DOE Workshop

HIGH THROUGHPUT/COMBINATORIAL SCREENING OF HYDROGEN STORAGE MATERIALS

June 26, 2007

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Symyx Technologies

Symyx develops and applies proprietary high-throughput research technologies and software to increase R&D efficiency in chemical, energy, electronics, pharmaceutical and academic labs.

- Pioneer of High Throughput Research (HTR) for materials science
- Founded in 1996; publicly traded since 1999 (SMMX: NASDAQ)
- 400 Employees (mainly in Santa Clara, CA)
- >$400 million invested in technology development over 11 years
- 340 issued patents and 185 pending applications covering broad range of applications and technologies
### Representative Customers

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<th>Chemical &amp; Energy:</th>
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Symyx

- Funded Research Collaborations for new technology development
- Symyx Software to manage research data and integrate R&D teams
- Symyx Tools to increase research productivity
Primary and Secondary Screening

1000’s

100’s

10’s

1’s

Lead Discovery: 1º Screening

Optimization: 2º Screening

Lab Reactor

Pilot Plant

Plant

Experiments per day

Symyx

Industry
Platform Technology Areas

- **Homogeneous Catalysis**
  - Ligand Synthesis
  - Catalyst Synthesis
  - Parallel Reactor Technology
  - HT Polymer Characterization

- **Heterogeneous Catalysis**
  - Substrate Synthesis
  - Catalyst Preparation
  - Parallel Reactor Technology
  - HT Product Characterization

- **Specialty Polymers**
  - Monomer, Initiator, Control Agent Syntheses (Organic)
  - Parallel Reactor Technology
  - HT Polymer Physical/Materials Properties Characterization

- **Optical/Electronic Materials**
  - Vapor Phase Thin-Film Synthesis
  - Solution Phase Library Synthesis
  - HT Materials Characterization
  - HT Device Fabrication and Performance Evaluation
Materials Classes Studied at Symyx

**Energy Storage and Generation**
batteries, fuel cell electrodes, thermoelectrics, photovoltaics

**Optical Materials**
photo- and electroluminescent phosphors for lighting/displays, materials for digital radiography, inorganic and organic OLEDs, TCOs

**Electronics Applications**
semiconductors, dielectrics, diffusion barriers, magnetics, electroless metals and metal alloys, photoresists

**Heterogeneous Catalysis**
mixed-metal oxides/sulfides, zeolites/mesoporous oxides, supported oxides, sulfides, clays

**Homogeneous Catalysis**
organic ligands, inorganic and organometallic complexes
# Materials for Hydrogen Storage

## Materials Classes Relevant to H₂ Storage
- High surface area organic and inorganic materials
- MOFs (Jeff Long)
- Nano-scale materials
- Complex metal hydrides
- Chemical hydrides (B, C, N)
- Homogeneous and heterogeneous catalysts for H₂ uptake/release

## Required HT Technology
- Automated, array-based materials synthesis platforms
- General materials properties analysis
- Reactors for direct H₂ uptake/release
Heterogeneous Catalysis: Synthesis

- Precursor preparation
- Support dispensing
- Parallel/rapid serial Impregnation

- Solid Transfer
  Transfer to reactor vessel by weight or volume, may dilute

- Characterization
  (e.g. XRD, BET, EDS, microscopy)

- Reduce, sulfide, etc.
- Wash