



Center for Automation
Technologies and Systems
A NYSTAR Designated Center For Advanced Technology

Center for Automation Technologies and Systems (CATS)

John T. Wen

Director, CATS

Professor, Electrical, Computer, & Systems Eng.

and Mechanical, Aerospace, & Nuclear Eng.

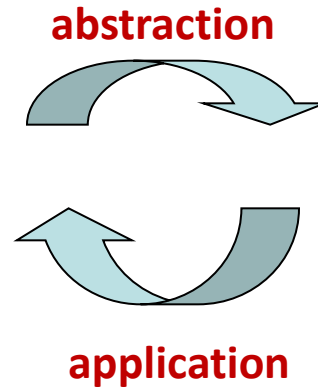
Rensselaer Polytechnic Institute, Troy, NY

April, 2010

- CATS is a Rensselaer research center founded in 1989 based on a New York State block grant
 - >\$4M annual expenditure
 - Emphasis on industrially driven research leading to economic development
 - 10-year designation allows staff retention, research continuity (re-designated in July 2009)
- Interdisciplinary environment with 32 faculty from 9 departments in 3 schools, 40 students (18 grad, 22 undergrad), 5 research technical staff, 3 post-docs, 1 business development staff
- Extensive laboratory facility and design tools

CATS Research Approach

Interdisciplinary
applied research and
development for
challenging industrial
problems with **no
existing commercial
solution**



Generation of
**general principles,
methods, and
technologies**

***Holistic Automation: Integrated Modeling, Design,
Optimization, Sensing, & Control***

Core Competency

- **Manufacturing:** industrial automation, flexible material handling, design of experiments, design for manufacturing, flexible manufacturing, robotics
- **Control Systems:** Model identification, high performance control algorithms, optimal control, iterative learning, design optimization, mechatronics
- **Computer Vision:** Vision guided assembly, vision based inspection, optomechatronics, adaptive optics, adaptive illumination

Applications

- Fuel Cell manufacturing
- Composite manufacturing
- Battery system design and manufacturing
- Material processing
- Investment casting
- Construction robotics
- Power systems monitoring
- Thermal management
- Active flow control
- 3D MEMS assembly
- Live cell imaging
- Distributed sensor network
- Distributed lighting system
- Tissue engineering with cell printing

Recent CATS Projects

Manufacturing Automation

- NYS: Albany Int., Arcadia Supply, Brown Coach, Ceralink, Construction Robotics, Crystal-IS, Dynabil, Ecovative Design, Kintz Plastics, MPI, PMD Welch Allyn
- Non-NYS: BASF Fuel Cell
- Federal: DOE, NSF, ONR
- State: NYSERDA

Sensing and Monitoring

- NYS: NYISO, NYPA, Kitware, KAPL
- Non-NYS: AEP, PJM, 1st Energy
- Federal: NSF

Precision Motion and Assembly

- NYS: O'Brien & Gere, Solidus
- Non-NYS: ESI, Thorlabs
- Federal: NIST

Modeling and Design

- NYS: GE, IBM, InfoSciTex, Northrop-Grumman, Simmetrix, Somstech
- Non-NYS: Boeing
- Federal: AFOSR, ONR

Mechanisms to Work with CATS

- Technical consultation, feasibility study, **exploratory research**
- **Collaborative research** for process improvement or product development with **professional project management**
- **Joint proposals** to State (e.g., NYSERDA) and Federal Agencies (e.g., through SBIR/STTR or BAA)
- Identification of **RPI faculty and organizations** and/or **external partners** best matched with needs

