



# Commercial-Scale, Microchannel Hydrogen Production

Tad Dritz\*

Jeff McDaniel

Eric Daymo

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# Revolutionary Processing Systems



**Conventional Technology**

# Revolutionary Processing Systems



**Velocys<sup>®</sup> Technology**

# Presentation Agenda



**Velocys Introduction**

**Technology Overview**

**Development and Scale-Up**

**Manufacturing**

**Economics**

**Other Microchannel Applications**

# Velocys Introduction



**Formed in 2001 as a spin-out from Battelle Memorial Institute**

**Over \$70 million invested to date**

**50 employees, including 16 PhD's, many with 10+ yrs industrial experience**

**Located in a 27,000 sq. ft. purpose built facility near Columbus, Ohio**

**Established alliances with engineering and manufacturing firms**

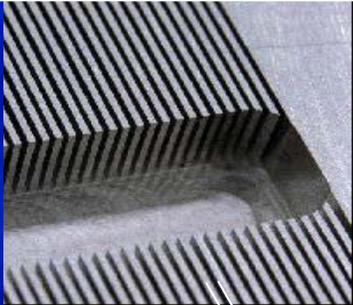


# Enabling Technology



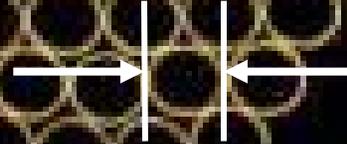
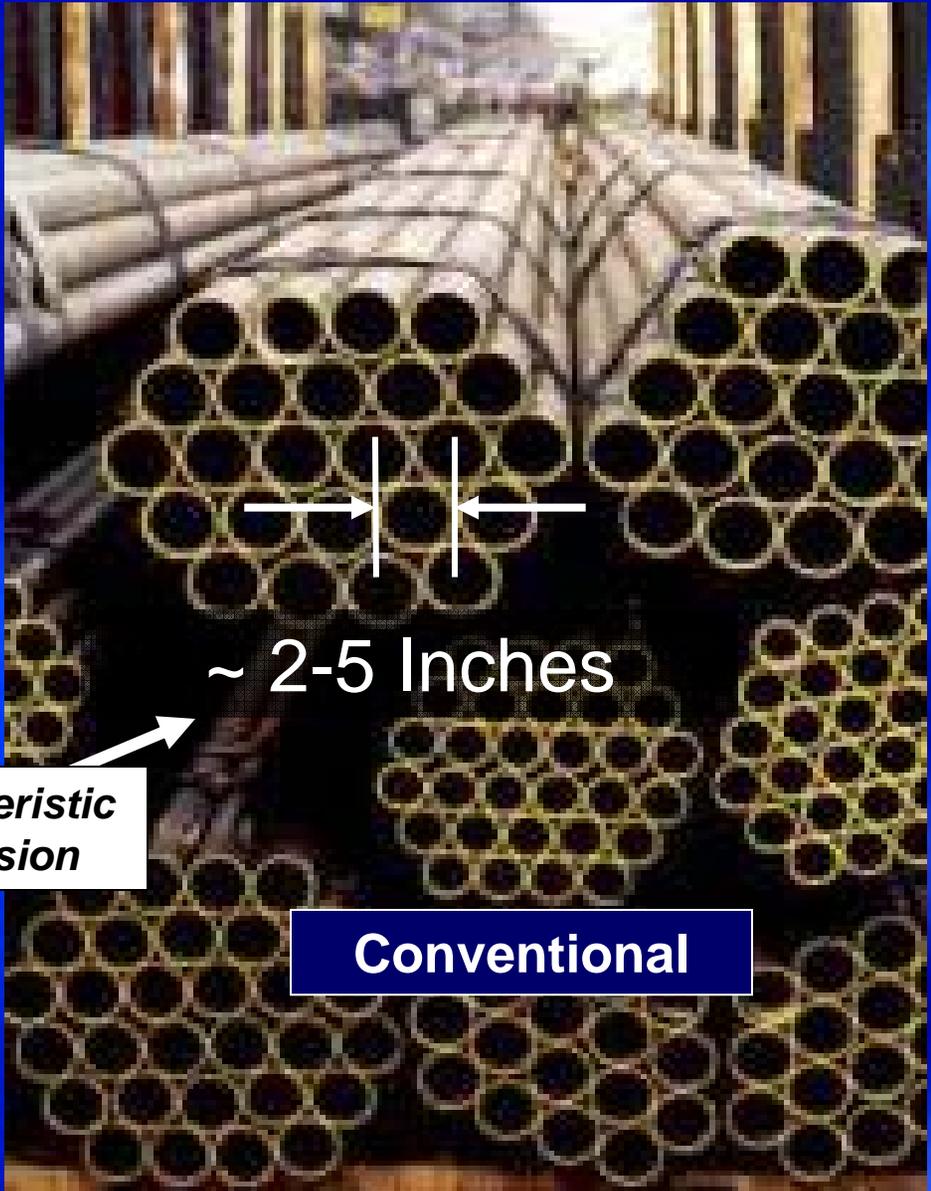
**Velocys  
vs  
Conventional  
Process Technology**

