Background

• Simultaneously improve catalysis and reaction engineering
  – Exploit heat and mass transfer advantages in engineered microstructures
  – Maximize catalyst performances

• What’s unique?
  – Increase space time yields
  – Explore unique chemistry
  – Reduce size, footprint, and weight; increase efficiency
Characteristics of Microchannel Reactor

- Faster heat transfer rate
  - Shorter distances between heat source and heat sink
  - Higher surface to volume ratio
- Higher mass transfer rate
- Low pressure drop
- Internal channel dimensions same as commercial reactor
- Dependent on economy of mass production, not economy of scale

\[ d \approx 0.05 - 0.1 \text{ cm} \]

\[ d \approx 5 - 10 \text{ cm} \]
# Engineered Catalysts for Microchannel Reactors

## Catalyst Tailored for Reactor Design Philosophy
- Limited Activity
- High Mass Transport
- High Heat Flux

## Porous Ceramic
- Low Heat Flux
- Low Mass Transport
- Limited Activity
- Catalyst Tailored for Reactor

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### Microchannel
- Porous Ceramic ~ 0.002 cm

### Conventional
- Porous Ceramic ~ 0.2 - 1 cm
Space time improve in GTL Applications: Fischer-Tropsch Synthesis


8 X activity increase

Sasol FT Slurry Catalyst

metal-time yield $10^4 \text{s}^{-1}$

Fractional Metal Dispersion
Oxidative Dehydrogenation of Ethane to Produce Ethylene

Yield Challenge

Catalyst Optimization in Microchannel
Hydrogen Production for Fuel Cells: A Compact mW Reformer

Air Products 35 million standard-cubic-feet-per-day hydrogen plant at Tosco Corporation's Avon refinery near Martinez, Calif.

World's smallest mW reformer system

Key Features
- Fuel Processor Vol: < 0.25cm³
- Fuel Processor Wt: <1 gm
- Operating T: 250-300°C
- Catalytic combustion
- Catalytic methanol reforming
- 3 vaporizer/heat exchangers
- Self-sustaining
Fuel Processor Development

FY 1998
- Full-size gasoline vaporizer/combustor
- R&D100 Award

FY 1999
- Fast SR kinetics demonstrated in a microchannel reactor

FY 2000
- Designed and built 25 kWe SR with integrated HX network

FY 2001
- 10 kWe reactor testing
- First “low dP” vaporizers
- Modular test stand established

FY 2002
- SR fuel flexibility, durability testing
- WGS/PROX catalyst studies
- Differential temperature reactor
- SR/WGS/PROX integration
- Full-scale low dP vaporizers

FY 2003
- 100 mW processor demonstrated

FY 2004
- 25W processor demonstrated
- 2 kWe “fast start” processor
- 12 second start demonstrated

Bradley Pre-Prototype

Velocys