Example Collaboration

Targeted challenging problems

- Innovative alternatives
- Prototype solution
- Assist in productization

Example: ESI

R&D assistance

- Identify bottleneck
- prototype solution
- Assist with finding vendor

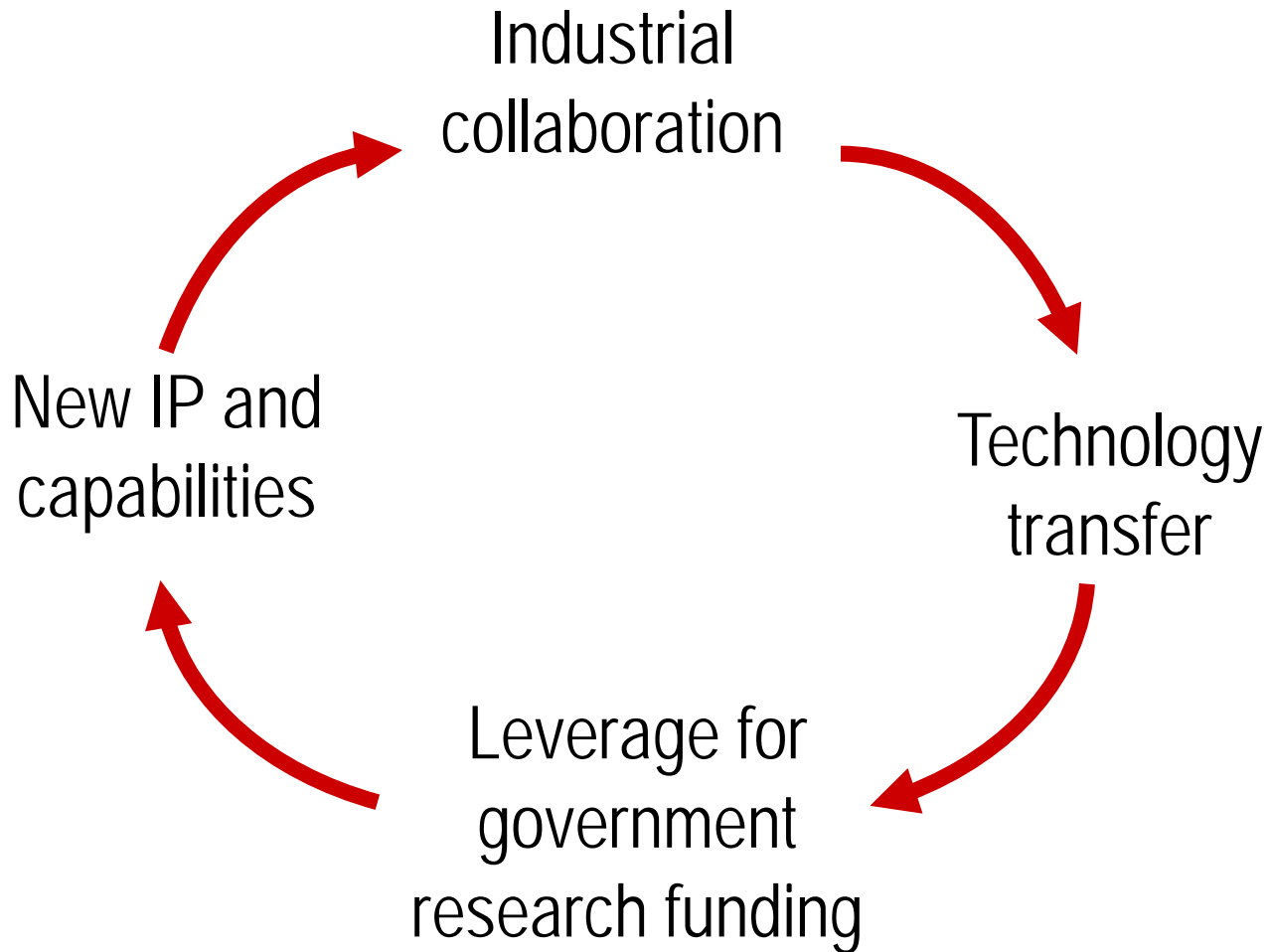
Example: BASF Fuel Cell

Collaborative research

- Joint proposal for 3rd party funding (SBIR/STTR, BAA, NYSERDA, DoD)
- Complementary research strength

Example: Northrop Grumman

CATS Model



Research Example: Precision Motion

- **Company specific problem:** Feedforward control design for vibration suppression in high speed motion control
- **Problem solution:** Phase 1 simulation study followed by experimental studies with production equipment
- **Technology transfer:** Training of company engineer and porting of algorithm to product
- **Government funding:** NSF GOALI grant for more fundamental research. Publication with company review: best student paper CCA 2004, best paper CASE 2006. Generation of new IP.
- **Licensing:** Commercialization and additional funding
- **Close the loop:** More company projects & fed proposals

