



PolyFuel™

**Stanford-Berkeley-MIT
Nanotech Forum on Fuel Cells**

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July 12, 2005



Outline

- **PolyFuel background**
- **Market pull**
- **Technology developments at PolyFuel**



About PolyFuel

- **History**

- 14 years of development work
 - Spun out from SRI 5 years ago

- **Headquarters**

- Mountain View, CA

- **Team**

- 140+ years of fuel cell experience
 - 33 staff

- **Intellectual Property**

- 19 Patent applications

- **Financial**

- \$40 million raised to date
 - Leading Silicon Valley VCs
 - Expert fuel cell & energy VCs
 - Leading international VCs
 - Intel Capital

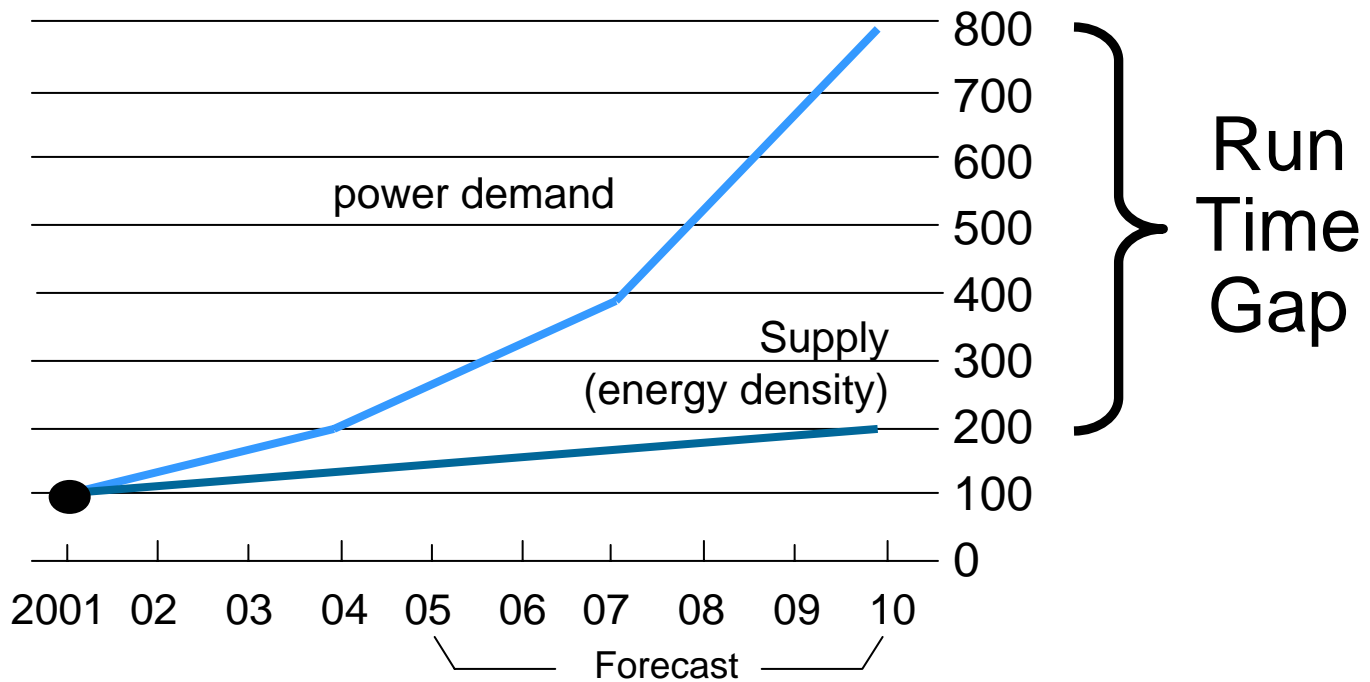




There is a Growing and Compelling Need

Flat batteries

Mobile devices:
2001=100



Source: Boston Consulting Group

Computing is Moving to “Anytime, Anywhere”

- **Wireless technology increases power consumption**
- **Wireless hotspots doubling every year**
- **Laptop sales growing at 27% per year**
- **50 million laptops sold in 2004**
- **Battery runtime the #1 issue among purchasers**

HotSpot



The Nature and Usage of Mobile Phones is Changing

- “Power Eater” applications growing in popularity
- 3G implemented in Asia 3 years ago
- Japan 3G market share increased from 10% to 36% in 3 years
- Started in Europe and the UK in 2003
- Advanced mobile technology delivers less than 1 hour runtime
- 600 million mobile phones sold in 2004



