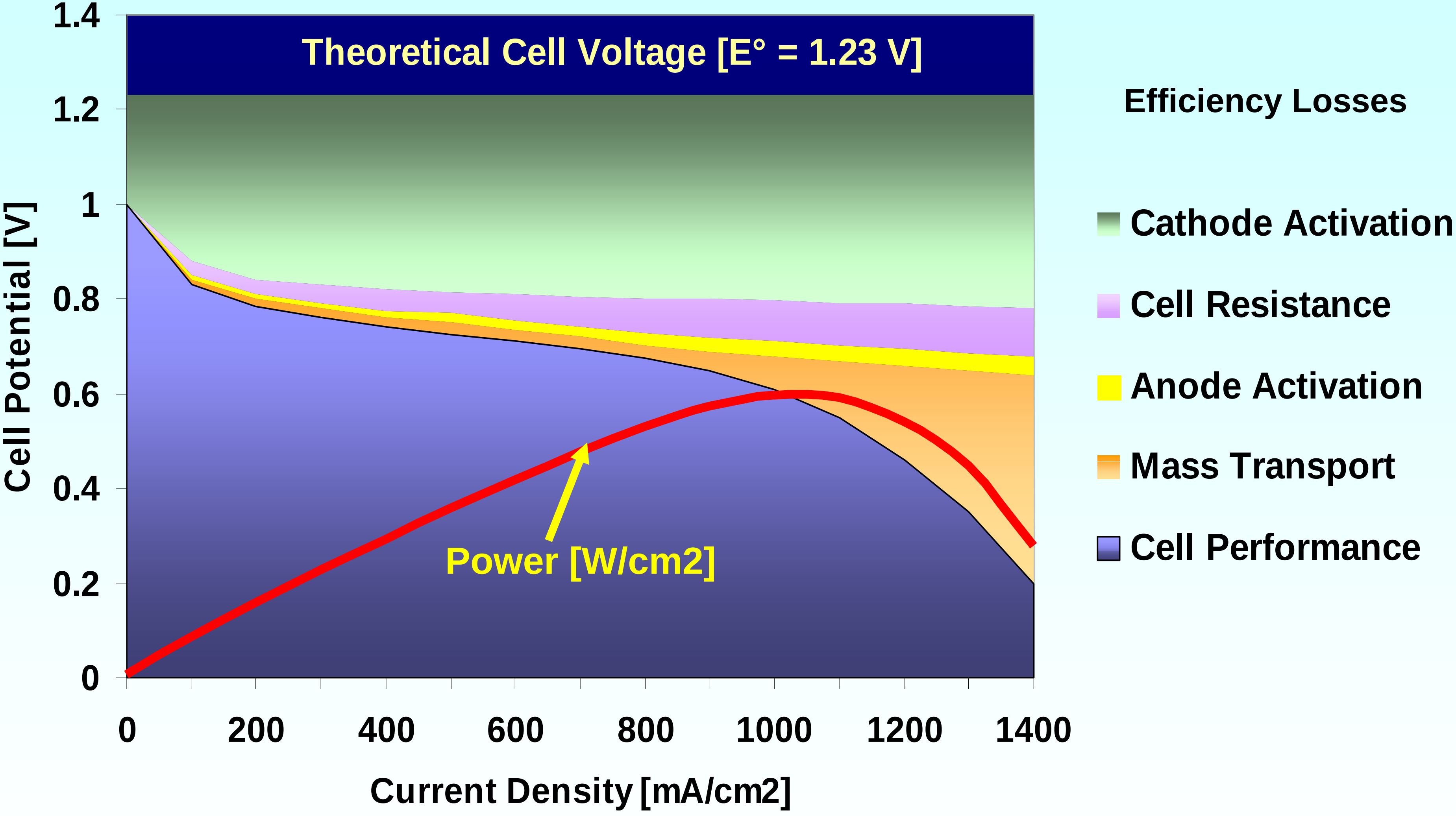
# Johnson Matthey R&D 1842