**Velocys**



~ 0.1-0.3 inches

*Characteristic  
dimension*



~ 2-5 Inches

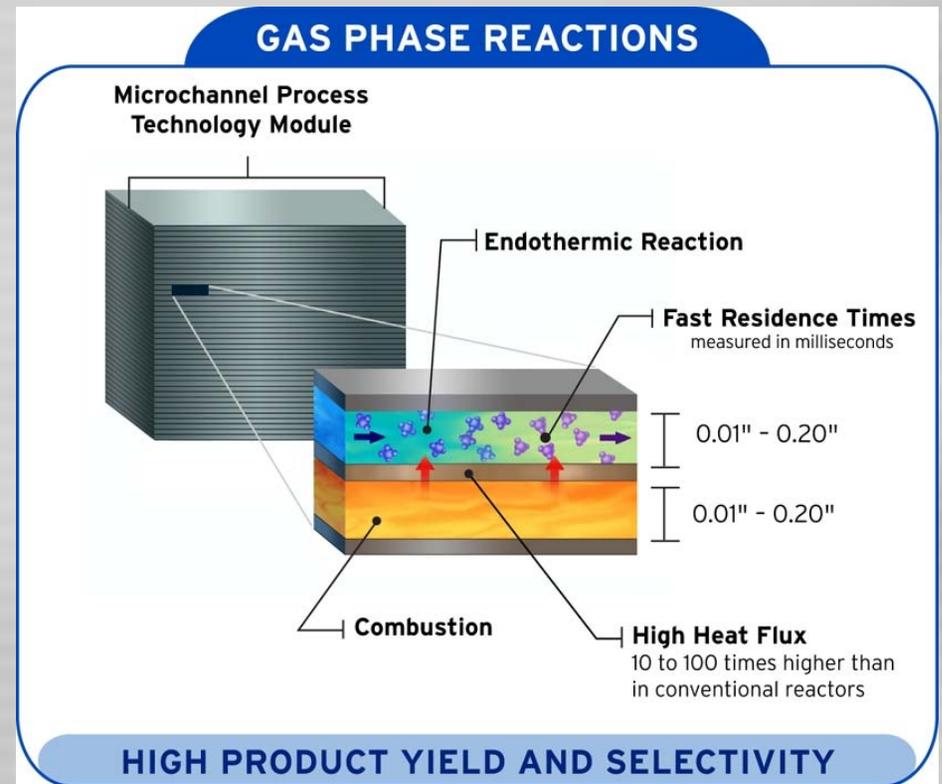
**Conventional**

# Velocys SMR Reactor Technology Advantage



## Very short distances to the wall:

- Enables extremely high rates of heat and mass transfer
- Allows use of novel, more active catalysts
- Accelerates chemical processes by factors of 10-1000X
- Facilitates control of reactions under optimum conditions
- Avoids production of undesirable by-products
  - Higher product yields
  - Reduces downstream separation requirements



# Benefits of Technology



**Reduced capital cost, lower operating cost, smaller footprint and shorter deployment time:**

- **Large scale economics at smaller scales**
  - Lower initial capital investment
  - Higher yield and efficiency/lower operating costs
- **Higher performance**
  - High throughput per unit volume of hardware
- **Greater product yield**
  - Precise control of process conditions
- **Lightweight and/or compact systems**
  - Modular plant expansion, debottlenecking
  - Location in space constrained environments (offshore)