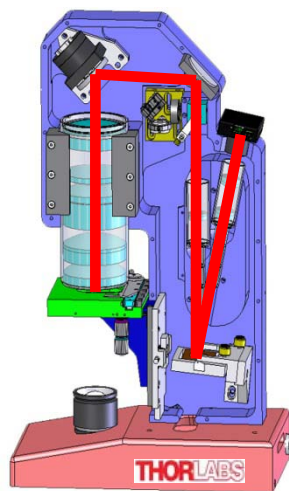
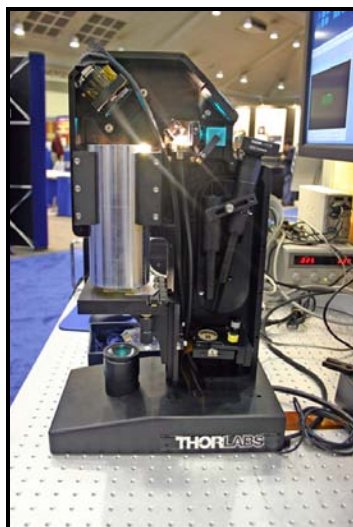


THORLABS



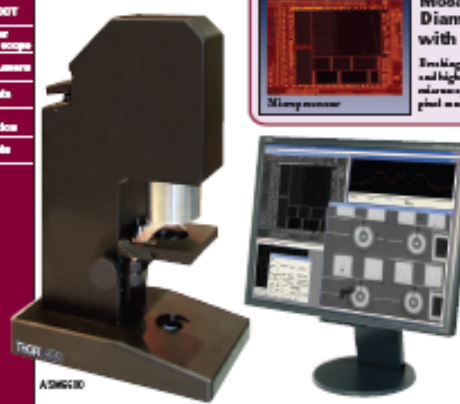
Licensing and Commercialization

- First ASOM prototype built at RPI CATS based on NSF and CATS funding. RPI licensed to Thorlabs in 2006.
- Close collaboration for Photonics West 1/07 live demo
- Thorlabs ASOM won Laser Focus World Product of the Year Award in CLEO 5/07
- ASOM sold through Thorlabs catalog (8-page spread) July 07



Microscopy and Laser Imaging
Adaptive Scanning Optical Microscope...Page 1 of 8

ASOM
Spectral Filter OCT
Smart Source OCT
Video-Rate Laser Scanning Microscope
Smart Source Lasers
OCT Components
Laser Microscopy Options
Microscopy Tools



Mosaic Imaging Provides 40mm Diameter Composite FOV Image with a 1.5µm Resolution

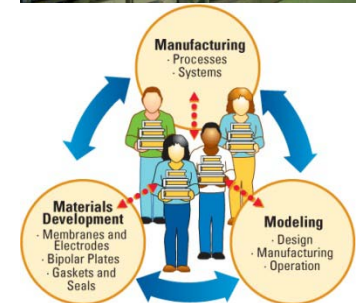
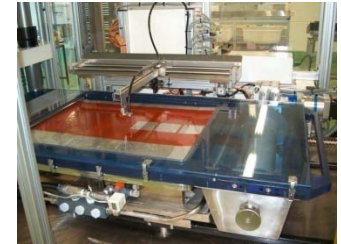
Breaking the barrier between large field of view (FOV) and high resolution with our smartest, the composite microscope, the ASOM offers superior 40,000 x 40,000 pixel mosaic images in just 20 seconds.

ASOM Specifications

- Composite Field of View: 40mm (Diameter)
- Total Observable Field Area: 1250cm² (315 Tiles at 0.39cm²/Tile)
- Resolution: 1.5µm
- Static Optical Magnification: 6.5X (0.8µm to 0.023 High Pass Filter)
- Numerical Aperture: 0.23
- Working Distance: 10mm
- Operating Wavelengths: 400-530nm
- Camera Pixel Counts: 3324 x 768
- Camera Pixel Size: 4.7µm x 4.7µm
- Camera Dynamic Range: 50dB
- Camera Shutter: 1/15 to 1/6000s
- Manual Sample Stage Translation Ranges X: 175", Y: 2.25", Z: 1.35"

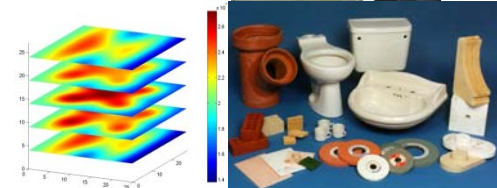
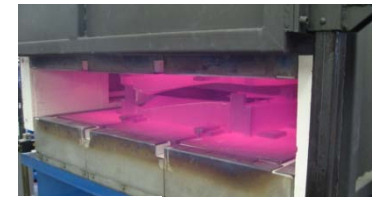
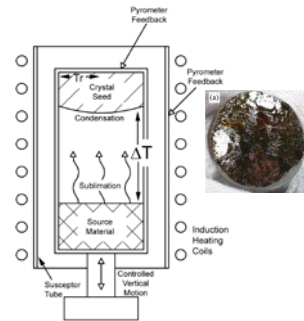
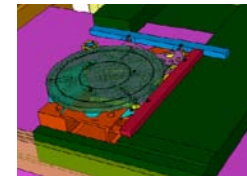
Research Example: Fuel Cell Manufacturing