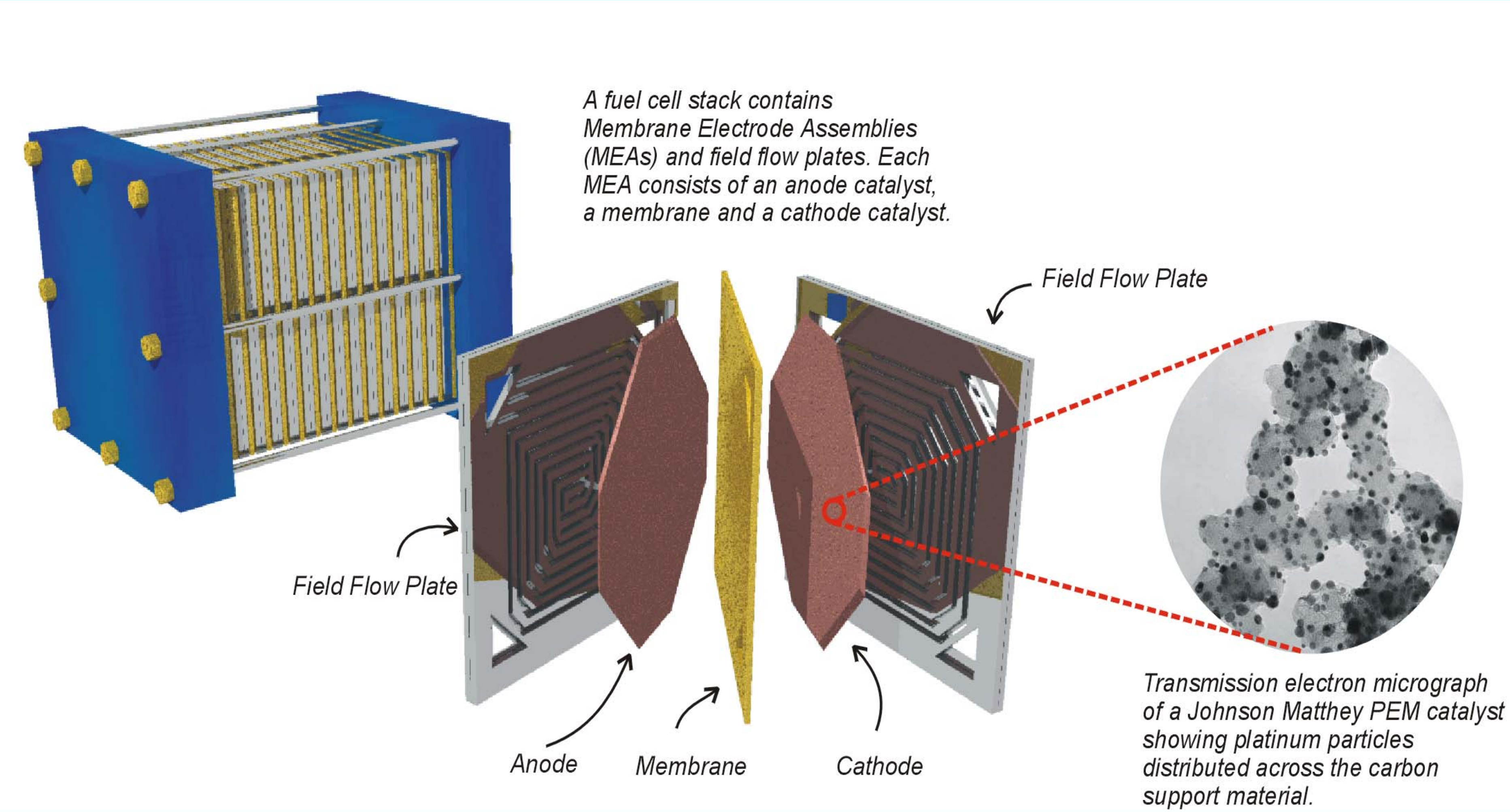
# Johnson Matthey Technology Centre

Sonning