# Integrated High Pressure Velocys Steam Reformer

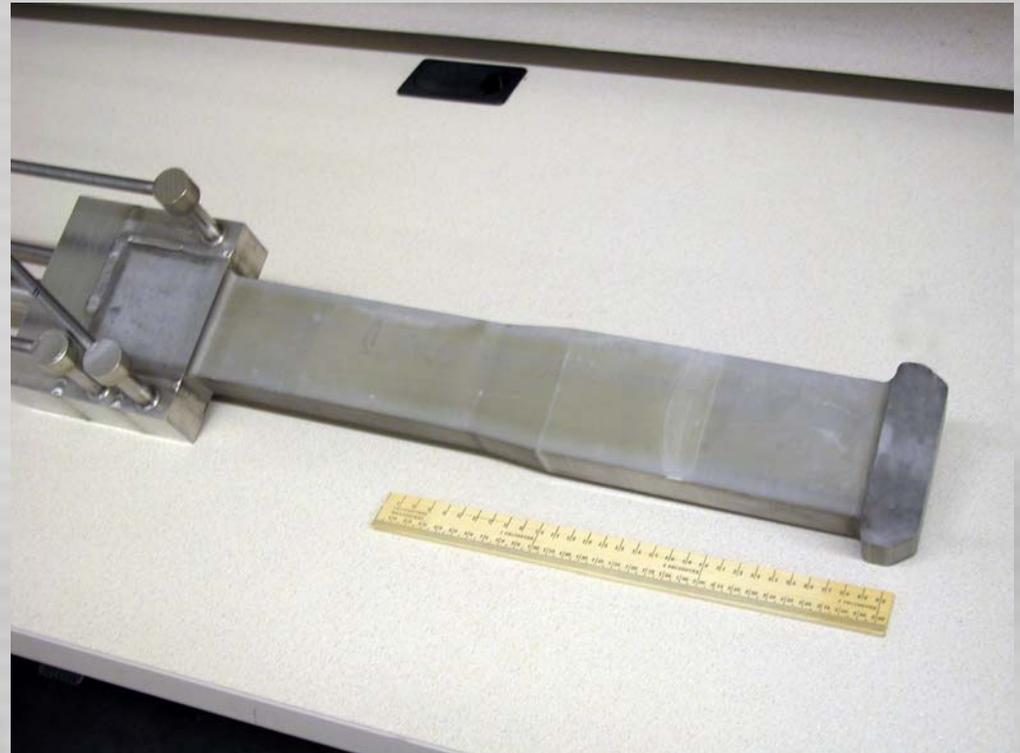


**All unit operations  
integrated within  
one box to improve  
efficiency**

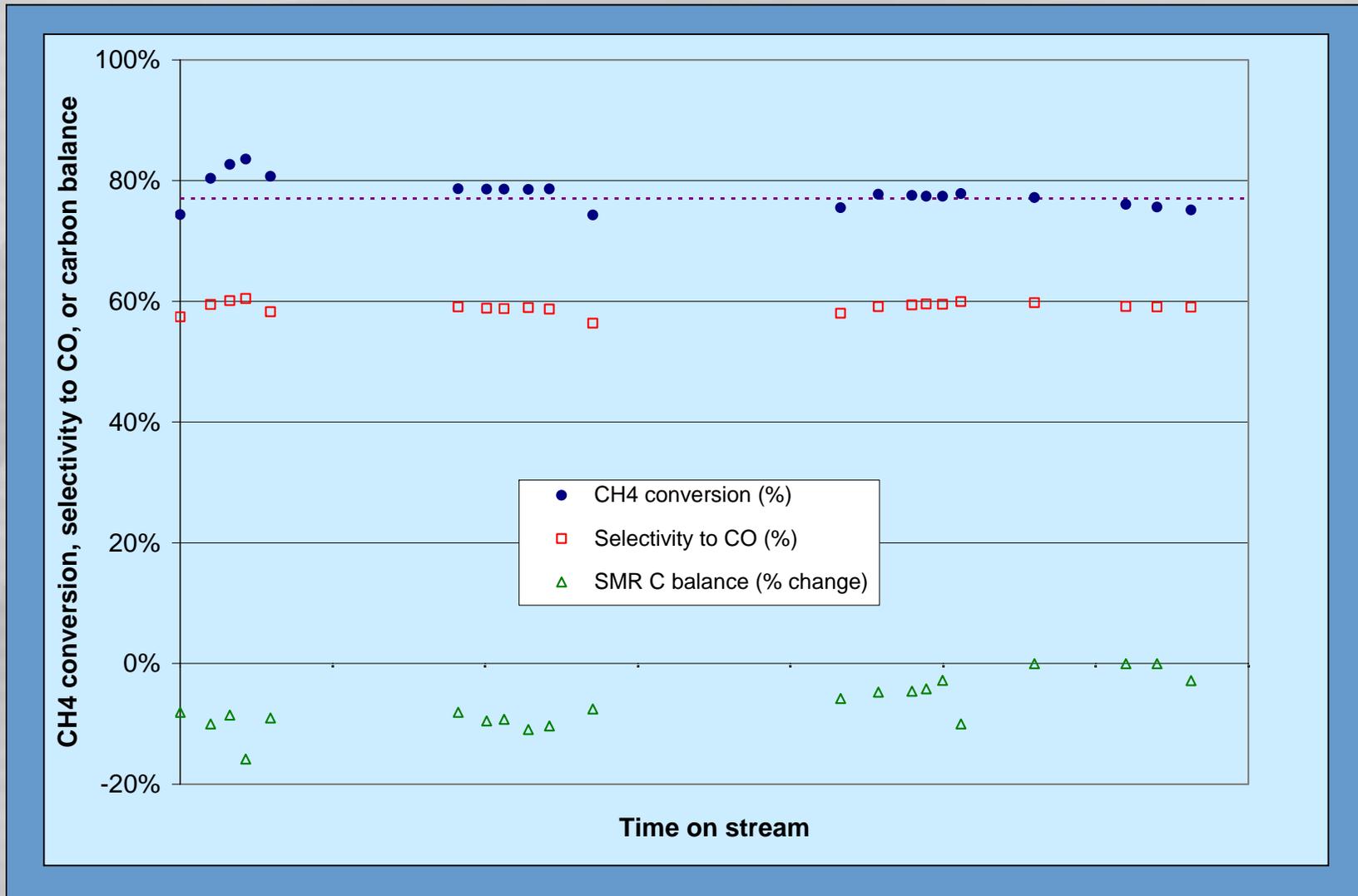
- Heat exchange
- Combustion
- Reforming

**Integrated Device**

- Multichannel
- Capacity ~ 9000 scfd
- High Pressure – up to 25 atm



# Velocys Hydrogen Reactor - 9000 SCFD Capacity



# Velocys Scale-up Methodology



## Cell

- Internal channel dimensions same as commercial reactor
- Number of channels increase; size of channels does not
- ~ 0.5 - 1 lb/hr