- **Company specific problem:** High temperature (PBI) FC membrane manufacturing
- **Problem solution:** Proof-of-concept model design
- **Technology transfer:** Specification for automation builder for production line
- **Government funding:** NSF IGERT grant for Ph.D. education and fundamental research. DOE grant on process control and improvement. New York State Energy Research Development Agency (NYSERDA) grants for laser processing research.
- **Close the loop:** Continuing company R&D projects + federal and State proposals



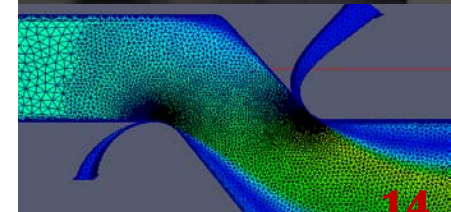
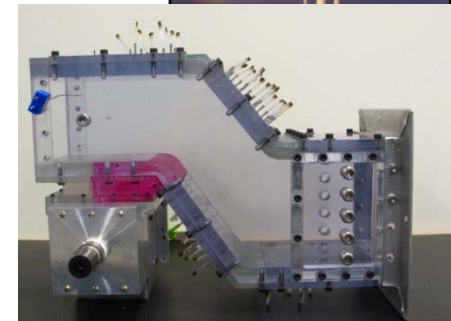
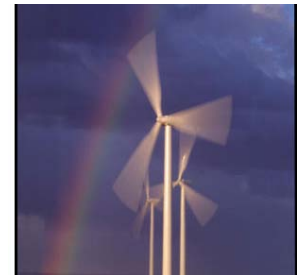
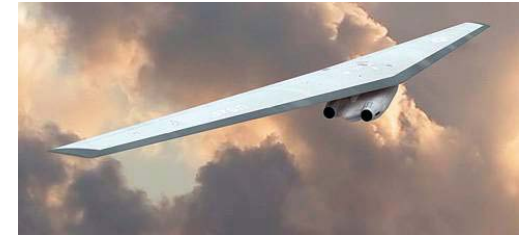
Research Example: Thermal Management

- **Company specific problems:**
 - Thermal growth management in wafer processing.
 - Heat-up, cool-down, thermal gradient management for crystal growth.
 - Temperature distribution estimation and control for metal and ceramics processing.
- **Problem solution:** Integrated methodology combining finite element modeling, model reduction, sensor-actuator placement, estimator and controller design.
- **Leveraging:** ONR Multidisciplinary University Research Initiative (MURI) and NYSERDA funding
- **Close the loop:** Further projects and joint proposals with companies.



Research Example: Active Flow Control

- **Initial Engagement:** Multidisciplinary Design Laboratory (MDL) projects on active flow control from different companies: aggressive fighter maneuvers, morphing wing, wind turbine control.
- **Follow-on Projects:** Active flow control for UAV inlet duct designs
- **Leveraging:** Boeing, AFOSR, NYSERDA (wind turbine)
- **Close the loop:** Further company projects, joint proposal /projects with company (NASA, AFRL)



Education and Training

- Participation of **undergraduate and graduate students** in research programs (undergraduate research projects, thesis research)
- Placement of students in partner companies through **internship, co-op, employment** (in coordination with Career Development Center)
- Fostering student entrepreneurship: co-sponsorship of **student business plan competitions**, manufacturing and business advice and guidance.
- Collaboration with RPI **Multidisciplinary Design Laboratory** to mentor student design teams to assist partner companies.
- Providing student projects in **Introduction to Engineering Design**
- Assistance to and shared resources with **Advanced Manufacturing Lab (AML)**
- **Short courses and workshops** (e.g., composite manufacturing, lean manufacturing) together with sister organizations (e.g., Center for Economic Growth, Chief Executive Network, High Tech Rochester) to organize
- Providing guidance and support to **local high schools** US FIRST Robotic teams