Nanomaterials and Devices for Energy Conversion and Storage

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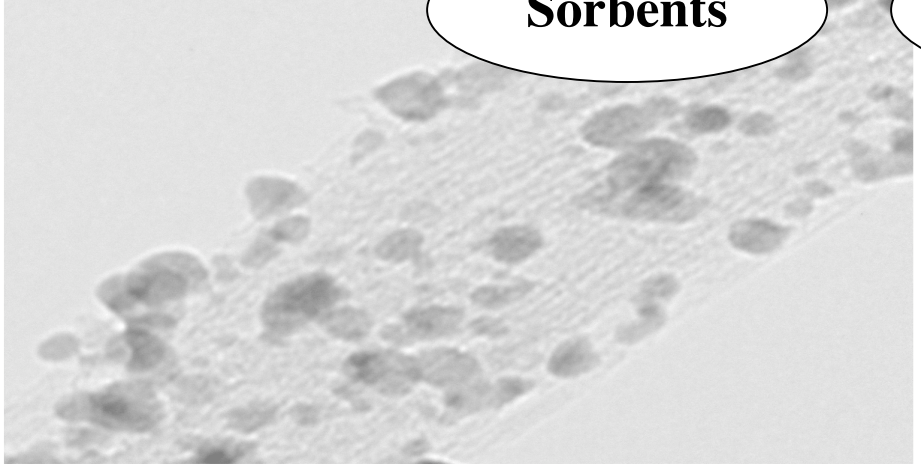
Emerging Technology Investment Opportunities:

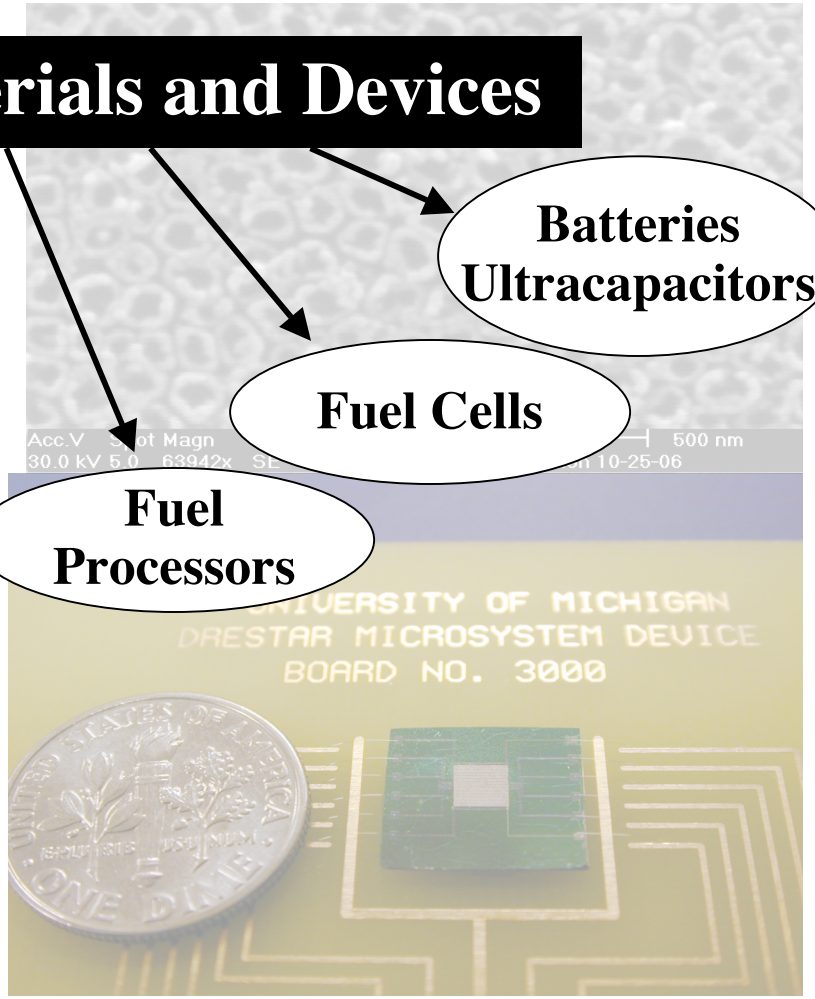
Cleantech at Michigan

Research Overview

Nanostructured Materials and Devices

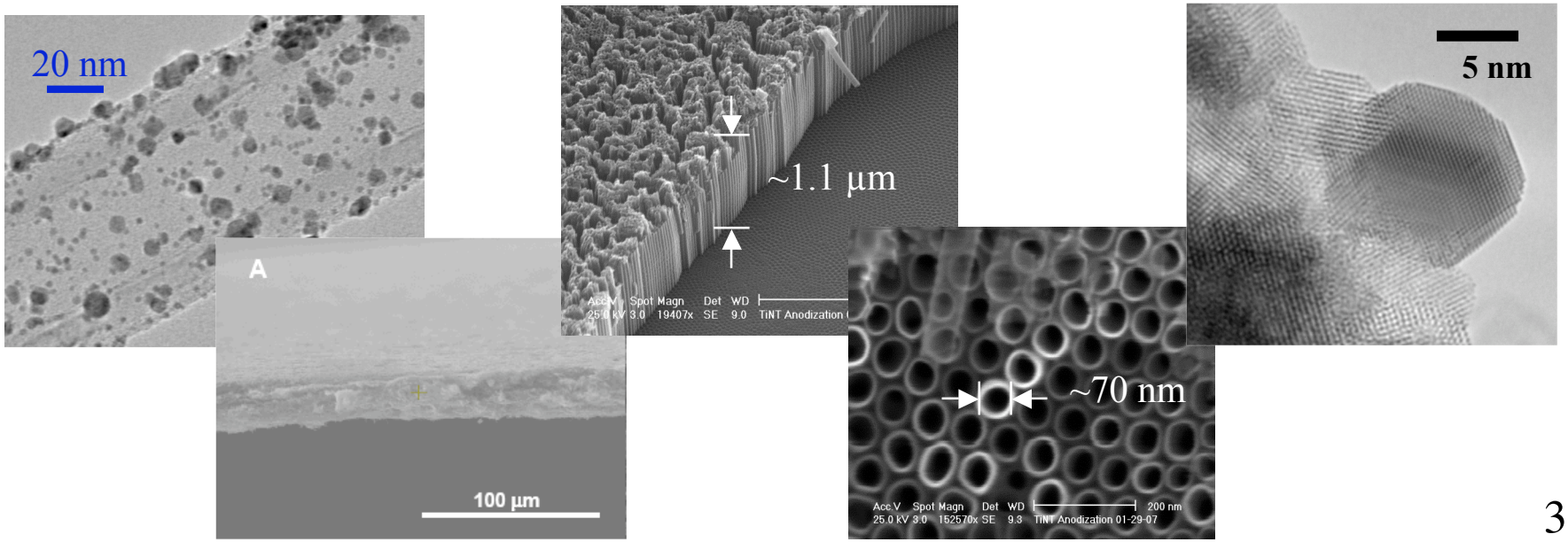
- Catalysts
- Electrocatalysts
- Sorbents
- Fuel Processors
- Fuel Cells
- Batteries
- Ultracapacitors