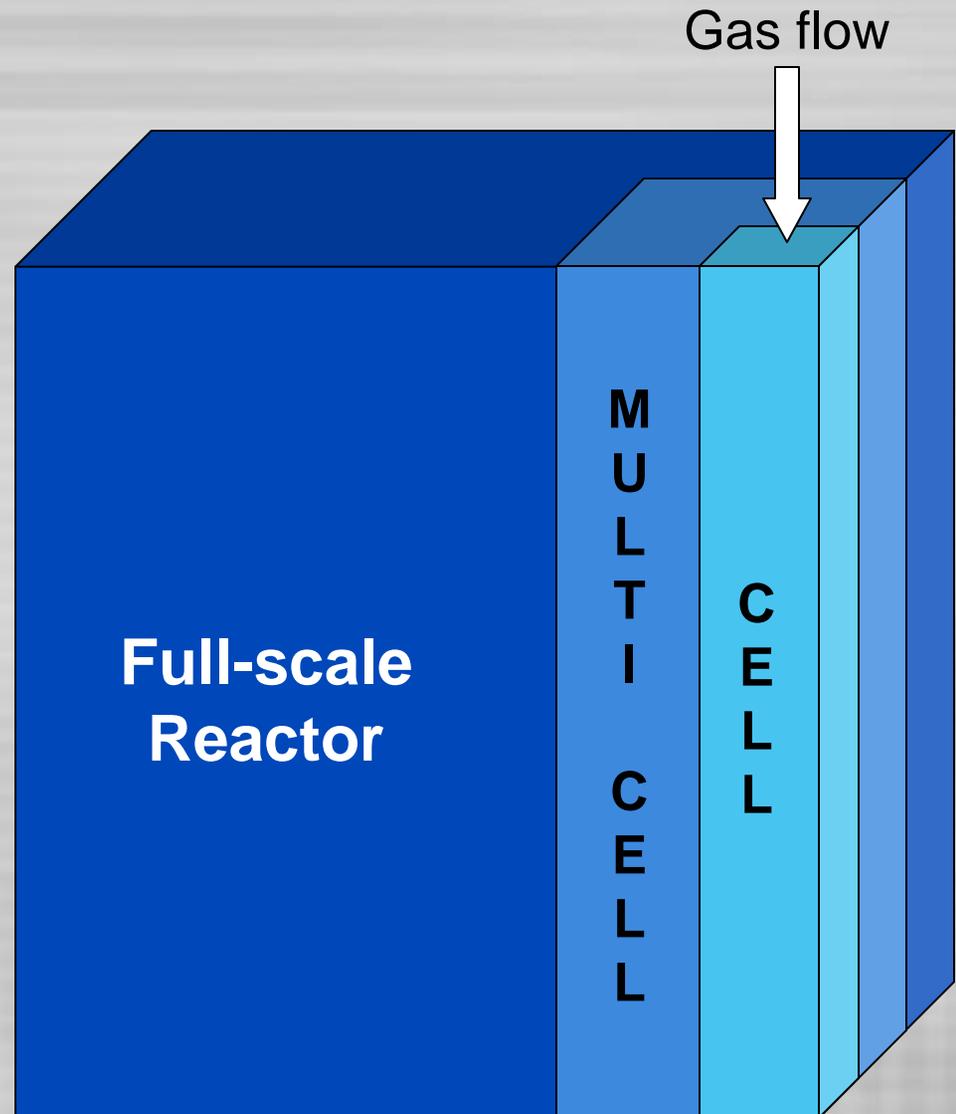
## Multi-Cell

- Many channels
- 10 – 100 lb/hr

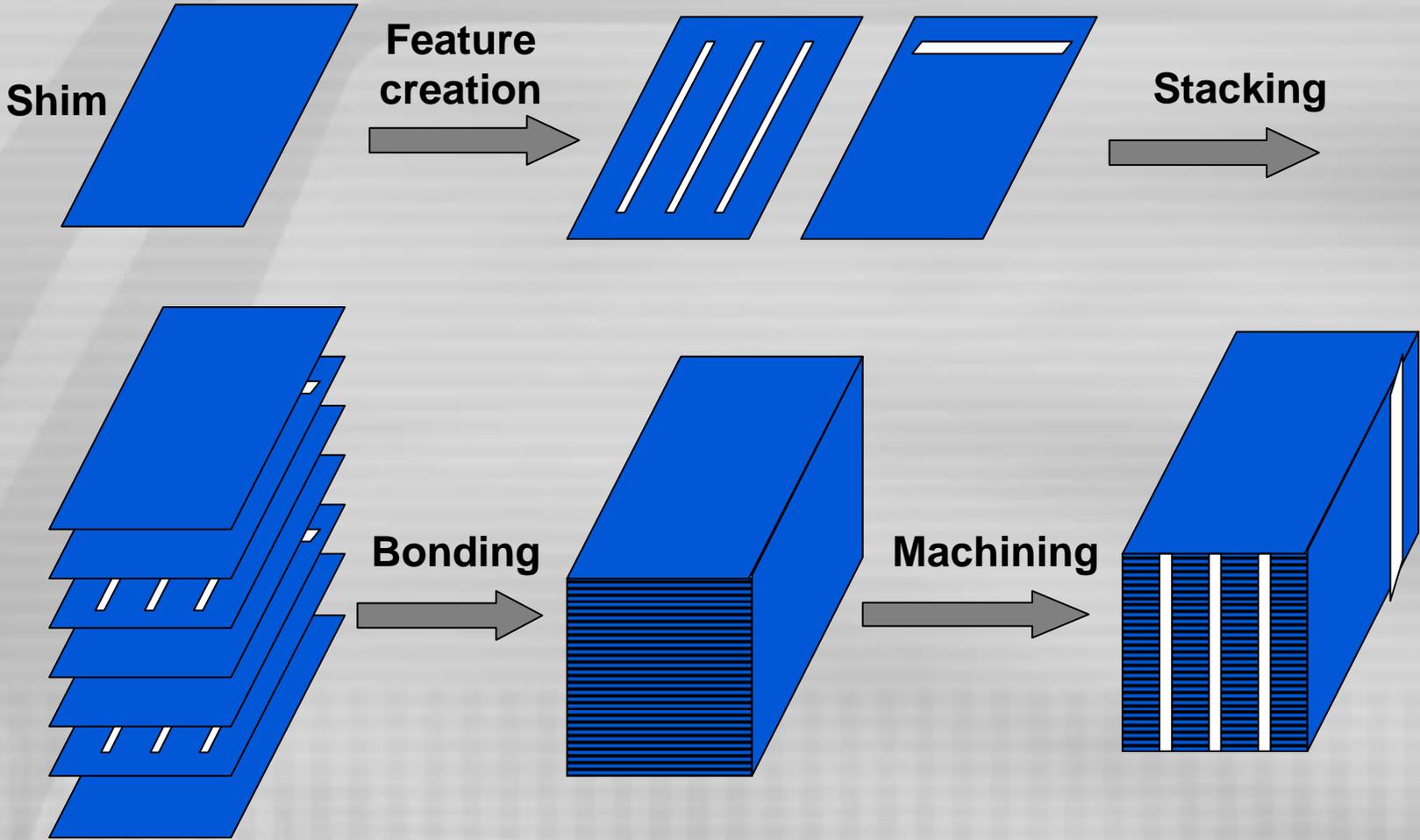
## Full-Scale

- >1000 channels