Common, UK

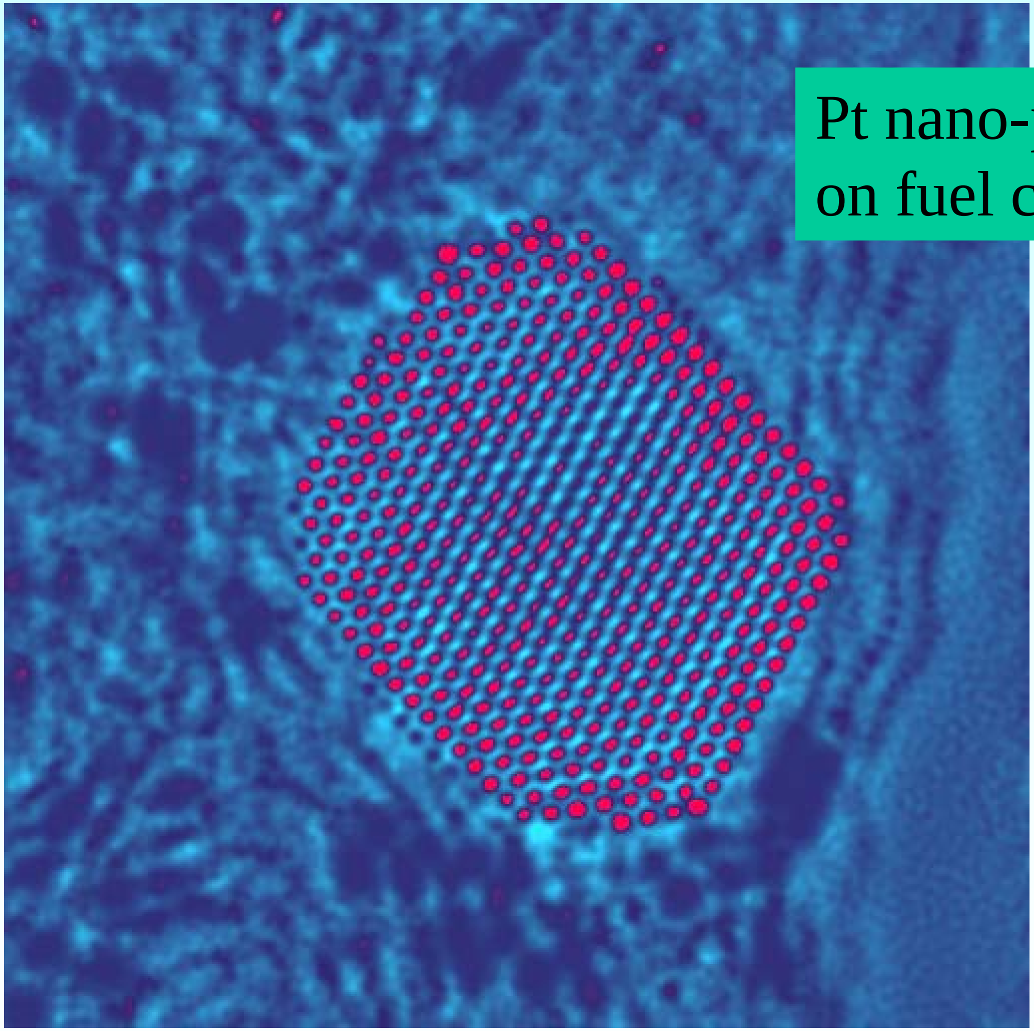

# Fuel Cell Efficiency



