

Emerging Nanotechnology

**How advances in nanotechnology and manufacturing technology are
changing the work environment**

Yuma Pacific-Southwest Section

41st Annual Meeting

January 22, 2015

Charles L. Geraci, Ph.D., CIH

Associate Director for Nanotechnology

Centers for Disease Control and Prevention

National Institute for Occupational Safety and Health

Objectives

Understanding the Interface of Two Key
National Initiatives

- Nanotechnology
- Advanced Manufacturing

Objectives

- Nanotechnology (Covered many times but always good to update)
 - The absolutely fastest overview of Nanotechnology you will hear today.

Objectives

- Advanced Manufacturing
 - What is 'Advanced Manufacturing'
 - Key drivers
 - Benefits and concerns
 - OS&H issues?
 - Current state of adoption
 - How will it change the workplace?

Merging Initiatives

Nanotechnology: AKA Nanomaterial Science

---Has Given Rise to-----

Advanced Material Science

Nanomaterials, Nano-bio materials, Synthetic
Biology

---All Moving into---

Advanced Manufacturing Technology

Nanotechnology: A Review

Nanotechnology: 30 Second Review

Old: Material behavior driven by chemistry and making things from big pieces

Nanoscale Science: making materials one molecule at a time at the nano scale

New: Material behavior driven by size, shape, surface chemistry. More active and efficient

Result: New material properties and behavior:

Higher or newer hazard?

Nanotechnology: the US Investment

The cumulative investment of NNI agencies since fiscal year 2001, including the 2016 request of \$1.5 Billion, now totals almost \$23 Billion.

Is EHS important?

Cumulative investments in nanotechnology-related environmental, health, and safety research, EHS, since 2005 now total nearly \$900 million.

Nanotechnology is Everywhere

- Not a matter of ‘if’, but of ‘when’
- It is the new material science
- Boundaries between technical disciplines have been erased to exploit new activity
- Already in manufacturing workplace as ‘new and improved’ products are created
- Moving into established and advanced manufacturing processes.

Challenges of Nanotechnology

- Growing number of ‘new-to-the-world’ materials, and many new forms of familiar materials
- Beneficial properties associated with the technology and the materials – highly promoted
- Potential hazards were identified (10 years ago!)
- Governance in the absence of regulation
- Potential for many ‘generations’ of the technology and the materials
- **Moving into every sector**

Complicating the Task

- Applications research is moving faster than EHS research
- No overt cases of injury or illness reported: giving rise to *Nano Chicken Little and Ostrich effect*?
- “Nano has gone stealth” : now Advanced Materials
- Reporting and tracking requirements are minimal
- A precautionary approach, though warranted, is difficult to sell

Take Home Message

- Nanotechnology is here to stay
- It will be integrated onto multiple 'sectors'
- There are OS&H issues, and they are real
- The OS&H issues can be managed
- Effective risk management now is good for:
 - Workers and the evolving modern workplace
 - Public trust and societal benefit
 - Business and a competitive advantage

Why is this so important as we move toward Advanced Manufacturing?

Defining 'Advanced Manufacturing'

We are moving from the Industrial Age to the Information Age, but we still need to **make things**.