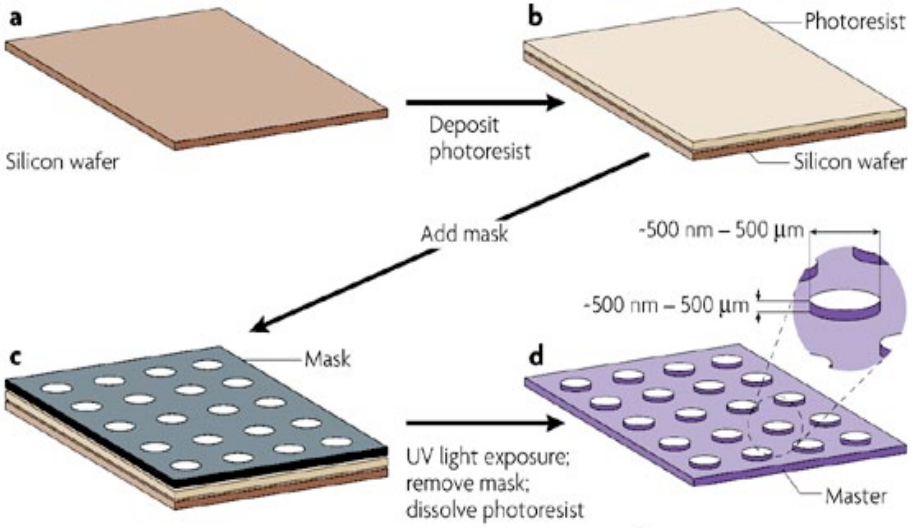
Background- Nanomaterials

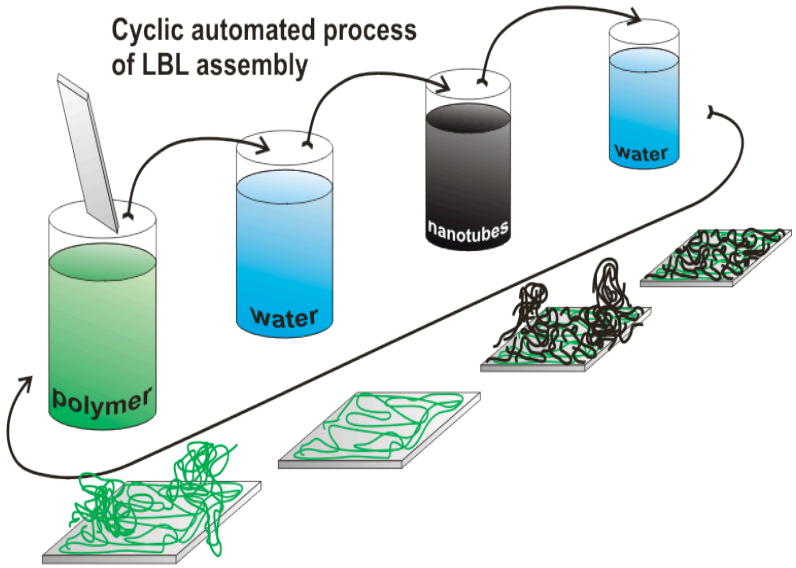
- "***Transition Metal Carbides, Nitrides & Borides***," U.S. Pat. 6,623,720 (2003)
- "***Carbide & Nitride Based Fuel Processing Catalysts***," U.S. Pat. 6,897,178 (2005)
- "***Ceria Supported Gold Water Gas Shift Catalysts***," U.S. Pat. Appl. 11/744,510
- "***Catalysts for the Electrochemical Hydrogenation of Oils***," UM Disclosure 3682
- "***Catalysts for NOx Selective Catalytic Reduction with Reformate***," UM Disclosure 3628