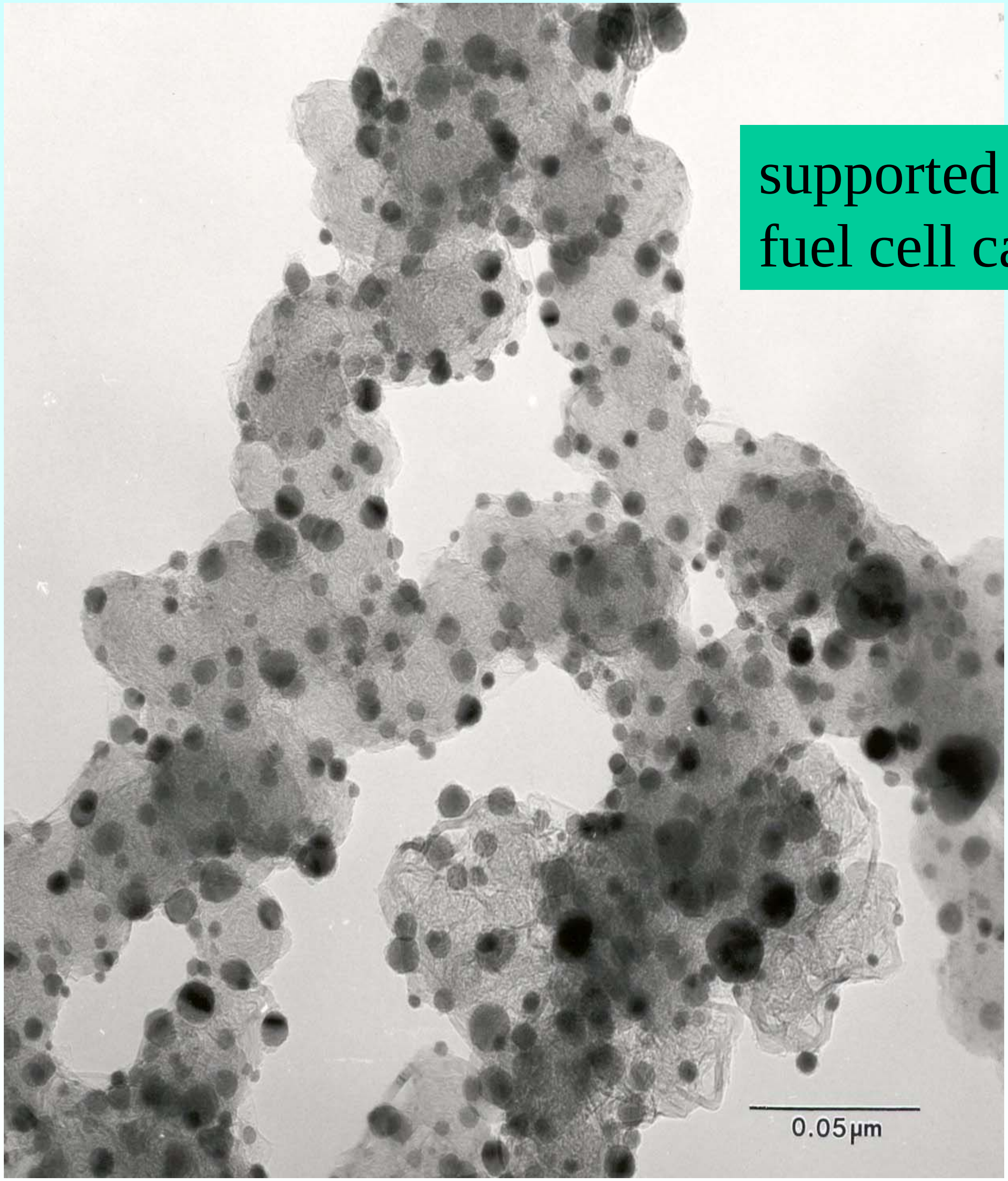
# Catalyst Layer is critical...