Japan Market Demand

- Mobile phone rechargers provide 1-2 recharges each
- Widely available in shops in Japan
- Selling for \$5 to \$18 each
- Estimated 300,000 sold per year
- Sales growing at 10% per month



More Evidence of Things to Come

- **Mobile phone recharging stations**
- **Recently introduced in Europe & the UK**
- **~25,000 in use in Asia**
- **~\$2 to \$4 per recharge**



Most Major CE Manufacturers Are Active in DMFC

FUJITSU

SANYO

SHARP

HITACHI

TOSHIBA

SAMSUNG

SONY

IBM

 **LG**

NEC

- **Several have announced DMFC product launches in 2006 – 2007 timeframe**

Mobile Phone Early DMFC Prototypes



MTI Mobion®

Release tbd
(MTI Micro announcement June 2004)



NTT DoCoMo 3G Mobile Phone Charger by Fujitsu

Release early 2006
Built into mobile phone as early as 2007
(Announced September 2004)

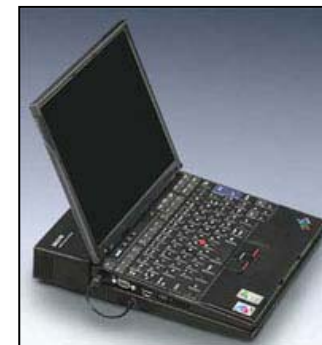
Laptop Early DMFC Prototypes



NEC Notebook
Release 2007
(NEC Oct 2004)



Hitachi Notebook PC
Release 2006
(CEATEC October 2004)



Sanyo-IBM Notebook PC
Release 2007-2008
(Sanyo-IBM April 2005)

- **Pure Methanol is attractive fuel**
 - Active involvement by companies interested in fuel cartridges
 - Bic, Duracell, Tokai
 - Significant energy density advantage over batteries
 - 1200 W-hr/litre, 1500 W-hr/kg Net Energy Density
 - Path for regulatory approval is progressing well
 - UN TDG new classification number
 - Exemption proposal to ICAO in October
 - Cartridge and System safety draft standards released
- ⇒ **Anticipate regulations to be in place Jan 07 for general use worldwide**

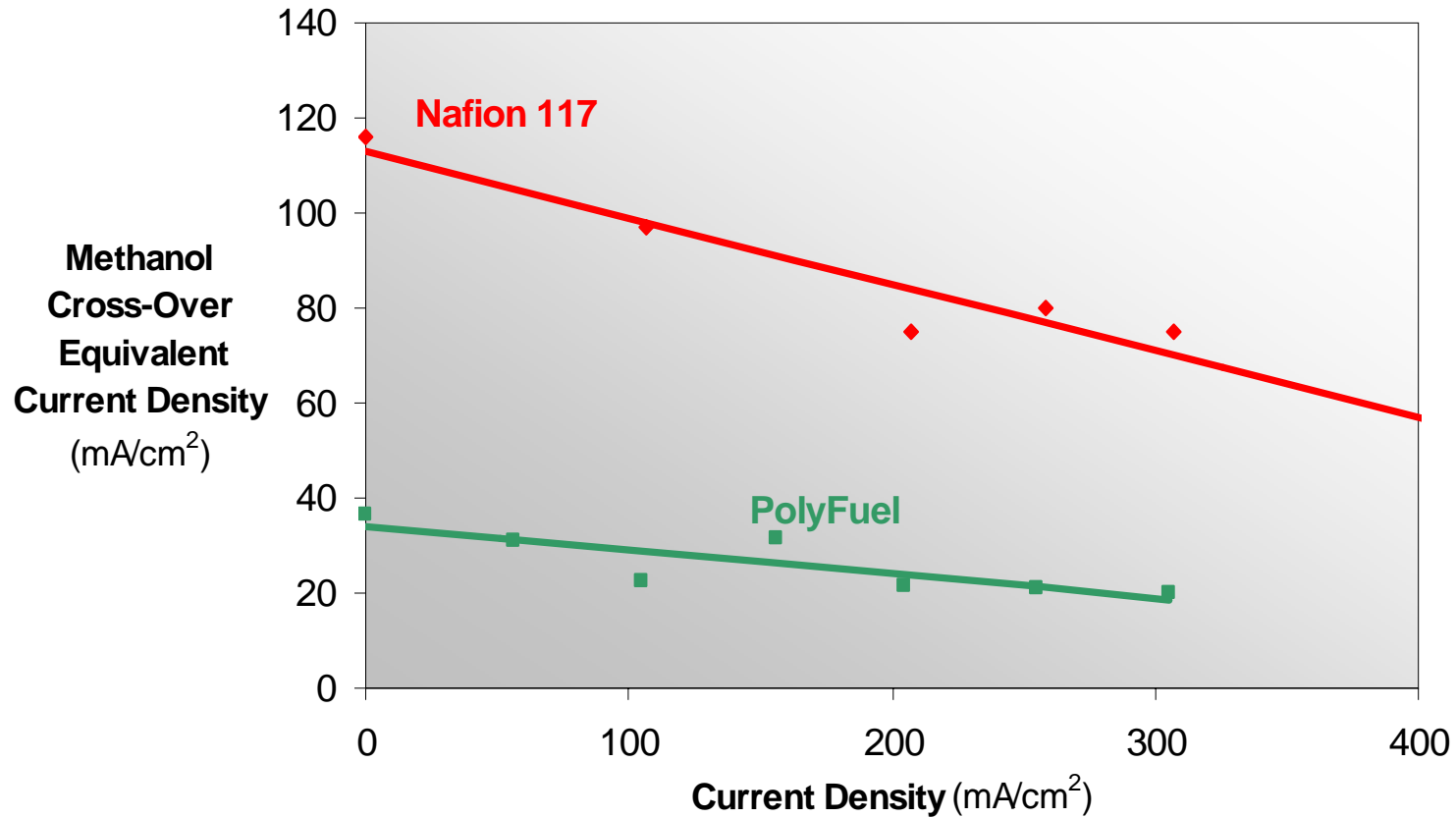
- **Developed by DuPont for hydrogen fuel cells in the 1960s**
- **Nafion™ Membrane**
- **Fluorocarbon based chemistry**
- **Three principal problems:**
 - High Fuel Cross-over = excess heat, shorter runtime, larger systems
 - High Water Cross-over = excess water, larger systems
 - Low Methanol Tolerance = less robust, larger systems