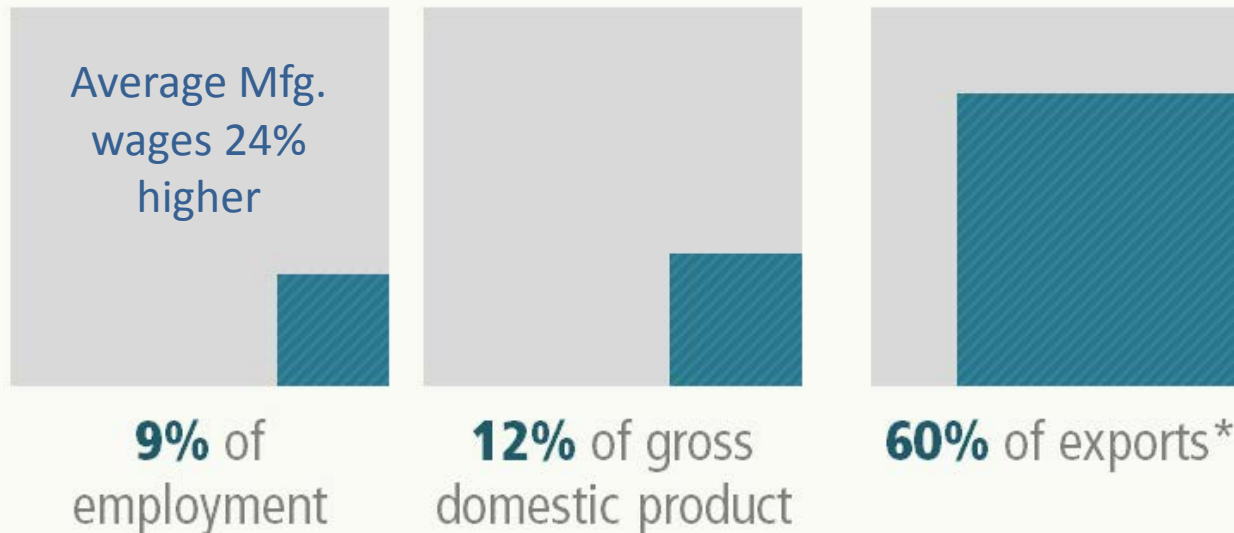
How we make things is evolving from mechanical processes (traditional manufacturing) to information and technology based processes (advanced manufacturing).

Manufacturing: Still a Huge Economic Impact



If U.S. Manufacturing were a separate country, 9th largest economy worldwide

U.S. manufacturing fundamentals strong again: 900,000 direct jobs added since recession



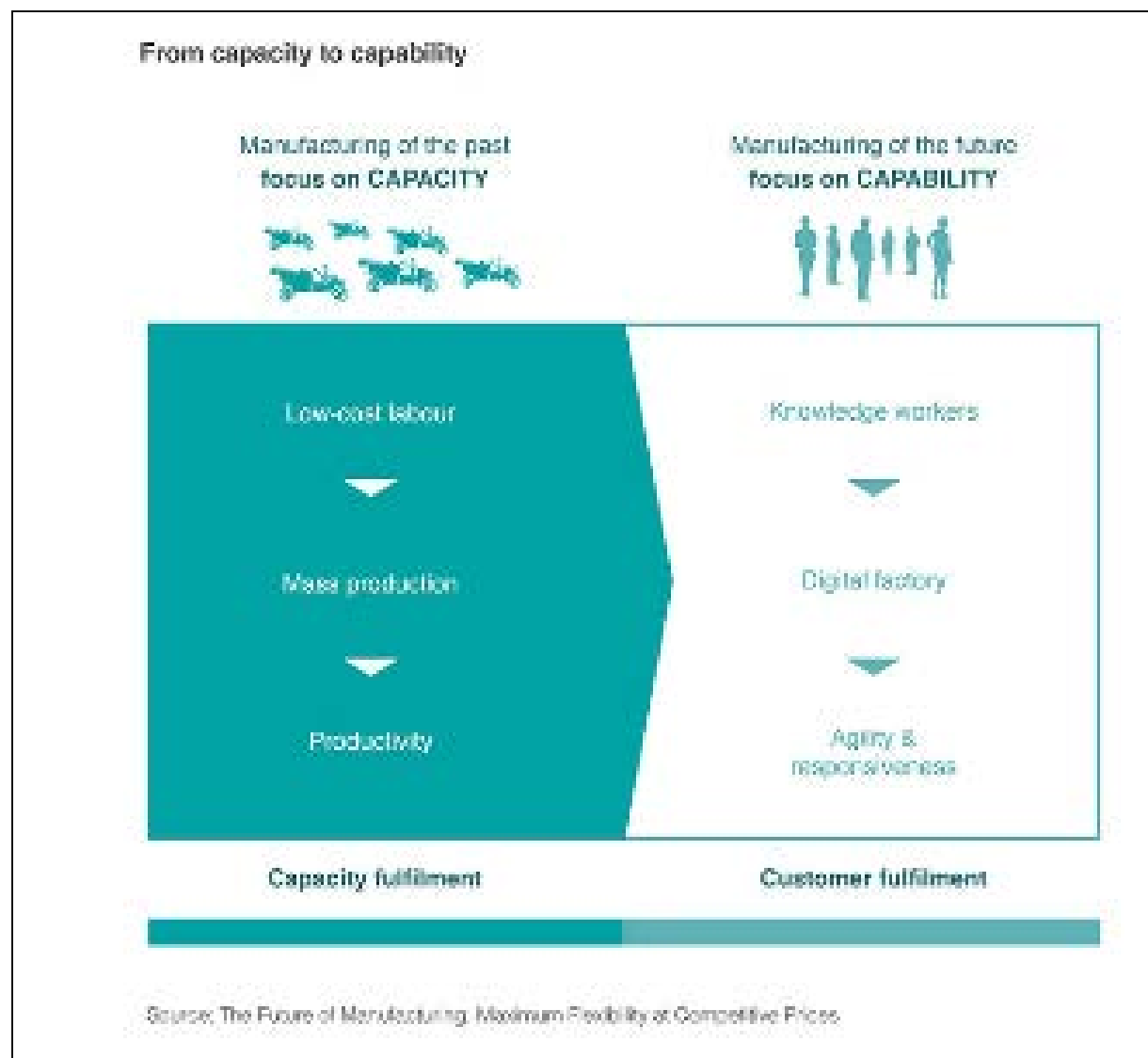
* EXPORTS DATA FROM 2010. R&D DATA FROM 2009, THE LATEST YEAR AVAILABLE. ALL OTHER DATA FROM 2011.