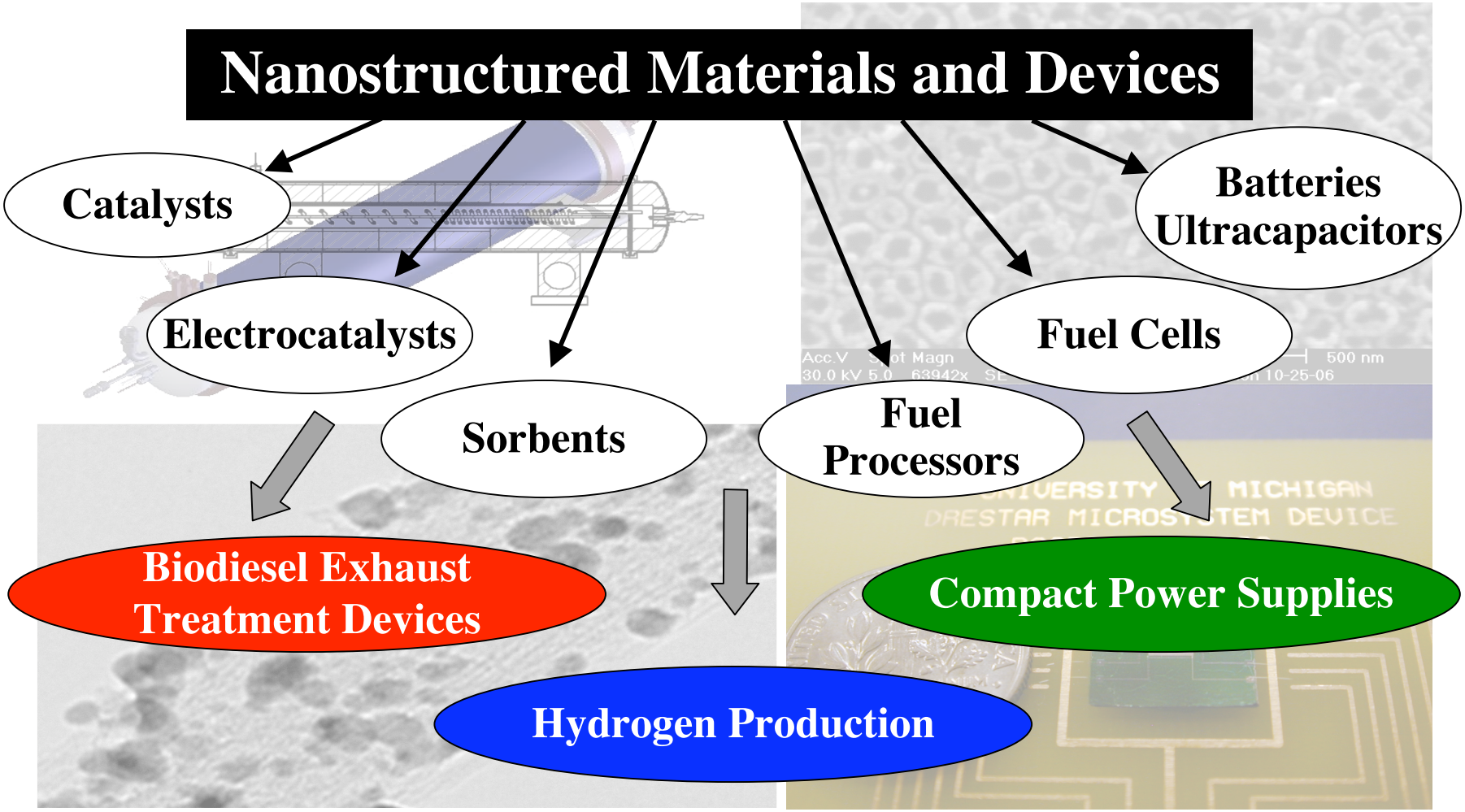
Background- Nanostructured Devices

- "***Thermal Integration Strategy for Hydrocarbon Fuel Processor,***" UM Disclosure 3291
- "***Fully CMOS Compatible Micro-Fuel Cells for Portable Device Power,***" UM Disclosure 2992
- "***Battery and Fuel Cell Production using Layer-by-Layer Self-Assembly Methods,***" UM Disclosure





Market Applications



Compact Power Supplies

- **Challenges**
  - Low energy density
  - High cost

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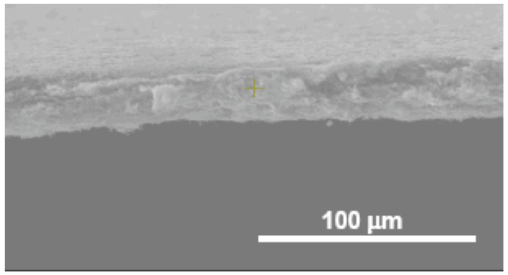
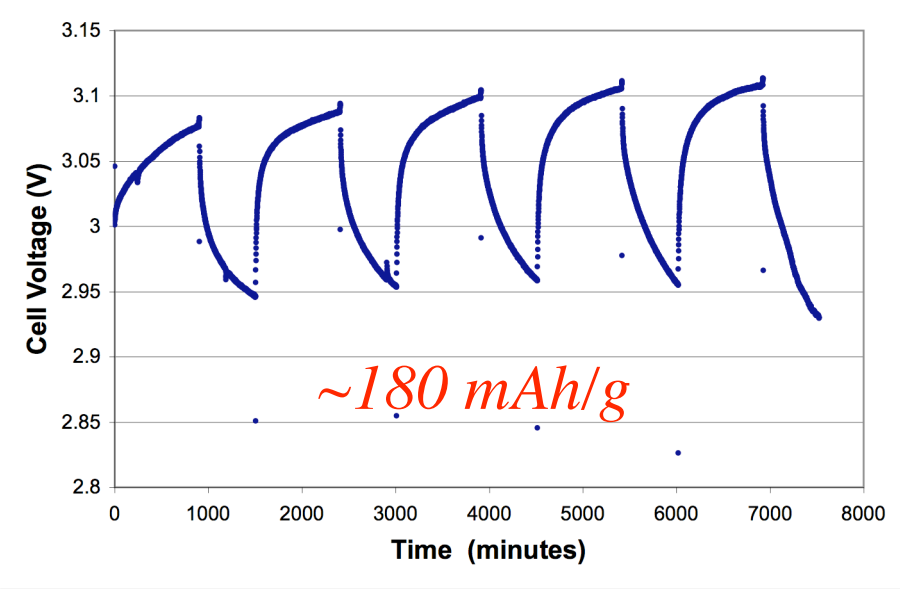
- **Solutions**
  - Hybrid power supplies including nanostructured fuel cells, batteries and ultracapacitors
  - Low-cost manufacturing based on microfabrication and Layer-by-Layer self-assembly methods