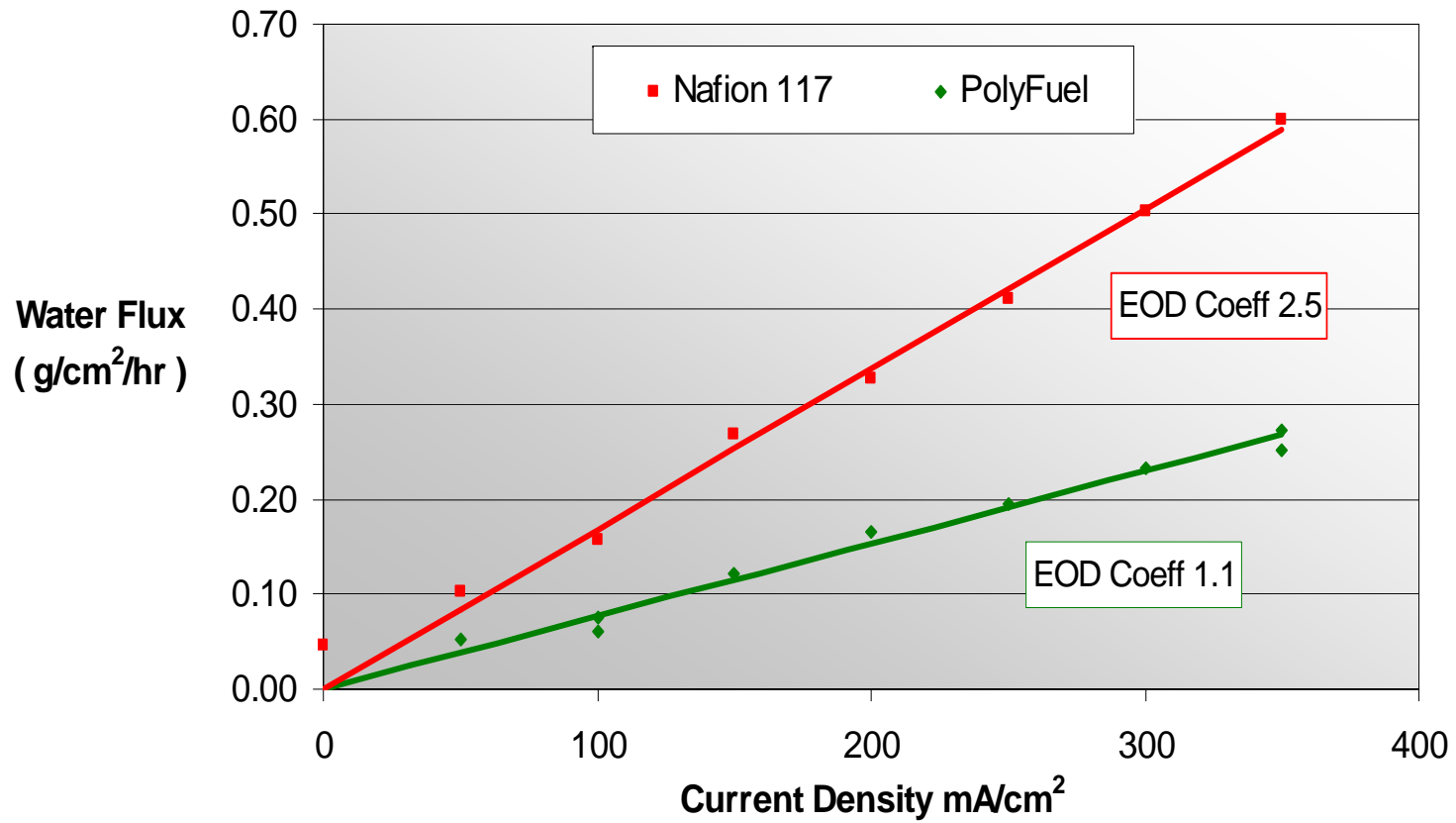
PolyFuel's DMFC Membrane Breakthrough

- **Based on environmentally friendly hydrocarbon chemistry**
- **Engineered specifically to address key DMFC requirements**
 - Nano-architecture approach to polymer design
 - Control movement of protons, water and methanol
- **Significantly outperforms the incumbent**
- **Delivers substantial advantages to system customers**