“Industry and Manufacturing in the Future” is not too far off.

The three industrial revolutions



Source: The Future of Manufacturing: P. Manenti



Attributes of Advanced Manufacturing

- Heavy and increasing use of information technology
- Modeling and simulations in manufacturing processes
- Closing the innovation to commercialization gap
- Flexibility to meet customer need
- Sustainable manufacturing (*CLG says this must include worker safety*)

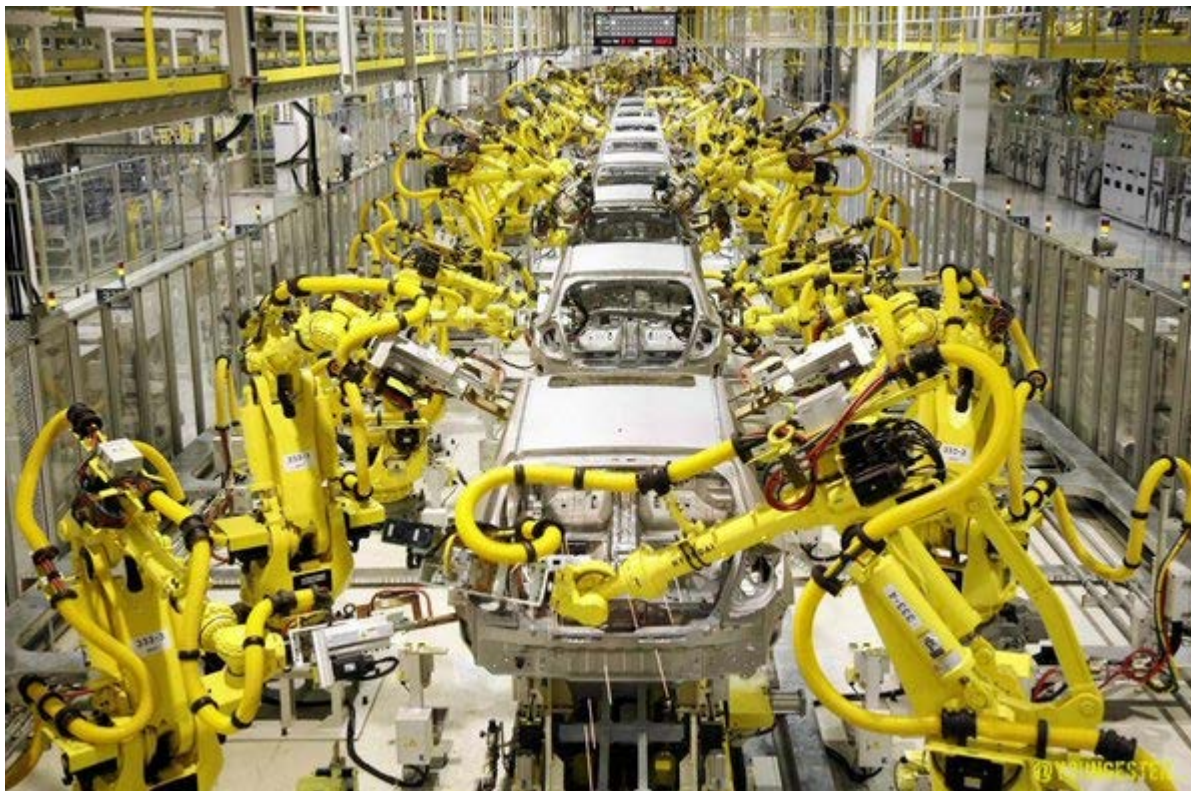
Trends, Examples?

