NPI Subcommittee on Advanced Manufacturing

Subcommittee Chair:
Mark Taggart
Laser Mechanism Inc.
Economic Impact/Photonics Impact

- Photonics, and particularly lasers, enable Advanced Manufacturing
- Versatile tools for:
  - Fabricated metal production is on the rise, and with it, laser sales trends

2010 data from Baer & Schlachter
“Lasers in Science and Industry: A report to OSTP on the contribution of lasers to American jobs and the American economy”
Role of Photonics in Enabling Competitiveness in Advanced Manufacturing

• Vital to keeping leading edge
  – Advances in photonics go hand-in-hand with advances in product development and manufacturing (i.e. scaling of laser performance is tied to the semiconductor industry roadmap and to addressing new requirements in metal processing for lightweight materials; improved metrology and imaging techniques improve quality control)

• Key to making Caterpillar’s construction equipment, Ford’s automobiles, Intel’s processing chips, or Apple’s computers - all mentioned by President Obama as companies bringing manufacturing jobs back from overseas

*We must work to make it easier for more of our companies to take advantage of Advanced Laser Manufacturing because other nations are already well ahead of us.*
Barriers to Competitiveness and Possible Solutions

**Barriers:**
- Other nations are putting resources into developing advanced manufacturing capabilities (German Fraunhofer Institutes; Chinese Laser Manufacturing Institutes)
- Other nations are supporting industries that require advanced manufacturing
- Lack of qualified staff at all levels

**Solutions:**
- Industry/Academic and Non-Profit/Government research programs that focus on real world applications to better understand laser/material interactions; NNMI or similar institutes
- More effort placed in coordination of a national effort, i.e. through NNMI
- Better coordination of industry needs with education system

**Call to Action:** Let’s “Light the Way” to the jobs and products of tomorrow by creating National Institutes based on Photonics Technology for Advanced Manufacturing with substantial support provided by the US government in forming a public/private partnership.
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Industry Representative:
Magdi Azer
GE Laser Research Center
Market-focused R&D

• First U.S. industrial lab
• Began 1900 in Schenectady, NY
• Founding principle … improve businesses through technology
• One of the world’s most diverse industrial labs

Cornerstone of GE’s commitment to technology
Robert N. Hall

In 1962, Hall invented the semiconductor injection laser, a device now used in all compact disk players and laser printers, and most optical fiber communications systems. Hall retired from GE in 1987. Also, Dr. Hall is credited with the invention of a process to purify germanium and the invention of the semiconductor pin rectifier.

Hall’s schematic of the injection laser
## Leveraging the Breadth of GRC Mfg

### Advanced Machining
- Electro-Machining
- Shaped-Hole Drilling
- Superfinishing Processes
- "Intelligent" Machining

### Metal Processing
- Centrifugal Casting
- Directional Solidification
- Powder Metallurgy
- Forging Processes

### Laser Processes
- Thick-Section Welding
- Laser Additive Fabrication
- Laser Surface Treatments
- Process Controls

### Additive Manufacturing
- Design for Additive Tools
- Metal & Ceramic Processes
- Polymer Rapid Prototyping
- Micro-scale Processing

### Manufacturing Scale Up
- Mfg Readiness Level Assessment
- Equipment Design
- Pilot Scale Production
- Low Rate initial Production

### Composites
- Ceramic Matrix Composites
- Polymer Matrix Composites
- Automated Fiber Placement
- Inline Inspection & Monitoring

### Coatings
- Low-Cost TBC’s
- Suspension Plasma Spray
- Thin Films for Solar
- Ice-Phobic Nano Coatings

### Inspection
- 3D Boroscope Inspections
- Optical Metrology
- Inline CT
- Automated Defect Recognition

### Services
- Repair Applications
- On-Site Field Services
- In-Situ Inspection & Repair
- Automated Workscoping

### Operations Research
- Factory Simulation & Optimization
- RFID Tracking
- Data Telecommunications
- Mfg Data Informatics
Laser Applications Across a Jet Engine

Lasers Touch Every Aspect of the Engine
Global environment

**Materials** … rising costs & supply constraints

**Production** … overcapacity in most industries

**Labor** … increasing costs in the developing world

**Product development** … shorter cycle times, more price points

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Must innovate differently
Rethinking Industrial R&D

Old
Design dictates materials and manufacturing selection

• Mostly sequential process
• Few interactions
• Limits design options

New
Manufacturing and materials differentiate product design

• Non-sequential process
• Creates interactions
• New degrees of freedom

Design innovation
Materials selection
Manufacturing & supply chain planning

Manufacturing
Innovation
Design
Materials
SOFTWARE
Enabler #1 – Advanced Mfg Research

Requirements to Realize 20% Wind

- Jobs expected to stay in US, only if investments are made in certain components and in Adv Mfg tech.
- US factories must reduce labor hours/blade by 30-35% to be competitive.

80% Increase in Throughput
65% Decrease in Consumables
Enabler #2 – Technology Transition Path

- **IR&D (Internal Research & Development)**
  - Concept development
  - Jugular experiments
  - High risks/High Pay-off

- **NTI (New Technology Introduction)**
  - Lab Demonstration
  - Mfg Costs Understood
  - Producibility Confirmed
  - Retire Key Risks

- **NPI (New Product Introduction)**
  - Product Development
  - Technology Mature
  - Final Validation/Testing
  - Risks Abated

- **Product Manufacturing**
  - Mfg Procedures Fixed
  - High Mfg Yields
  - Lean Mfg/Six Sigma
  - No tech risk

**Business Tollgate Process**
- Avoids New Technology Development During NPI
- Enables Retirement of Key Risks Prior to Commercialization
Infrastructure to Support Mfg Scale-Up

Supporting NPI Cycle Time of 3-5 Years
Enabler #3 - Integrated Computational Tools

Alloy Chemistry  ↔  Processing  ↔  Microstructure  ↔  Properties  ↔  Materials Solution

Forging & Heat Treatment Models  ↔  Microstructural Evolution  ↔  Mechanical Property Predictions  ↔  Component Life prediction

Tools allow materials solutions to keep up with product design
**Enabler #4 – Additive Manufacturing**

Ultrasound Probes via Additive Manufacturing

- **Rapid evaluation of design concepts**
- **Unique designs of piezocomposites**

**Sintered PZT:**
- Uniform 1-2 μm grains
- Dielectric constant: 3200
- $K_t$: 0.53 (95% of theoretical)
Enabler #5 - A New Model for Collaboration

Fraunhofer Cluster of Innovation »TurPro«

»TurPro«
integrative production technology for energy efficient turbo machines

- Manufacturing and repair processes for compressor and turbine components
- Industries: Power Gen & Aerospace
- Budget: 10.25 Mio. €
  - Industry: 3.1 Mio. €
  - Fraunhofer: 4.05 Mio. €
  - NRW: 3.1 Mio. €

Partners:

Additive BLISK manufacture

Granted by North Rhine-Westphalia

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Impact of Photonics

Global Photonics Market
(Current € Billions)

Europe, 55.0
Global, 215.0

# of Companies Involved in Photonics 21
- 2005 – 250
- 2009 – 1400

# companies that mfg products in Europe
- 5,000

# people directly employed in photonics
- 300,000

# new jobs from 2005-2009
- 40,000

2008
Innovation today requires a more integrated approach.

Acceleration possible in fields like ICME & Additive Mfg.

Collaborations essential.

... need to consider new models.