Cathode: $LiCoO_2$
Anode: Carbon nanotubes
Charge: C/2
Discharge: C/10

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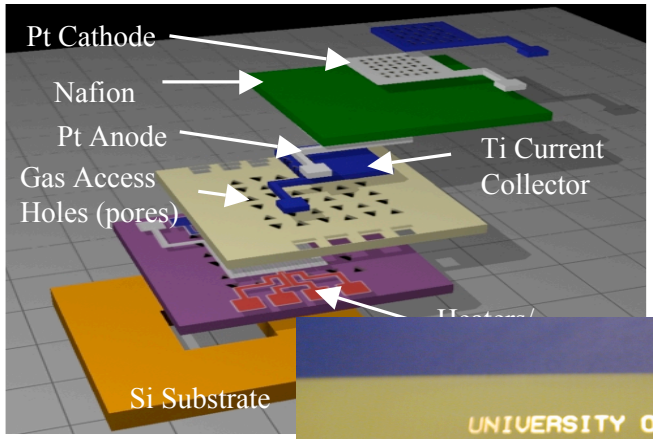
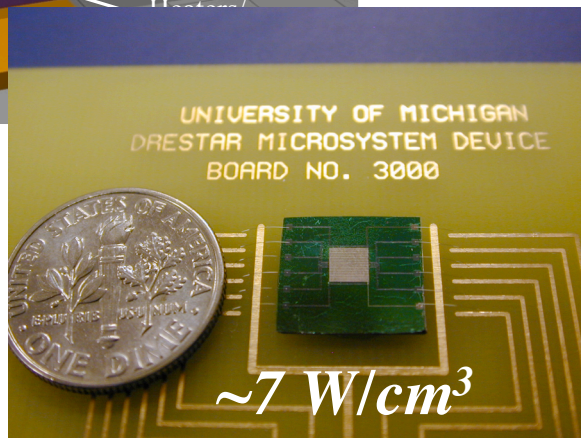
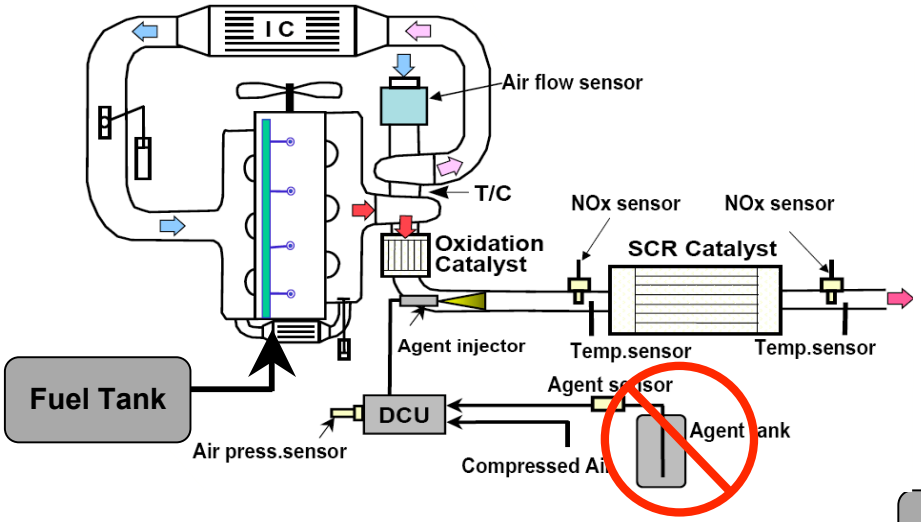