- Semiconductors
 - Foundation of information technology applications
 - Rapid research to improve performance
 - New materials and structural technology
- Advanced (Nano) Materials
 - Superior performance properties tuned needs
 - Enhanced performance; reduced quantities
 - Computational engineering

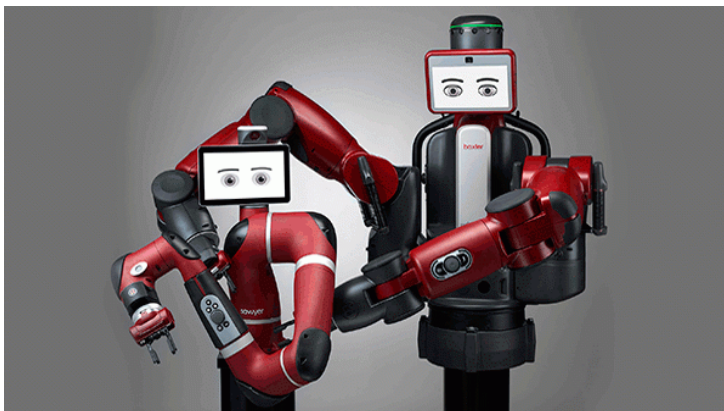
More Trends, Examples?

- Additive manufacturing
 - 3D Printing
 - Direct write
- Synthetic Biology
 - Manufacture biological substances from engineered biological systems
 - Biomanufacturing: using biological templates or processes for manufacture of materials systems

Is the focus on creating 'jobs' that can be done better by robots?



No! The focus is on high-tech, high-value materials, processes and products that require a skilled workforce.



Advanced Manufacturing
will create additional needs
and challenges at the
'machine worker interface'

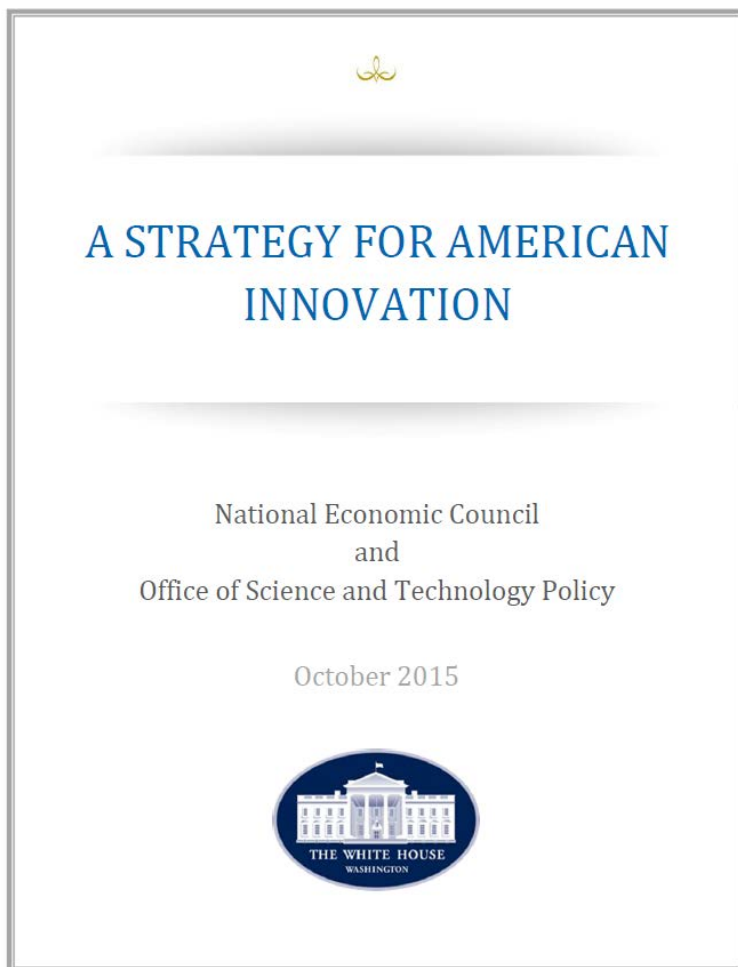
Yes, robotic processes will continue...