# Nano-scale

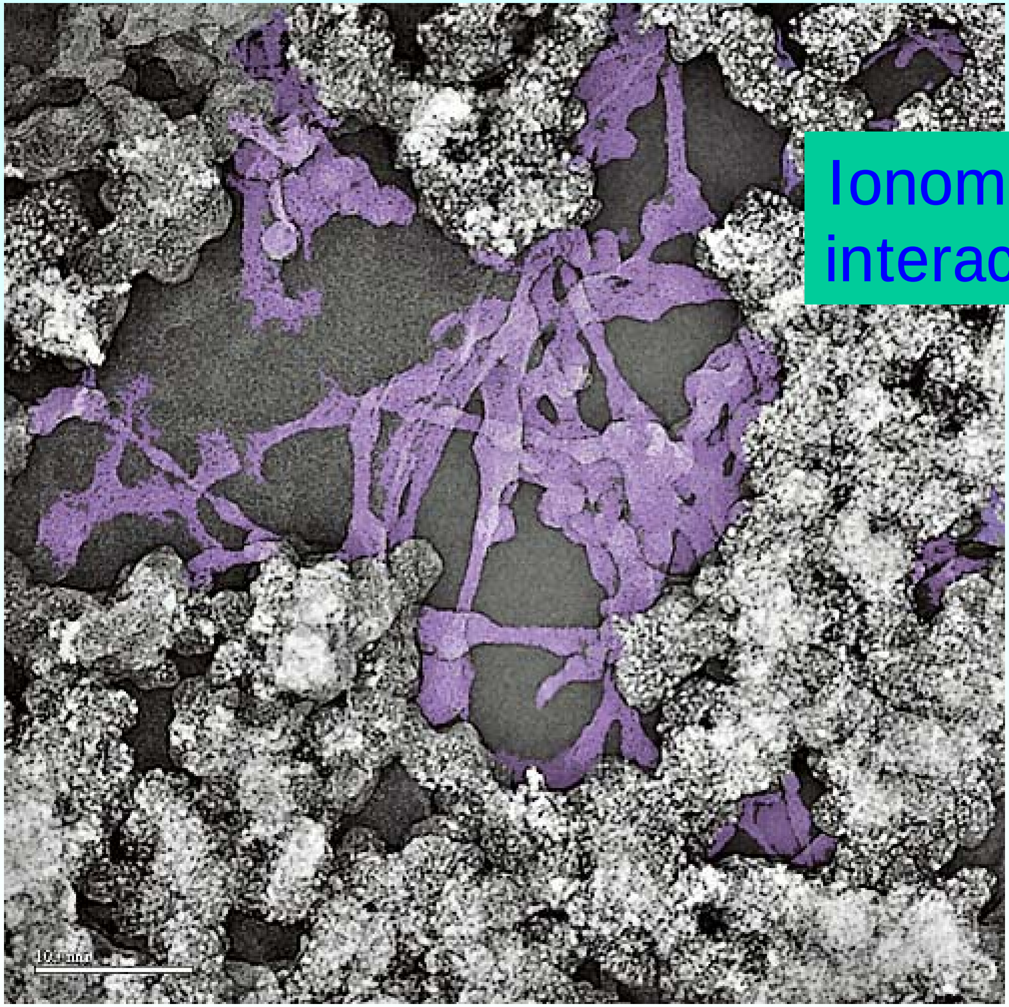


# Less nano




supported Pt on carbon fuel cell catalyst

# Micro-scale




Ionomer and catalyst interactions

# Further Challenges in MEAs

- Control of metal
  - composition
  - size, shape
  - location

- Less Metal
  - better metal utilisation
  - activity

- Better membranes
  - durable
  - non-fluorinated

- More durable systems
  - system integration and control

# Hydrogen Storage

a problem waiting for a solution...

# On-board Storage Problem

- A 500km range a fuel cell powered car means 6kg hydrogen on board [1]
- None of the current hydrogen storage technologies is yet fully acceptable:
  - compressed hydrogen
  - liquid hydrogen
  - solid state hydrogen stores
- UK DTI acknowledges that '..hydrogen storage is the fundamental technical barrier to the more widespread use of hydrogen'
  www.dti.gov.uk/renewables/publications/pdfs/technologies/tech11.pdf
- US DoE '..hydrogen storage is a key enabling technology. None of the current technologies satisfy all the H storage attributes sought by manufacturers and end users...'
  http://www.eere.energy.gov/hydrogenandfuelcells/pdfs/national_h2_roadmap.pdf

[1] *6kg hydrogen is equivalent to 810 cubic metres of hydrogen gas at atmospheric pressure)*