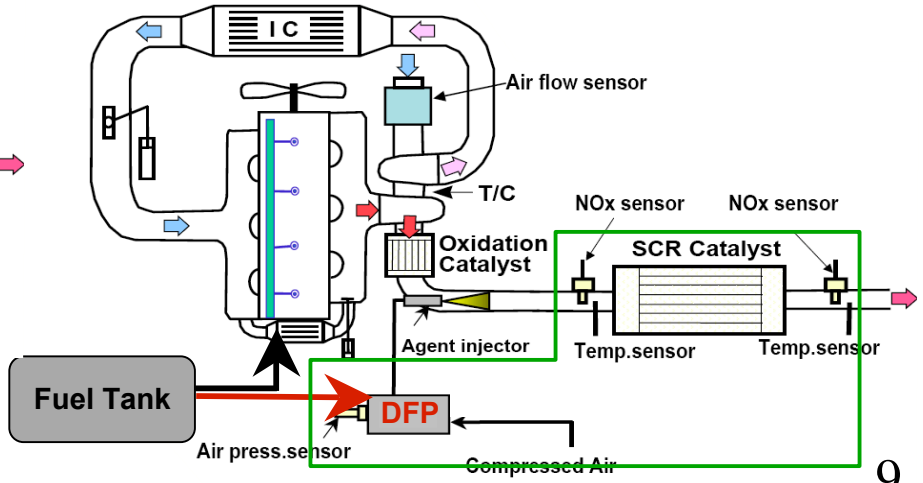


Component	Conventional	μ-PEMFC
Catalyst particles	5-20 nm	-
Catalyst Layer	10-20 μm	5 nm → 0.005 μm
Electrolyte	Nafion 117 (175 μm)	0.5 μm
Gas Diffusion Layer/ Current Collector	350-470 μm	2 μm

Diesel Exhaust Treatment

- **Challenges**
  - NOx, a regulated greenhouse gas
  - Current technologies → extra tanks (e.g. urea)
  - Poor low temperature performance
- **Solutions**
  - Diesel fuel-derived reformate (H_2/CO) as reductant
  - Integrated on-board system
  - High performance catalysts





