Direct Methanol Fuel Cells for Portable Power

A Fuel Cell System Developer Perspective

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MTI Microfuel Cells, Albany, NY

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Direct Methanol Fuel Cells for Portable Power

Outline

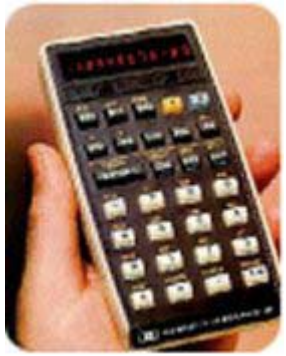
(1) The potential market for portable power sources based on DMFCs

(2) DMFC Technology under ambient conditions

(3) DMFC Technology Development at MTI Microfuel cells

Portable Electronics Trends

- Increasing intelligence (computation)
- Increasing connectivity (bandwidth)
- Always on



1973

2001

IMPROVEMENTS IN POWER TECHNOLOGY HAVE NOT KEPT UP WITH MOORE'S LAW RATE INCREASES IN COMPUTATION AND BANDWITH.

Micro Fuel Cells

The iRobot-LE™ "opens a new chapter in home robotics..."
-- Wired Magazine

the power behind new energy™

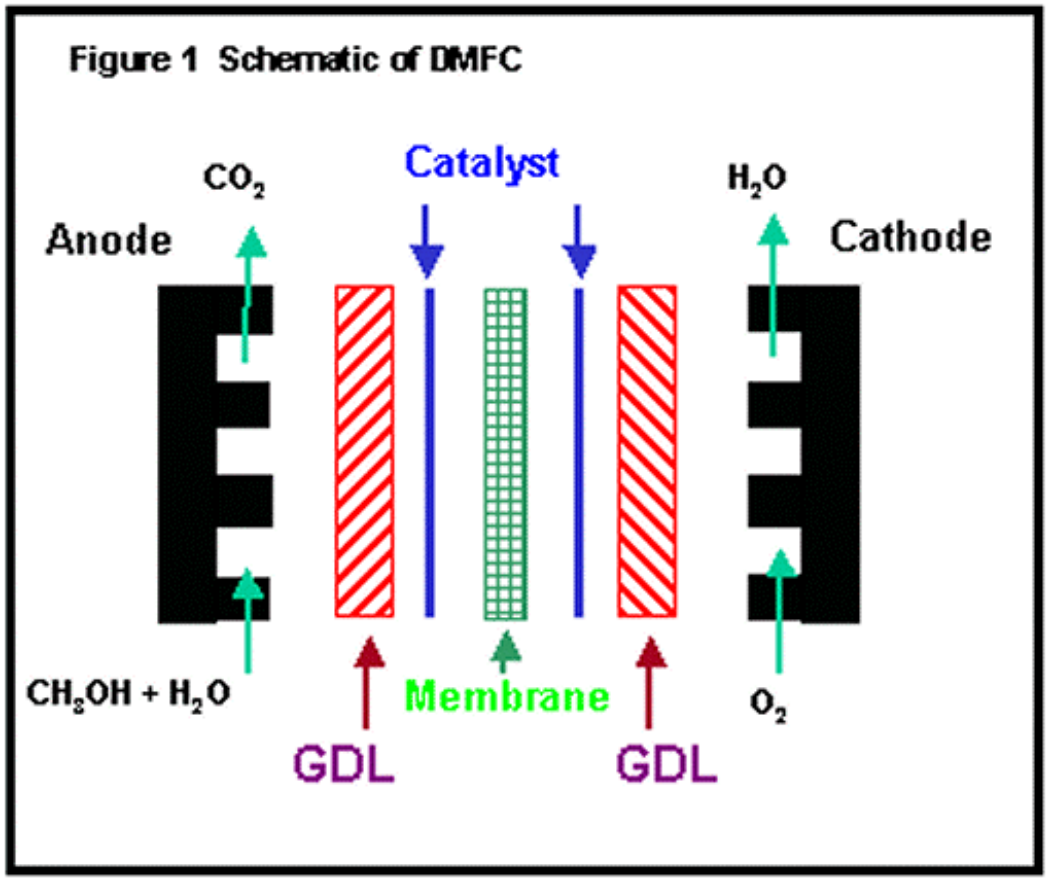
CH_3OH + "Air"