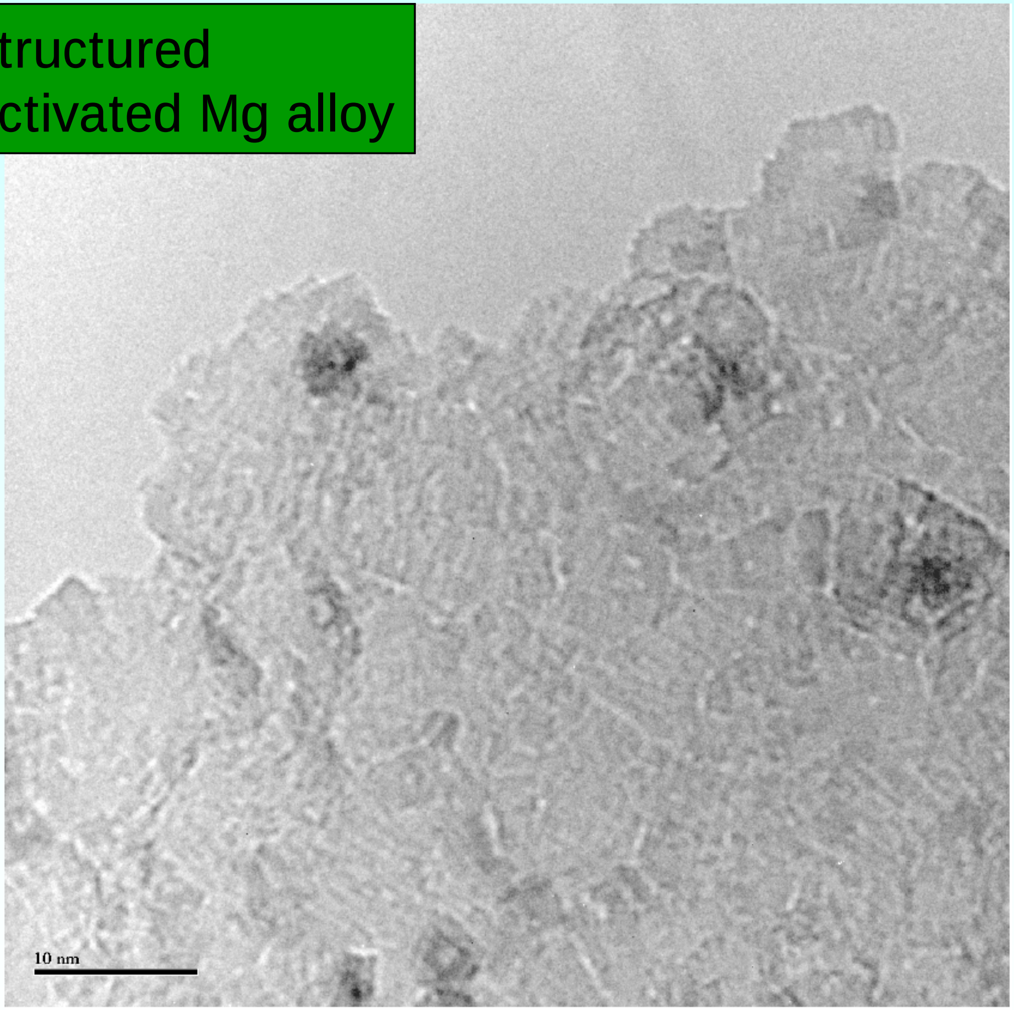
# US DoE HYDROGEN STORAGE ROADMAP

| Store parameter | Units | 2005 | 2010 | 2015 |
|---|---|---|---|---|
| **Specific energy** | kgH2/100kg system | 4.5 | 6 | 9 |
| **Energy density** | gH2/l system | 36 | 45 | 81 |
| **Storage system cost** | $/kgH2 capacity | 200 | 133 | 67 |
| **Refuelling speed** | kgH2/min | 0.5 | 1.5 | 2 |
| **H2 leakage** | (g/h)/kg stored | 1 | 0.1 | 0.05 |
| **Cycle life** | Cycles(1.4 to full) | 500 | 1000 | 1500 |

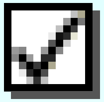
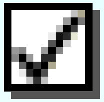
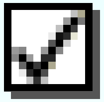
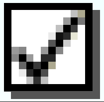
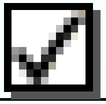
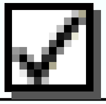
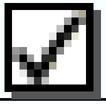
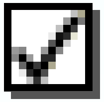
# Promoted Magnesium hydrides have showed promise

Nanostructured
pgm activated Mg alloy

- high energy milling to create high defect materials
- surface promoted to increase hydrogen uptake
- demonstration prototype gives good reversibility
- but...temperatures still too high



# Promoted $MgH_2$ performance

| store parameter | units | 2005 | 2010 | 2015 |
|---|---|---|---|---|
| Specific energy | $kgH_2$/kg system% | 4.5  | 6  | 9 |
| Energy density | $gH_2$/l system | 36  | 45 | 81 |
| Storage system cost | \$/$kgH_2$ capacity | 200  | 133  | 67 |
| Refuelling rate | $kgH_2$/min | 0.5  | 1.5 | 2 |
| Loss of $H_2$ | (g/h)/kg stored | 1  | 0.1  | 0.05  |
| Cycle life | Cycles(1/4 to full) | 500  | 1000 | 1500 |

# Summary

- Rapid advances in fuel cell technologies, based on a fundamental understanding of materials on different levels
  - nano
  - micro
  - system
- Further materials development will provide further breakthroughs in fuel cells, catalysts and storage
- Lots more work to do....