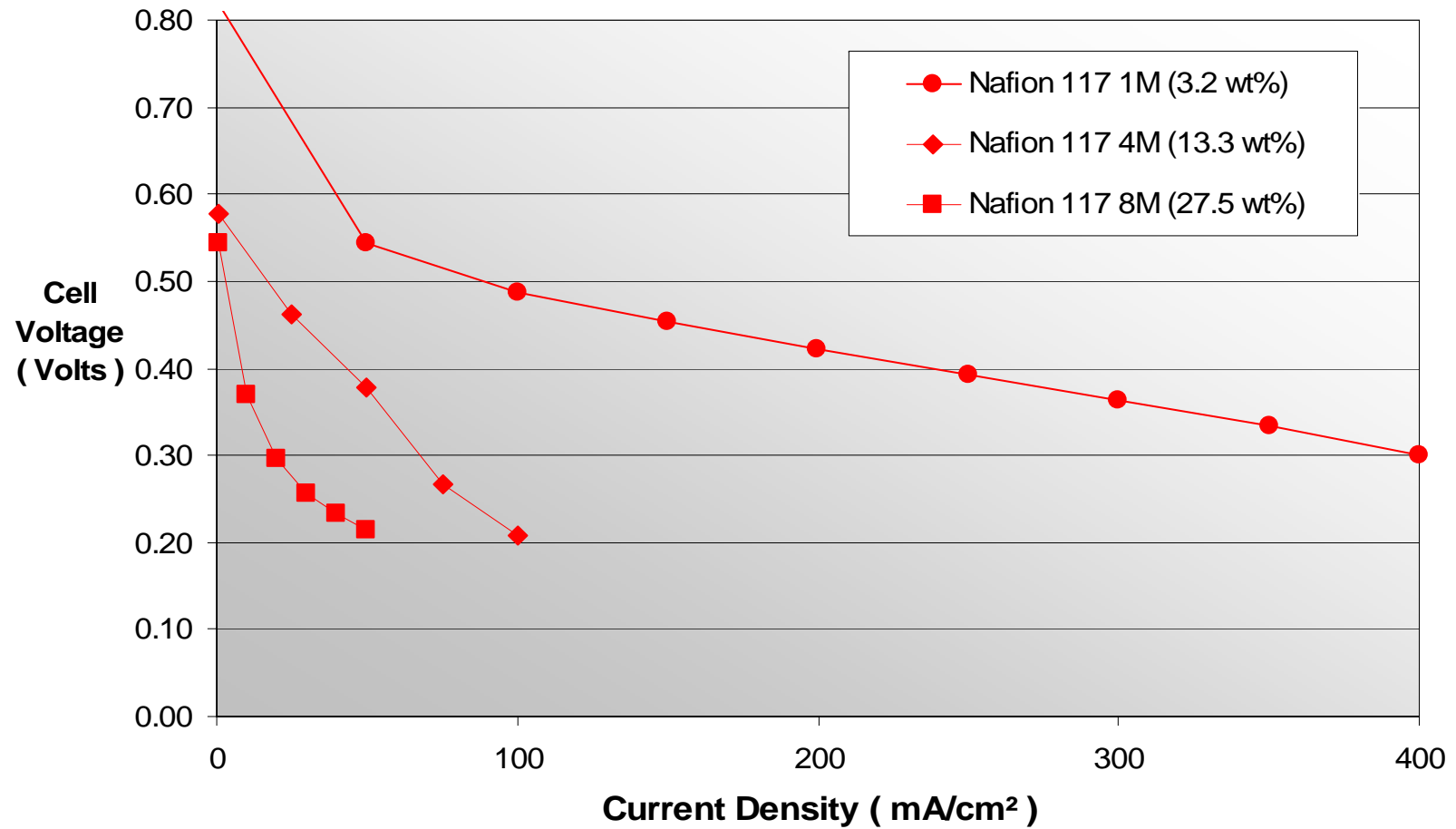
PolyFuel Methanol Cross Over Comparison