DIRECT CONVERSION

Electricity

+

Environmentally Benign Products



DMFC Technology Advantages for Portable Power Applications

Basis for extended use without recharge:

*** 5 Wh/cc; 6 Wh/gr MeOH**

*** System energy density of 1.5 Wh/cc; 1.5Wh/g = X5; x10 energy density of Li ion battery**

*** Direct & complete electro-oxidation at low T**
*** Readily stored liquid fuel**
*** Good potential for competitive cost**

DMFC Technology Advantages for Portable Power Applications

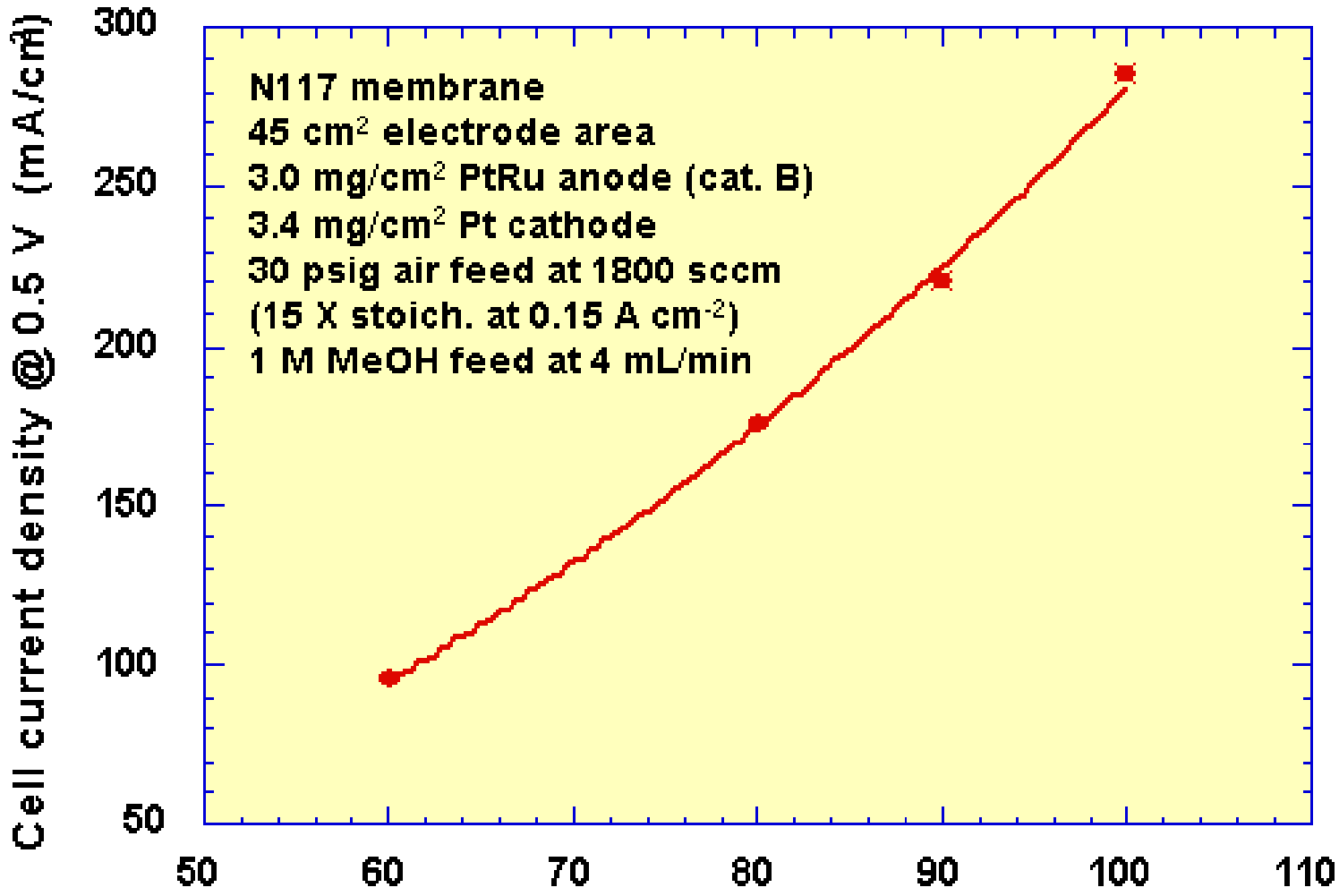
Challenges:

* Performance near ambient conditions

* System simplicity, i.e., air breathing mode of operation

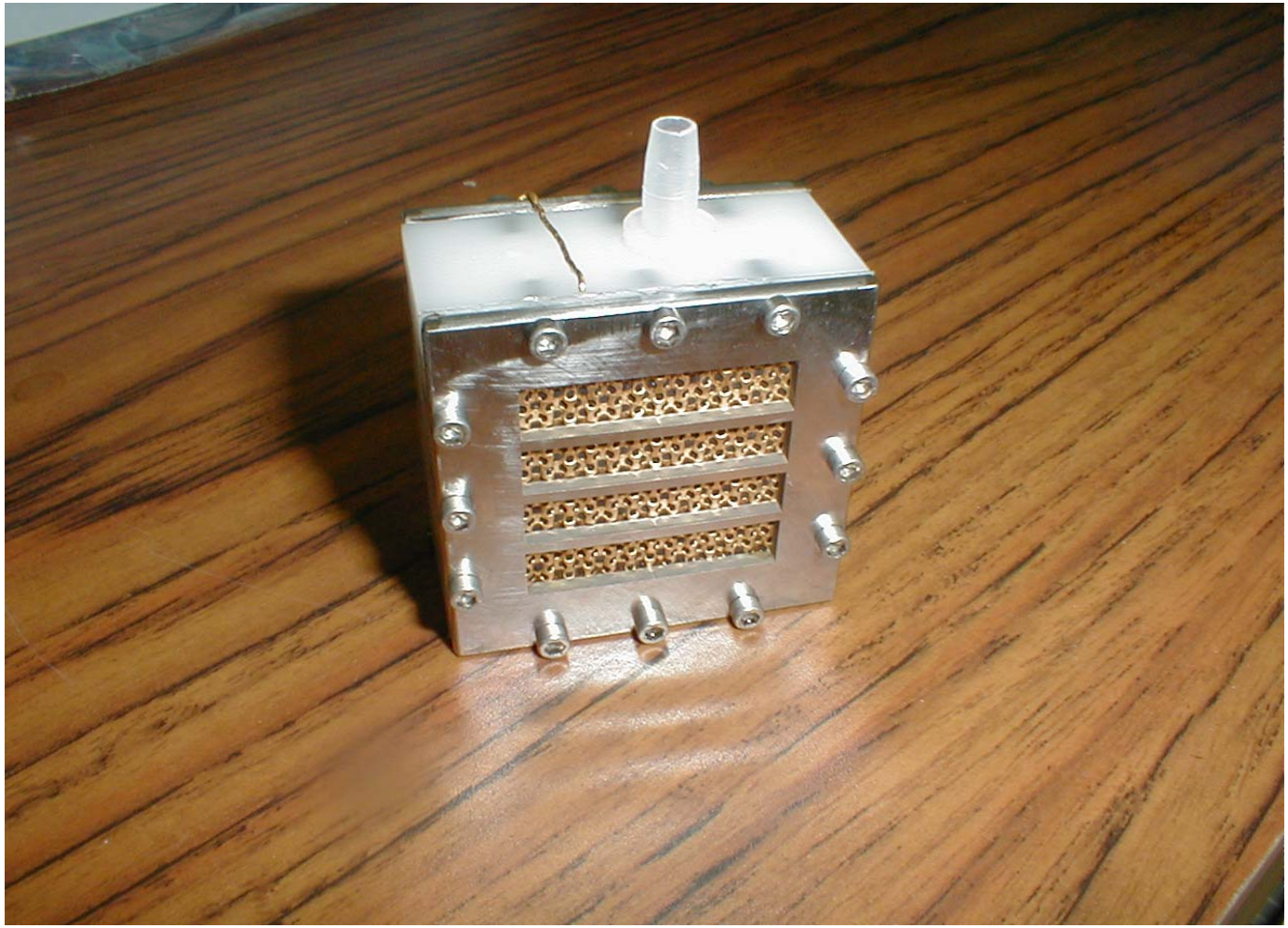
* Complete power system including sensing and control