- 1000-3000 lb/hr

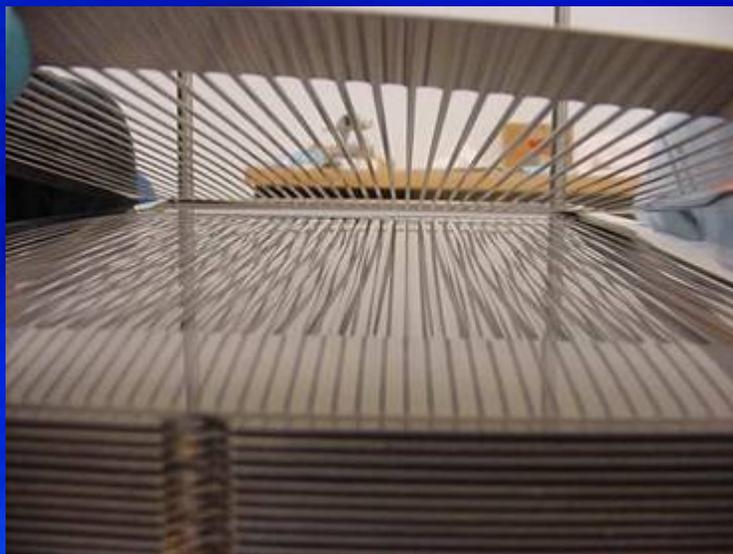
***Full-scale reactor is the basic building block of a commercial plant***



