Manufacturing Innovation at Georgia Tech

Ben Wang
Presentation Outline

1. Big M Manufacturing
2. AMP
3. Advanced Composites
4. Additive Manufacturing
5. Bio-Manufacturing
6. Q&A
Presentation Outline

- Big M Manufacturing
- AMP
- Advanced Composites
- Additive Manufacturing
- Bio-Manufacturing
- Q&A
Mfg. Innovation Eco-system

Stakeholders
- Univ.
- C.C.
- Workforce
- Governments
- Indus.
- Unions
- NGOs
- NLs
- Citizens

Concept → mfg. → E.O.L.

Enablers
- Tech.
- Policy
- Infrast.
- Education
- Supply chain
Mfg. Innovation Eco-system

Stakeholders

Univ.  C.C.  Workforce  Governments

Indus.  Unions  NGOs  NLs  Citizens

Enablers

Tech.  Policy  Infrast.  Education

Supply chain

Big “M” Manufacturing
Why Manufacturing?

- Major wealth creator
- Excellent return on investment
- Dominant innovation driver
Mfg. creates national wealth

U.S. Exports

- Mfg Goods: 70%
- Non-Mfg: 30%
Economic Multiplier Effect

$1 investment
In manufacturing

$2.48 economic activity
Innovation Driving Force

U.S. Patents

- Mfg Industry: 90%
- Non-Mfg: 10%
The Value of Innovation

What is the value of your research in to this so called "Theory of Electricity"?

One day sir, -- you can Tax it!

Source: Wiki Commons
Discovery to Application – A Slow Process

We need to do better!

After Gerd Ceder (MIT); materials information from T. W. Eagar and M. King, Technology Review 98 (2), 42 (1995).
Catalysis information from R. Schrock et al. and R. Adzic et al.
Current Innovation Value Chain Is Broken

Basic Research → Applied Research → Technology Maturation → Product Development

Academia → Valley of death → Industry
Big M Manufacturing

AMP

Advanced Composites

Additive Manufacturing

Bio-Manufacturing

Q&A

Presentation Outline
“Our first priority is making America a magnet for new jobs and manufacturing.”
President Barack Obama
What is AMP and why is it important?

- President Obama announced the Advanced Manufacturing Partnership (AMP) initiative on June 24, 2011
- Reinvigorating the U.S. manufacturing competitiveness
- Creating high-quality jobs
- Public-private partnership (PPP)
Formed a steering committee to provide guidance on this important national initiative.

- Committee consists of six university presidents and 12 company CEOs.
- Carnegie Mellon, Georgia Tech, Michigan, MIT, Stanford, UC Berkeley
- Allegheny Technologies, Caterpillar, Corning, Dow, Ford, Honeywell, Johnson & Johnson, Intel, Northrop Grumman, P&G, Stryker, UTC

GIT President Appointed to the White House AMP Steering Committee
REPORT TO THE PRESIDENT
ACCELERATING U.S. ADVANCED MANUFACTURING

Executive Office of the President
President’s Council of Advisors on Science and Technology

October 2014
The Start of a Network...

Additive Manufacturing

Power Electronics

Digital Manufacturing

Lightweight Metals


2015 Solicitation: Smart Mfg

2015 Solicitation: Photonics

2015 Solicitation: Flexible Electronics
Here is what we know about NNMI in 2016

<table>
<thead>
<tr>
<th>Agriculture</th>
<th>Defense</th>
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<tr>
<td>Bio-manufacturing (bio energy)</td>
<td>Nano engineered materials</td>
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<td>Nano celluloses</td>
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<td>Commerce</td>
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<td>Open topic 1</td>
<td>Roll-to-roll materials and mfg</td>
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<tr>
<td>Open topic 2</td>
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Georgia capabilities relevant to all NNMI institutes

- **Georgia Manufacturing Extension Partnership (GaMEP)** – one of the best run programs of the national NIST MEP network
- **Advanced Technology Development Center (ATDC)** – one of the oldest, most established and most successful incubator in the nation
- **QuickStart** – #1 in US in workforce development
- **Technical College System of Georgia (TCSG)** – 25 technical colleges producing a skilled workforce
- **Georgia Centers of Innovation (GCOI)** – Aerospace, Agribusiness, Energy, Life Science & Information Technology, Logistics, and Manufacturing
SIX THINKING HATS
Additive Manufacturing
Nano-Composite Processing
Sustainable Design & Manufacturing
Model-Based Systems Engineering
Clean Energy Manufacturing
Industrial Design
Precision Machining
Factory Information Systems
Robotics
Supply Chain & Logistics
Public Policy
Regenerative Medicine & Stem Cells
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Since 1960…