* Competitive cost

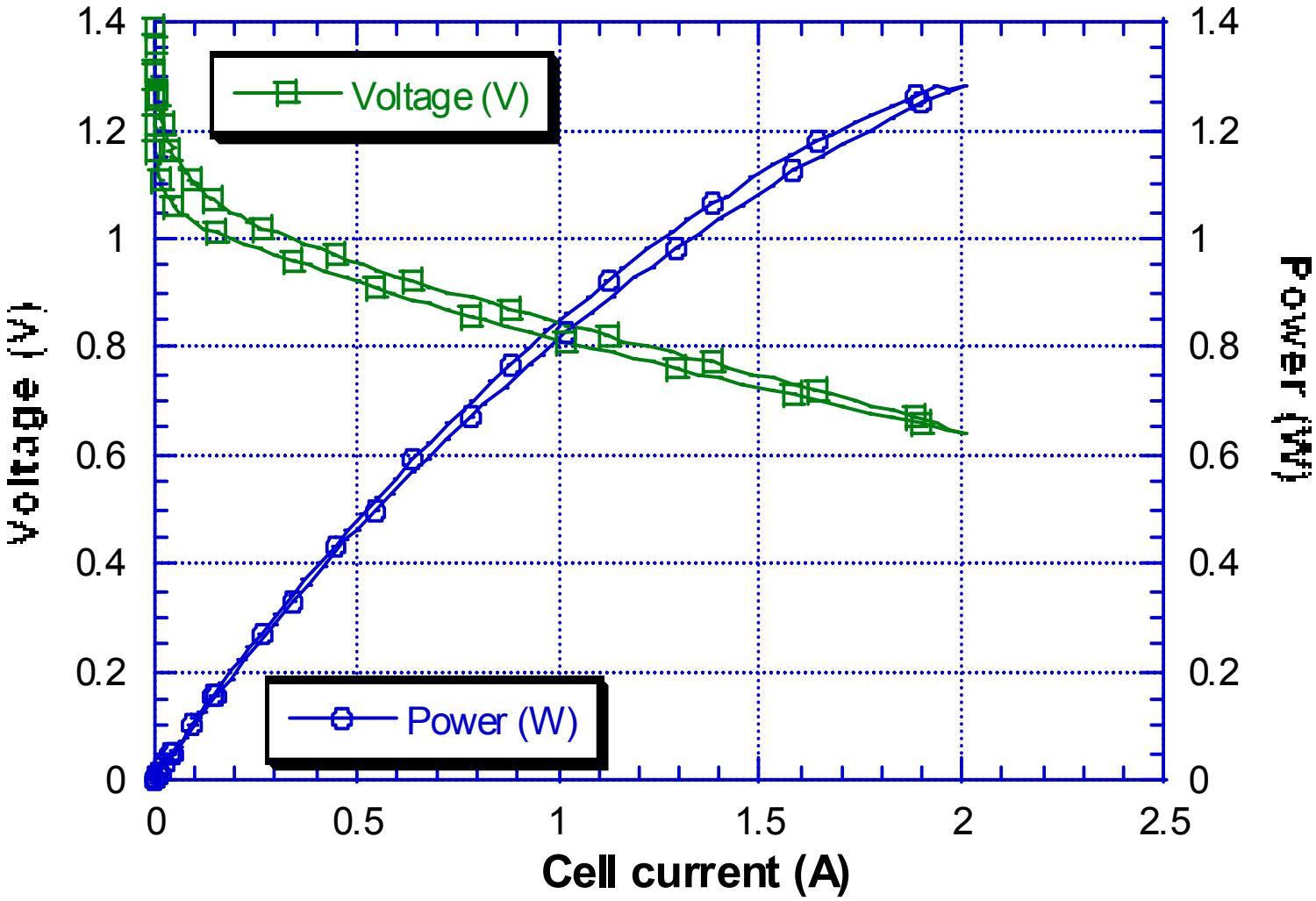

Cell current density @ 0.5 V (mA/cm²)
300
250
200
150
100
50
50
60
70
80
90
100
110
N117 membrane
45 cm² electrode area
3.0 mg/cm² PtRu anode (cat. B)