... but the way workers interface
with manufacturing processes will
change



EHS Today: Jan 2016

A National Priority



Reviews significant actions of the Advanced Manufacturing Partnership (AMP)

Recommendations on:

- Enabling innovation in emerging manufacturing technologies;
- Additional investments in innovation
- Securing the talent (worker) pipeline
- Improving business climate for innovative manufacturing firms

“ A broad public-private coalition involving business, labor, academia, government, and the community”.

The US Landscape

- Advanced Manufacturing Partnership Steering Committee
 - Build public-private partnership environment
- National Network of Manufacturing Innovation (NNMI)
 - FY 2016 Budget: \$1 Billion investment matched by private sector
 - Create **15 Manufacturing Innovation Centers** over the next 5 years, as many as 45 in 10 years

President's Council of Advisors on Science and Technology Advanced Manufacturing Partnership Steering Committee

Robert Birgeneau
Chancellor



Steering Committee Co-Chairs

Susan Hockfield
President Emerita



Andrew Liveris
President, Chairman & CEO



Bob McDonald
President



Jared Cohon
President



John Hennessy
President



Wendell Weeks
CEO



Paul Otellini
CEO



Louis Chenevert
CEO



G.P. "Bud" Peterson
President



Richard Harshman
CEO



Alan Mulally
CEO



William Weldon
CEO



Curt Hartman
Interim CEO, VP & CFO



Mary Sue Coleman
President



Douglas Oberhelman
CEO



David Cote
CEO



Wesley Bush
CEO



Interagency Advanced Manufacturing National Program Office (AMNPO)



Executive Office of the President



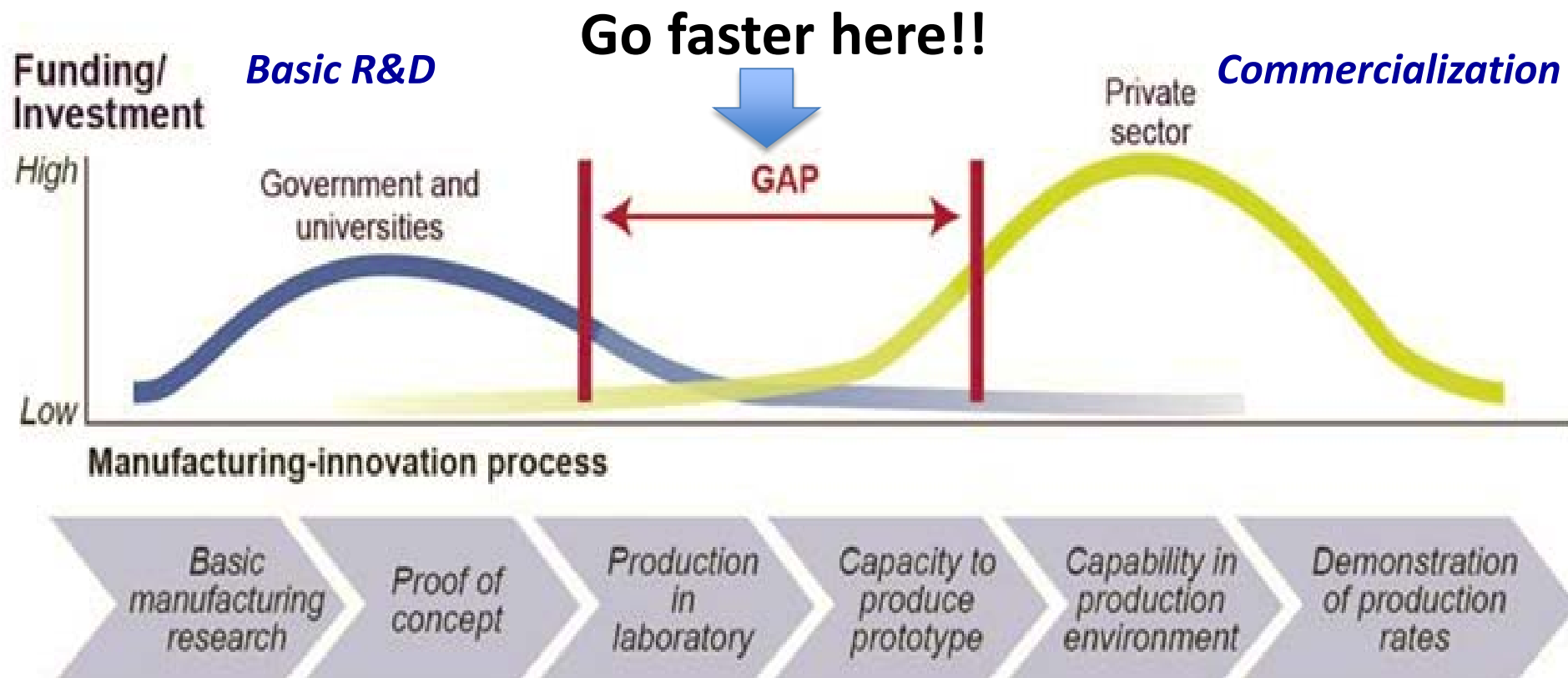
**Advanced
Manufacturing
Partnership
(AMP/PCAST)**