# Microchannel Manufacturing



# Shim Stacking



# Microchannel Manufacturing



**Successfully  
fabricated large stacks  
(~1000 shims)**

**Demonstrated mass  
manufacturing  
techniques**

**Established  
manufacturing supply  
chain partners**

**Finished  
Device**



# Refinery H<sub>2</sub> Market



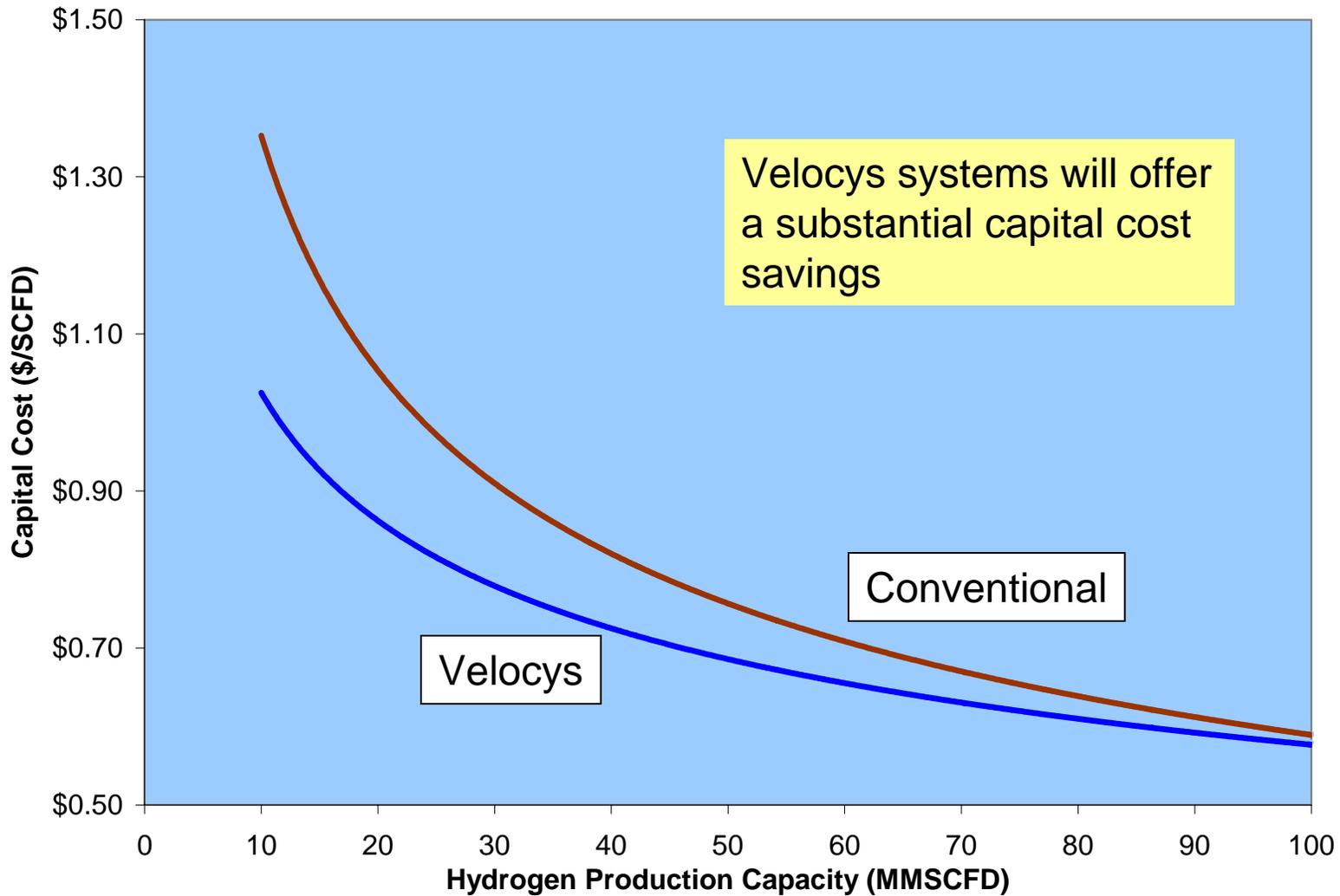
## Primary Drivers

- Changing environmental regulations
  - Lower sulfur requirements
  - Changing fuel composition
- Increasing volume of high-sulfur crude stocks

## Hydrogen Demand

- Primary means for improving fuel quality is using hydrogen to upgrade streams
- Refiners are forecasted to install \$1 billion/year of new hydrogen capacity