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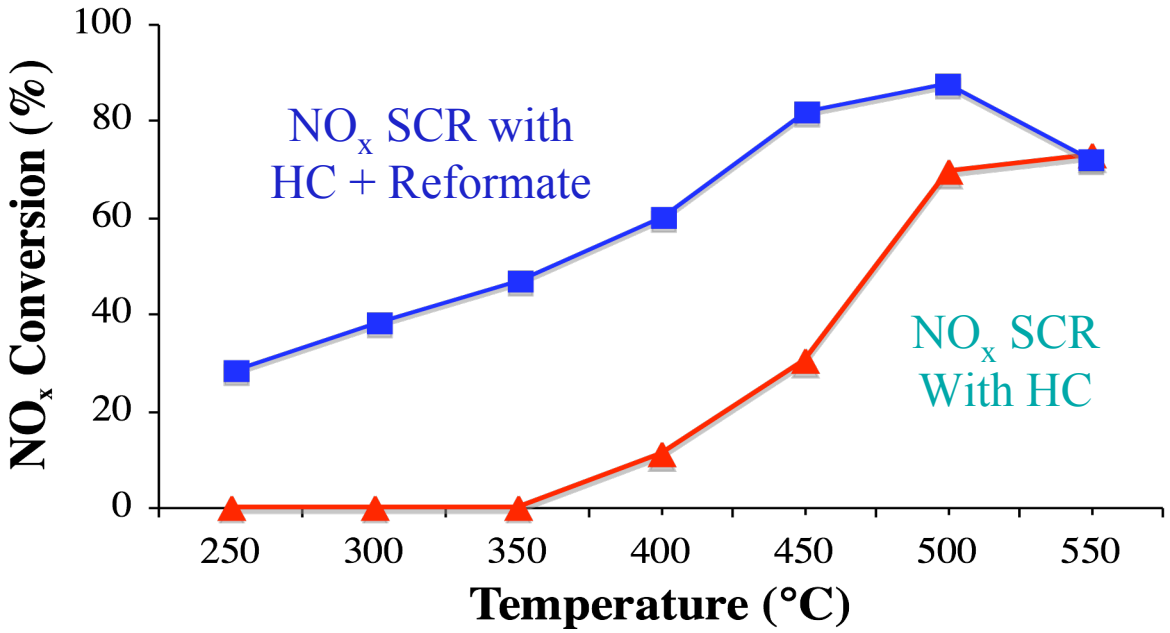
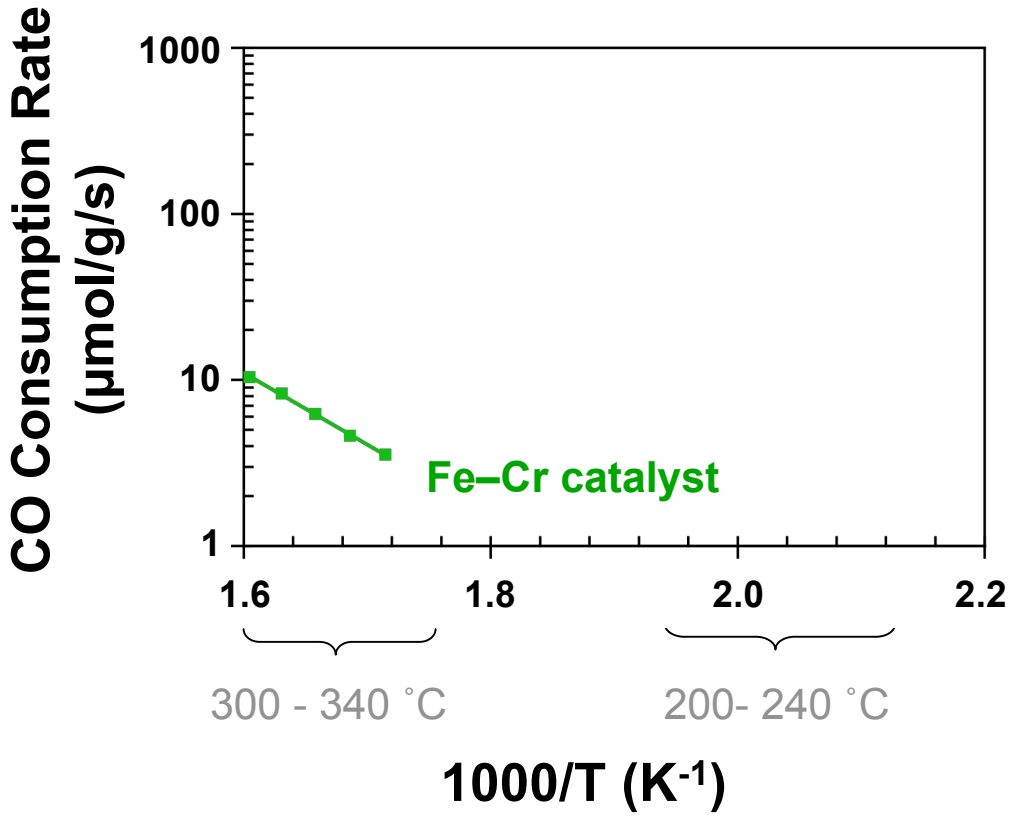


2 wt% Ag/Al_2O_3
NO_x in ~ 1000 ppm
HC = Propylene
W/F = 0.03 g_{cat}•sec/cm^3
$HC_1/NO_x = 2$
$H_2/CO = 2$

Hydrogen Production

- **Challenges**
  - Current catalysts relatively inactive, requiring large reactors
  - Catalysts contain hexavalent chromium

$$CO + H_2O \rightleftharpoons H_2 + CO_2$$



Hydrogen Production

- **Challenges**
  - Current catalysts relatively inactive, requiring large reactors
  - Catalysts contain hexavalent chromium
- **Solutions**
  - Highly active nanostructured carbide- and nitride-based catalysts
  - No toxic materials