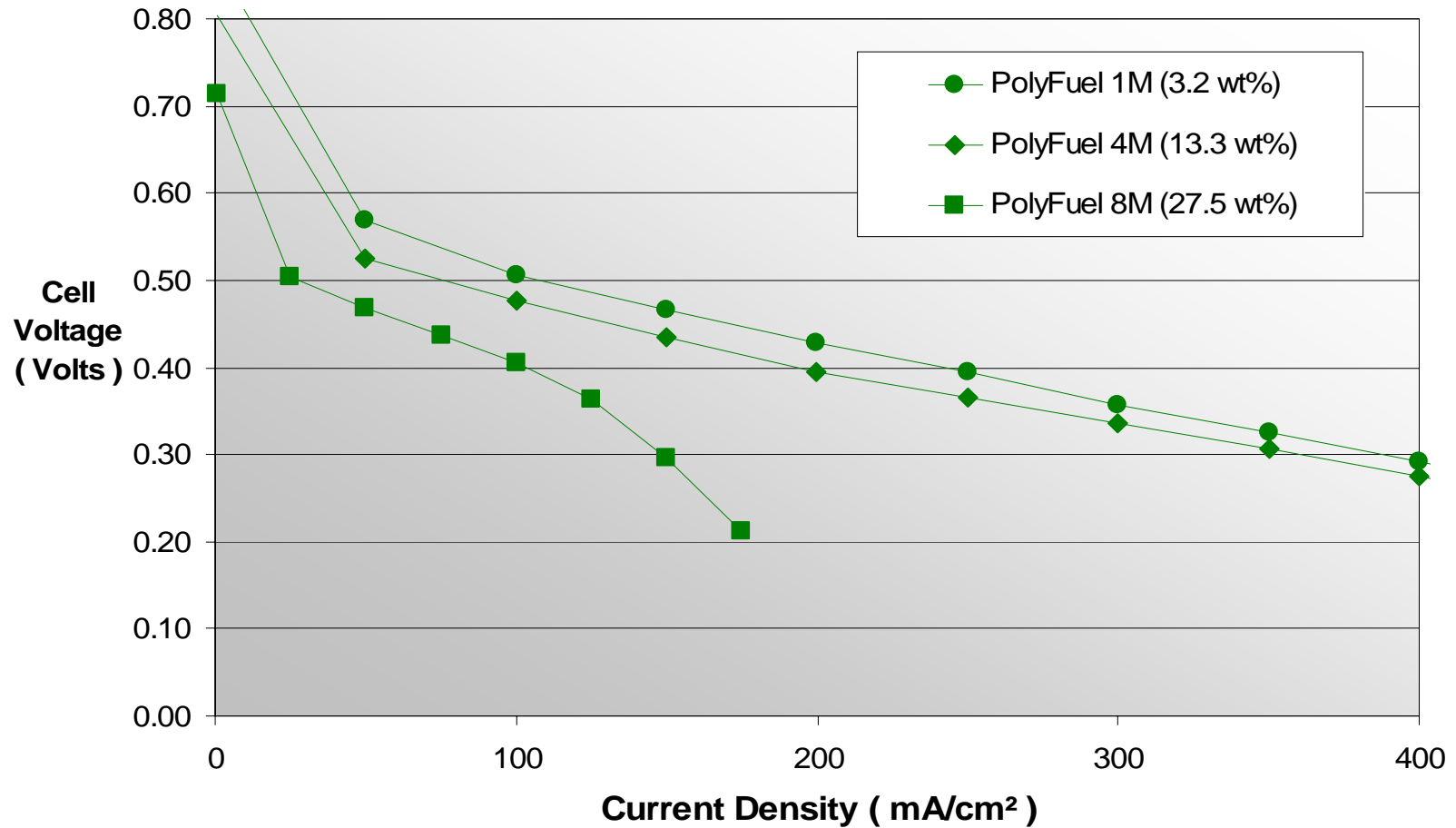
Water Flux