- Composites have grown 16 times
- Aluminum has quadrupled
- GDP has nearly quadrupled
- Steel has doubled

Index 1960 = 100

Source:
Evolution of Advanced Composites

System's Benefits

Future Requirements

Generation I  Generation II  Generation III
The Evolution of Composite Materials and Systems

**System performance**

- **Generation I** (1940s-1970s)
  - Initial fibers & resins
  - Metallic designs
  - Hand fabrication
  - Autoclave processing
  - Destructive inspection

- **Generation II** (1980s-2010s)
  - Intermediate modulus fibers
  - Toughened resins
  - Design & analysis tools
  - Designs for composites
  - Automation
  - Liquid composite molding
  - Non-destructive evaluation (NDE)

- **Generation III** (2020s-)
  - Multifunctional
  - Health monitoring
  - Adaptive manufacturing
  - Low life cycle cost
  - Nano – multiscale

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**Military aerospace**

**Commercial aerospace**

**Sporting goods**

**Today**

**Commercial / military aerospace**

**Sporting goods**

**Infrastructure**

**Consumer goods**

And many more…
The Nobel Prize in Chemistry 1996

Sir Professor Harold W. Kroto  
Dr. Robert F. Curl, Jr.  
Dr. Richard E. Smalley
Carbon nanotubes’ amazing properties

- Strongest fiber ever been made
- Electrical conductivity of copper or silicon
- Thermal conductivity higher than that of diamond

Dr. Richard Smalley, 1996 Nobel Laureate
Accelerating insertion of multifunctional technologies

- Advanced Helmet Technology
- Sensors
- Nanofoams
- Actuators
- Robust manufacturing process control
- Thermal management
- Field emission
- EMI shielding
- Energy conversion and storage
- High-performance composites
- Fire and smoke retardant composites
- Lightning strike protection

From Nanotubes and Buckypaper to Devices and Systems
Carbon nanotubes’ amazing properties

- Strongest fiber ever been made
- Electrical conductivity of copper or silicon
- Thermal conductivity higher than that of diamond

Dr. Richard Smalley, 1996 Nobel Laureate

*Can These Properties Be Realized In Bulk Materials?*
Carbon nanotube buckypaper
3D Printing is perhaps the most talked about technology in recent years.
3D printing: from art to part
3D printing applies to many sectors
Additive Manufacturing

Plastics
Metals
Ceramics
Printed electronics

Laser, electron beam, ultra-sound, etc.
Functionalized 3D plastic part

*EMI Shielding Circuits Printed onto a Dome*
RFID tag on polyimide

Temperature sensor printed with carbon nanotubes

RFID tag and antenna array on carbon fiber

RFID tag on polyimide

RFID tag on silicone
Integrated use of different groundbreaking 3D printing technologies
Innovative integration of 3D printing and printed electronics technologies for medical applications

CT Scan

Multi-Material 3D Printing

3D Printed Valve

Calcium Deposits

Strain/Deformation Measurement

3D Printed Valve with PE Strain Sensors on Surface

AJP Printing

In collaboration with Piedmont Heart Institute Atlanta
2012 Nobel Prize in Physiology or Medicine

Shinya Yamanaka
University of Kyoto, Japan

John B. Gurdon
Gurdon Institute in Cambridge, UK

iPS cells can now be generated from humans, including patients with disease. Mature cells including nerve, heart and liver cells can be derived from these iPS cells, thereby allowing scientists to study disease mechanisms in new ways.
Current & future stem cells are not the same as those in the 1960’s

- Embryonic stem cells (SCs) are one category of stem cells
- Current and future stem cells can come from your own body to cure your own illness
- Currently, lab cultures of SCs are all done manually – variability, low yield, contamination, etc.
**Stem Cell Biology**

- **Pluripotent**
- **Multipotent**
- **Unipotent**

**Stem Cell Engineering**

Manufacturing of diagnostic platforms & regenerative therapies from stem cells

- **Isolation**
- **Reprogramming**

**Stem Cell Applications**

- **Diagnostics**
- **Drug Discovery & Pharmaceuticals**
- **Tissue Repair**

Efficient, scalable & robust technologies

Credit: Todd McDevitt

[http://stemcelligert.gatech.edu](http://stemcelligert.gatech.edu)
Bio-manufacturing of cell therapies

- Scalable production techniques $>> 10^9$ range
- Characterization of cells and cell derivatives
- Cost of cell products
- Readiness of the supplier base
- Workforce needs
- Regulations and standards
The Future is Here