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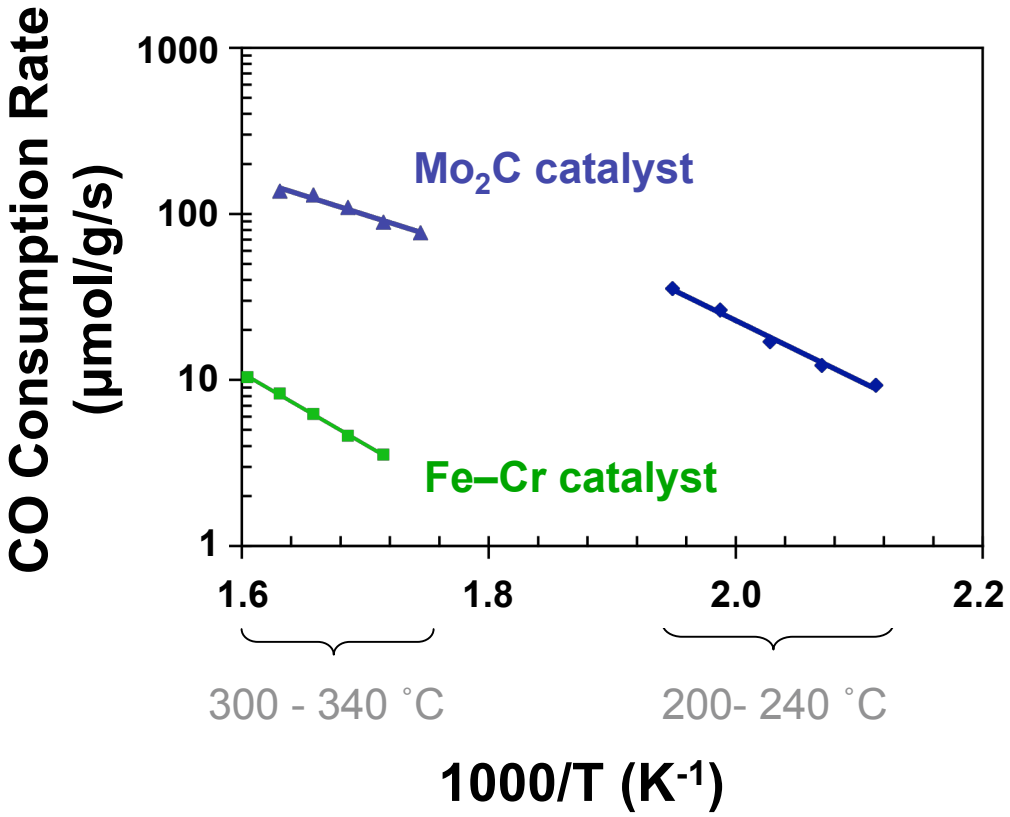


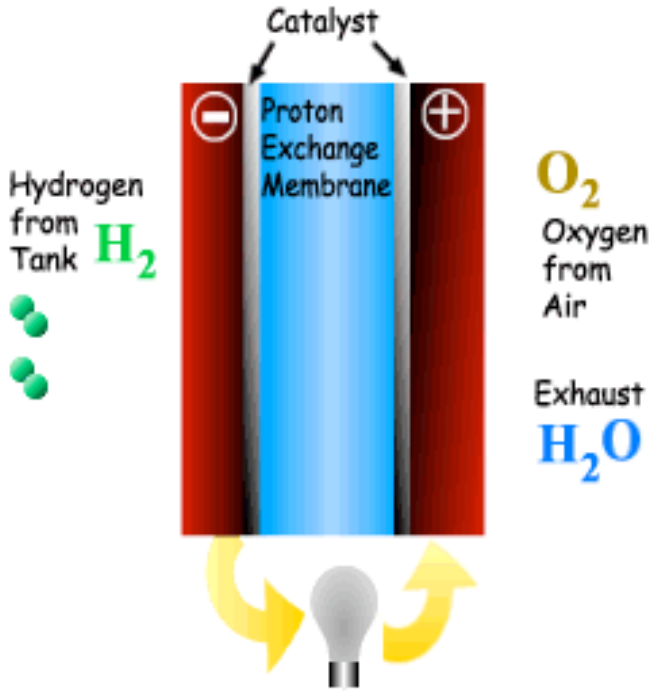
Path Forward

- **Compact Power Supply**
  - Milestones being developed
  - Contacting potential partners
  - Seeking additional grant funding
- **Diesel Exhaust Treatment**
  - Consultant hired to assess market potential
  - Discussions with Kettering Univ. on system integration and testing
  - Seeking grant funding or industrial partner for prototype
- **Hydrogen Production**
  - MUCI grant funding for product development
  - Consultant hired to assess markets for catalysts
  - Discussions with Air Products, Johnson-Matthey and ADM

Business Issues

- **Separate business being established**
  - Inmatech, Inc.
  - CEO and CTO identified
  - Licenses with UM being negotiated
  - Discussions with potential partners initiated
  - Licensing/royalty based business model being developed
- **Contacts**
  - Levi Thompson (UM) – ltt@umich.edu
  - Andrew McColm (UM OTT) – asmccolm@umich.edu
  - Bill Wood (Inmatech) – wwood@inmatech-inc.com

Thank You!



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