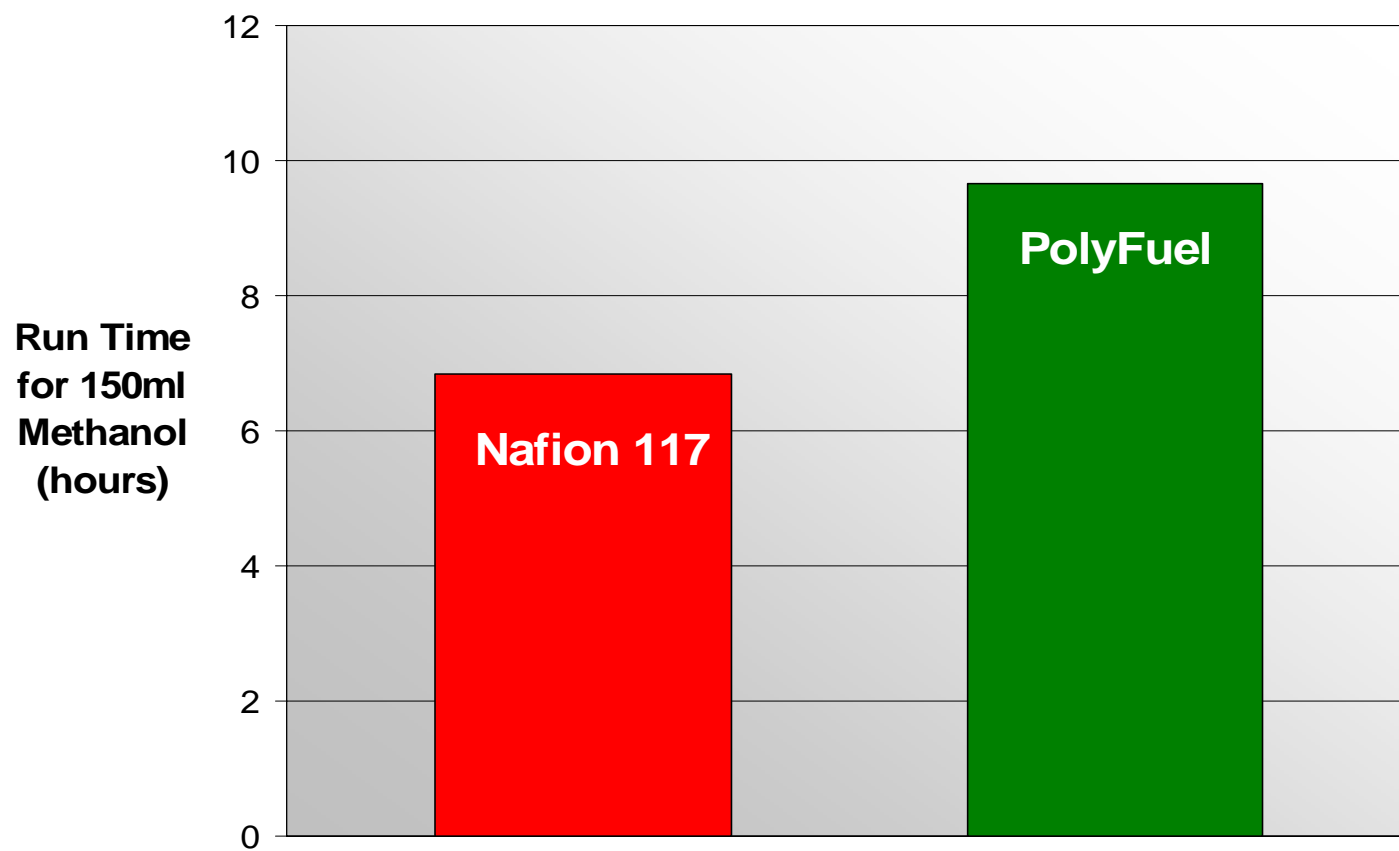
Performance Sensitivity – Fuel Concentration