3.4 mg/cm² Pt cathode
30 psig air feed at 1800 sccm
(15 X stoich. at 0.15 A cm⁻²)
1 M MeOH feed at 4 mL/min

mti.micro fuel cells

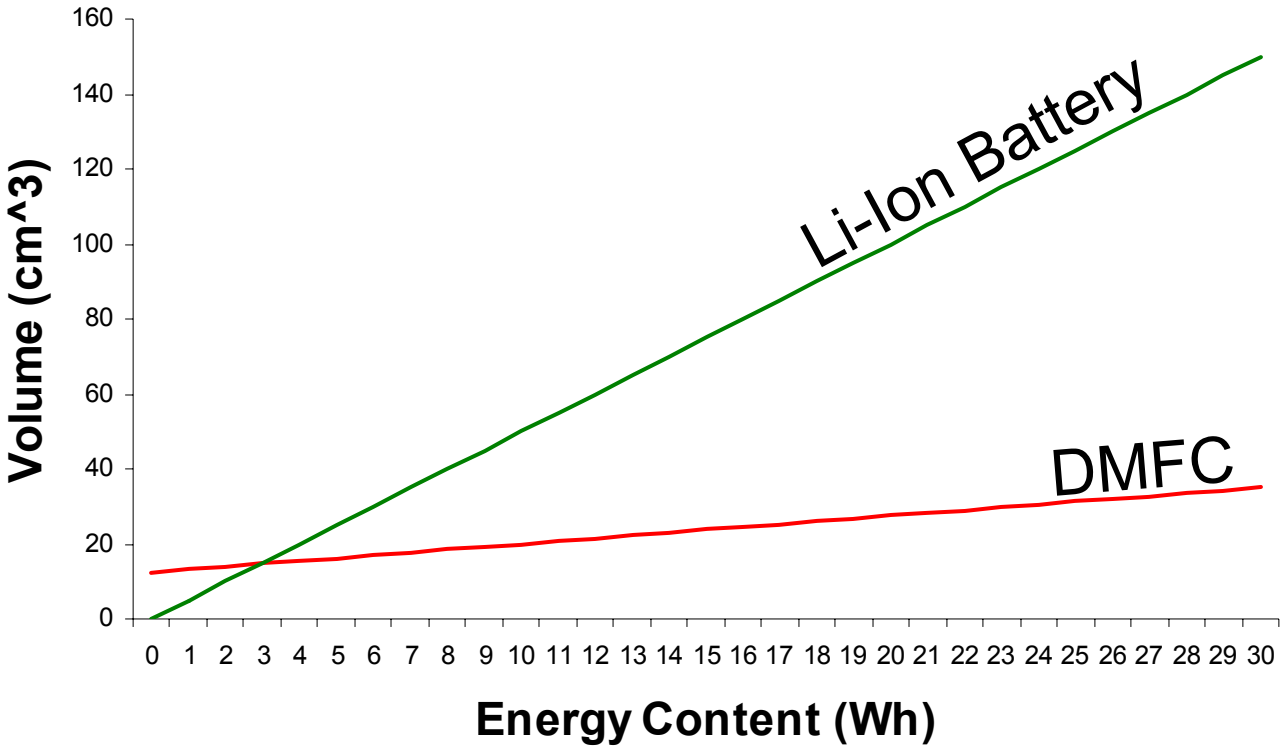
Twin cell DMFC, 10cm^2 active area per cell
May, 2001