# Substantial Cost Advantage



Velocys systems will offer a substantial capital cost savings

Conventional

Velocys

Note: cost comparison is for steam importing configurations

# Chemicals & Stranded Gas



## Chemicals

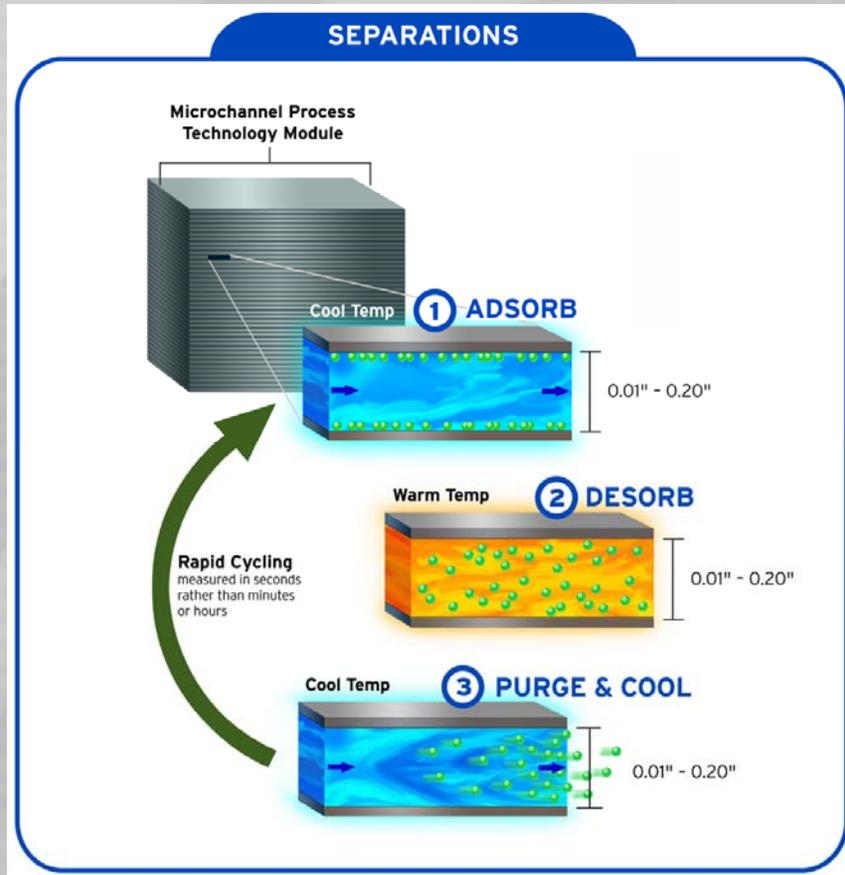
- Selective oxidation, dehydrogenation, others
- Enable de-bottlenecking
- Improve asset utilization



## Stranded Gas & Offshore

- Gas-to-Liquids – FT, Methanol
- Compact enough for installation on offshore facilities
- Attractive economics

# Separations



## Rapid TSA

- Rapid cycle thermal swing adsorption
- Low pressure drop
- Energy efficient

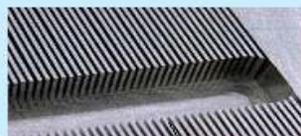
## DOE Funded Project

- Goal: lower the cost of nitrogen/methane separation
- Key for tapping
  - Coalmine Methane
  - Landfill Gas
  - Low-BTU Geological Gas

# Summary

**Velocys  
Technology  
will change  
how,  
where, and  
at what cost  
chemicals  
are produced**

*Velocys*



~ 0.05-0.1 cm



30 feet

*Conventional*

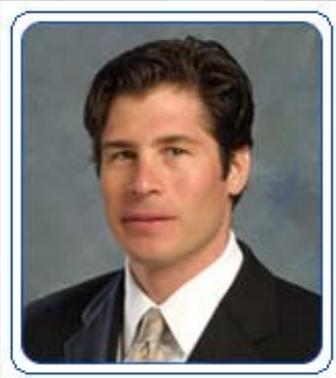


~ 5-10 cm



100 feet

# Contact Information



**Tad Dritz**  
**Business Development Manager**

**(614) 733-3340**

**[dritz@velocys.com](mailto:dritz@velocys.com)**

Velocys Inc.  
7950 Corporate Blvd  
Plain City, OHIO 43064 USA