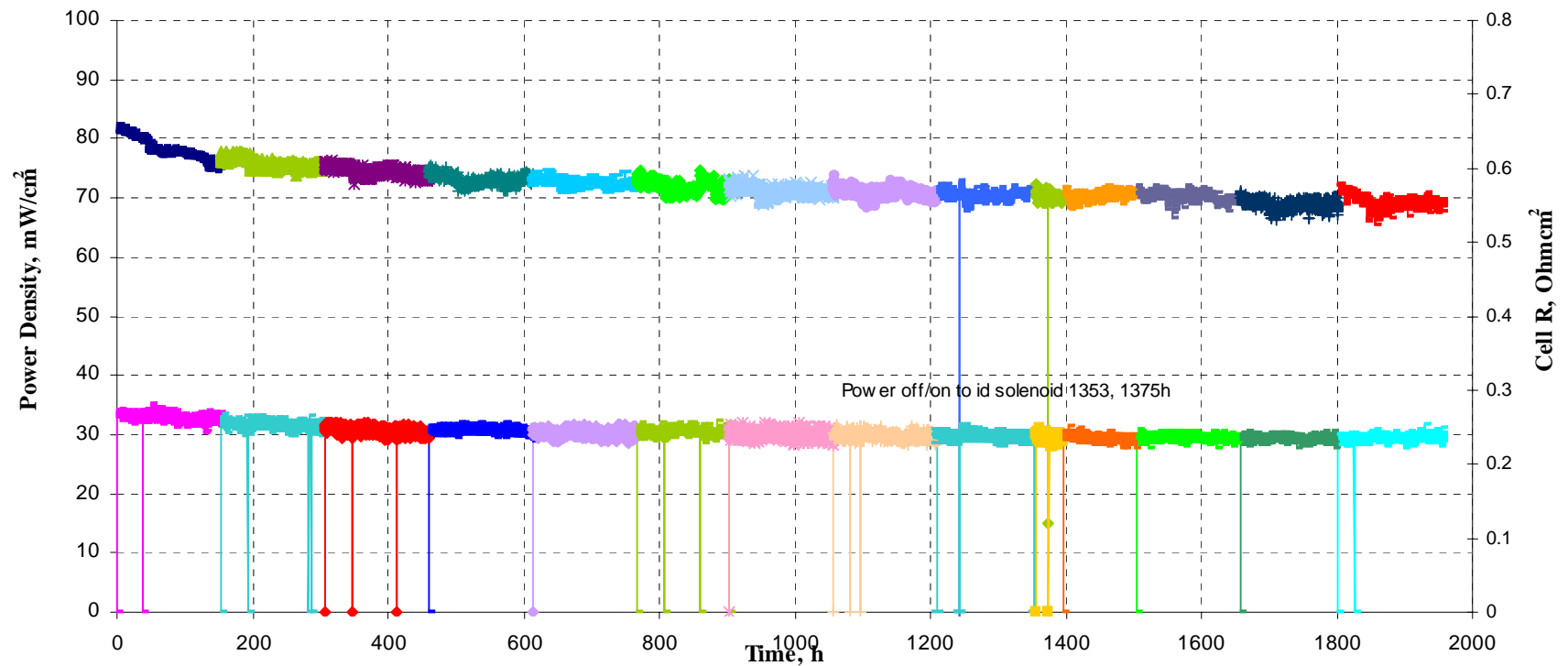
Performance Sensitivity – Fuel Concentration



Fuel Consumption



Membrane Durability



Membrane Features

- **2/3 reduction in fuel cross-over**
- **1/2 reduction in water flux**
- **Higher stability in methanol**
- **Greater mechanical strength**