Air breathing twin-cell; 10 cm² per cell
June '01: **1.2 W** generated at ambient temp.
60 mW/cm² of overall MEA area



Energy Density Comparison For a 1 Watt System



State of MTI Micro Fuel Cells Technology

Progress:

- Demonstrated fuel cell power density commensurate with cell phone requirements
- Demonstrated July ’01 DMFC coupling to DC-to-DC converter to power a PDA (proof-of-principle)
- Demonstrated concept for power system simplicity potentially leading to enhanced product introduction
- Demonstrated Oct ’01 packaged system with air breathing DMFC (proof-of-concept) powering Kyocera’s smart phone

Challenges:

- System integration
- Tight packaging
- Manufacturing costs

Packaged DMFC Cell Phone System Demonstration

mechanical technology

Oct.'01: Packaged System with Air-Breathing DMFC Demonstrated Powering Smart Cell Phone (proof-of-concept)

Developments Towards Commercialization

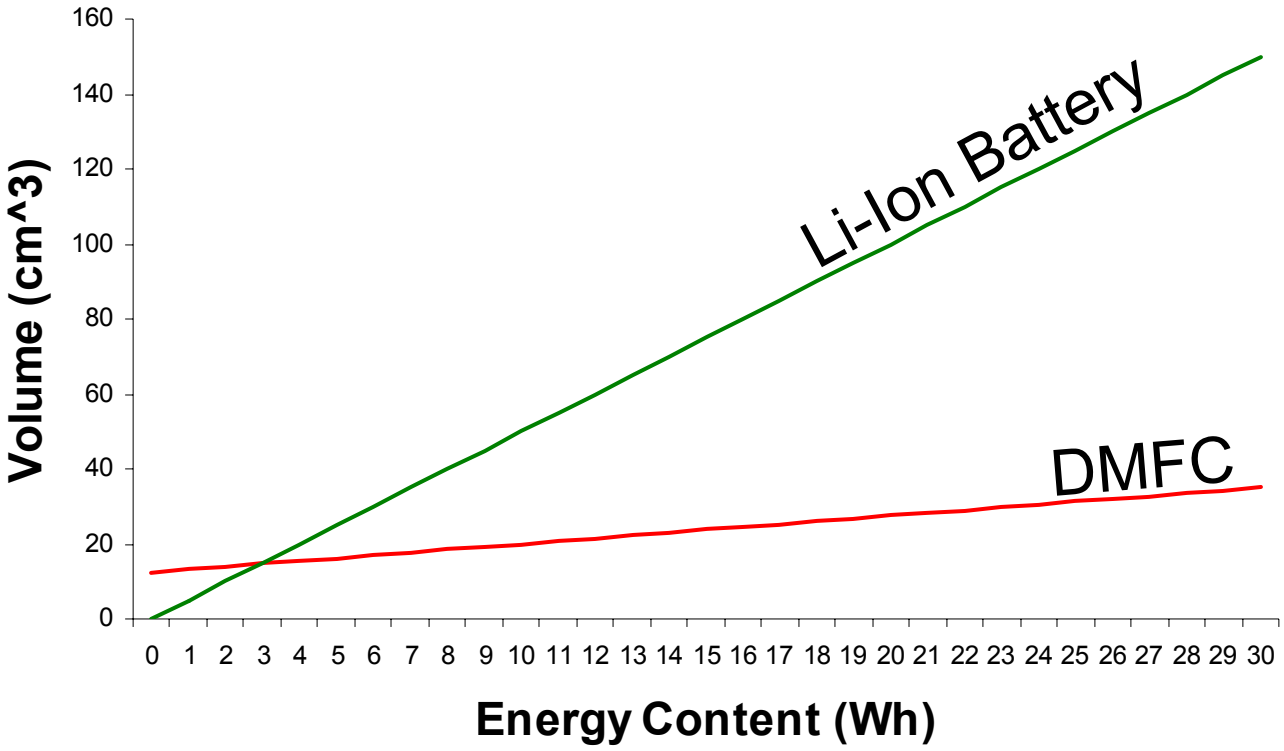
Progress:

- Strategic relationship between MTI micro fuel cells and Dupont as follows:
  - Joint Development of customized membrane
  - Equity ownership of MTI Micro by Dupont
  - Long-term supply agreement
- $4.6 million awarded to MTI micro by US Department of Commerce to develop micro fuel cell system
- Systematic market research defining charting portable electronics opportunities and applications

Requirements:

- Consumer acceptance of unknown technology
- Distribution of new products

Energy Density Comparison For a 1 Watt System



Direct Methanol Fuel Cell Technology for Portable Power

Technical Barriers to Commercialization

Improved Membrane/Electrode Assembly
& cell design for methanol and water management

Higher power at higher cell voltage

Reliability and durability of cells and systems

Understanding and broadening environmental window of operation
(temp., humidity, contaminants)

Manufacturing Cost : Lower catalyst loading; inexpensive cell hardware

Direct Methanol Fuel Cell Technology for Portable Power

R&D Plan to overcome Barriers

Develop specialized cell components for DMFCs, particularly air breathing DMFC

Enhance anode and cathode catalysis

Identify performance decay modes and address with optimized cell materials, structure and operation conditions

Model and measure performance, heat & mass transport for air breathing cells

Develop advanced cell structure and power system concepts

Direct Methanol Fuel Cell Technology for Portable Power

Relevance to and synergy with larger fuel cell systems

Market entry with power sources sold today at 1,000-10,000$/kW is likely to happen first

Experience with specialized cell structures and materials as well as BOP elements (e.g., sensors and control) could be relevant to the larger systems

Relevance to larger systems of technology platforms addressing strong requirements of:

* System simplicity
* Operation near ambient conditions

Direct Methanol Fuel Cell Technology for Portable Power

Present State of the Art

Initial demonstrations of laboratory level devices or early prototypes

Encouraging single parameter demonstrations
but not simultaneous achievement of power density, energy density and durability required for a commercial product

Manufacturing technology for micro-fuel cells non-existent

Direct Methanol Fuel Cell Technology for Portable Power

Technology Demonstration Projects to Validate Technology

Following a technology development program:

Demonstrate portable electronics Powerpack for

Convergence device

Laptop

in volume of 50-100 units for environmental test and Beta test

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Technical issues associated with the Balance of Plant

Propose to focus on:

* Control algorithms

* Sensing

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Critical Barrier to be Resolved Before Commercialization

PERFORMANCE and COST

Enhanced CELL PERFORMANCE is key for both
Packaging
and
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Proper Roles in Effective RD&D Program

A Government/Private Sector Partnership should include:

Funding

Guidance on Needs

Fostering Collaboration

Working with Codes and Standards

Working on Education and increased Awareness

To build mind share and momentum