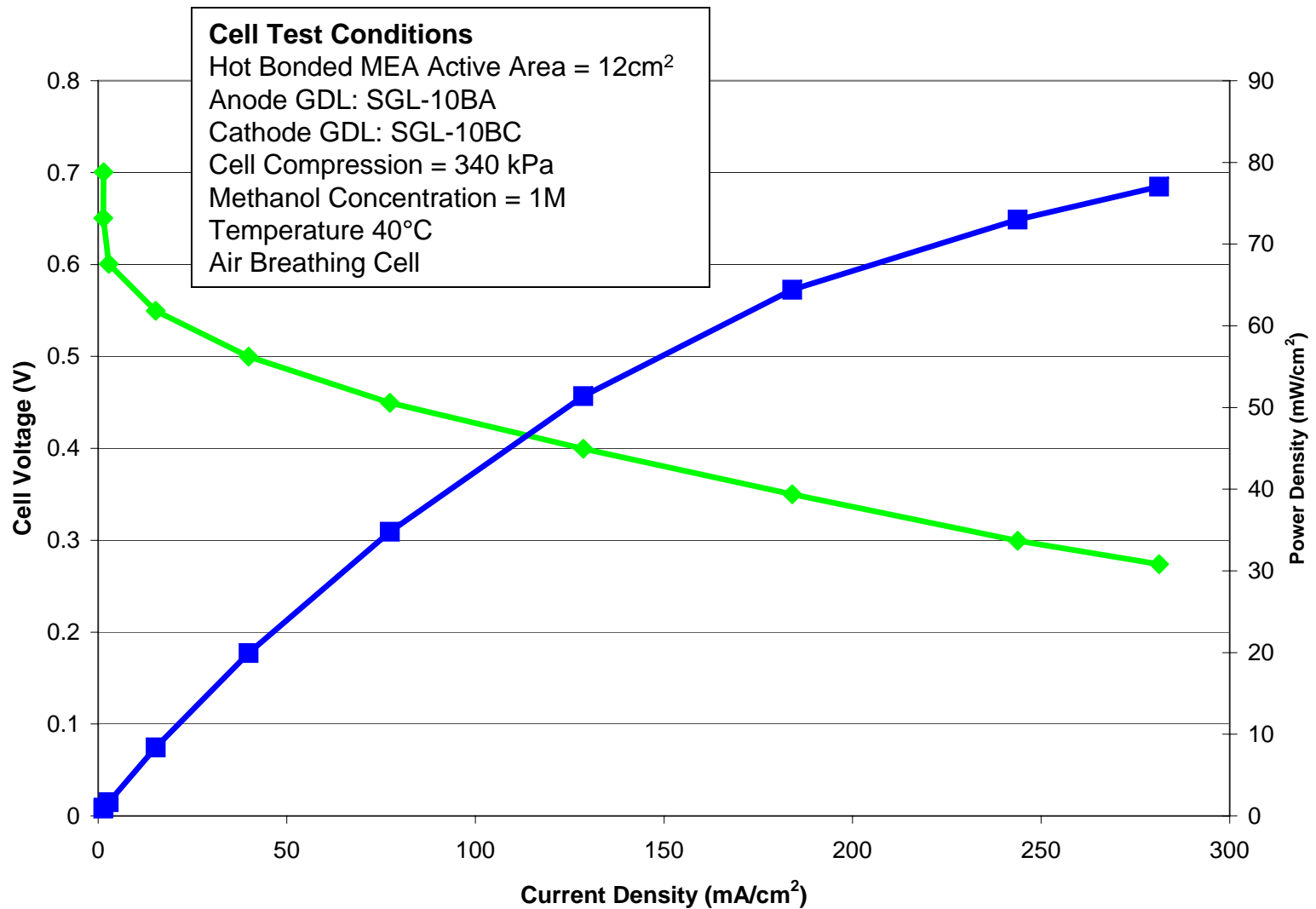
Customer Benefits

- **2/3 less water produced**
- **1/3 less waste heat produced**
- **1/3 longer run time**
- **Smaller system size**
- **Lighter system weight**
- **Lower system cost**
- **More robust designs**
- **Easier manufacturability**



- **High Tg membrane could be manufacturing issue**
 - Nafion is typically 'hot bonded' to electrodes
 - Catalyst on membrane (CCM) techniques work well but lack mechanical bond between catalyst and backing media (gas diffusion layer)
 - Issue for low compression cell / stack designs
- **PolyFuel released 'hot bondable' version of its DMFC membrane**
 - Similar performance advantages
 - Can be used with hot-bonding process used for Nafion

Polarization Curve for Hot Bonded Membrane



- **PolyFuel has answered the market need for DMFC membrane technology**
 - Focused on manufacturing scale-up
- **DMFC will be the first volume fuel cell market**
 - Test market systems to be launched in Asia in 05/06
 - Anticipate first wave of commercial launch in 06/07



PolyFuel™