**Advanced Manufacturing
National Program Office**
(hosted by DOC - NIST)

**NSTC - Advanced
Manufacturing
Subcommittee**

NNMI: Addressing the “Scale-up” Gap

Focus is to address market failure of insufficient industry R&D in the “missing middle” or “industrial commons” to de-risk promising new technologies



NNMI: Enabling a Manufacturing Renaissance

Accelerating Discovery to Application to Production

- Establish a presence, at scale, in the “missing middle” of advanced manufacturing research
- Create an Industrial Commons, supporting future manufacturing hubs, with active partnering between all stakeholders
- Emphasize/support longer-term investments by industry
- Combine R&D with workforce development and training
- ***Overarching Objective: Unleash new U.S. advanced manufacturing capabilities and industries – for stronger global competitiveness and U.S. economic & national security***



Manufacturing Innovation Institutes so far...



America Makes
Additive
Manufacturing
DOD–Youngstown OH



DMDII
Digital Mfg & Design
Innovation
DOD – Chicago IL



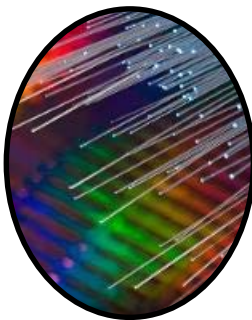
LIFT
Lightweight &
Modern Metals
DOD – Detroit MI



PowerAmerica
Power Electronics
Manufacturing
DOE – Raleigh NC



IACMI
Adv. Composites
Manufacturing
DOE – Knoxville TN



**Integrated
Photonics**
DOD
Rochester NY



**Flexible Hybrid
Electronics**
DOD
San Jose, CA



**Smart
Manufacturing**
DOE
Solicitation



**Revolutionary
Fibers & Textiles**
DOD
Solicitation

Links to Advanced Manufacturing

A lot of activity....

NNMI Institutes
America Makes - 3D/Additive
DMDII - Digital Mfg. & Design
LIFT - Lightweight Metal Mfg.
Power America - Wide Bandgap Semiconductors
IACMI
AIM Photonics
Flexible Hybrid Electronics
<i>Pending Institutes</i>
Smart Manufacturing
Revolutionary Fibers and Textiles



... with a lot of Federal support

Federal Initiatives
MForesight: Alliance for Manufacturing Foresight
Investing in Manufacturing Communities Partnership
NIST Advanced Manufacturing Technology Consortia (AMTech)
Manufacturing Extension Partnership
Materials Genome Initiative
National Network for Manufacturing Innovation
National Nanotechnology Initiative
National Export Initiative
National Robotics Initiative
SelectUSA
Startup America
Sustainable Manufacturing



Key link for new materials moving into manufacturing

The Nano-AM Link

- Nearly every process uses advanced materials that have come out of Nano
- Manufacture of products not discovery of new material phenomena
- Responsible Development principles carry over
- Occupational safety and health approaches will need to mature with these technologies

NNMI Highlights

- National Additive Manufacturing Innovation Institute (now known as *America Makes*)
 - Launched in 2012 in Youngstown, OH
 - A 94-member consortium of business, academia and non-profits
 - Focus on grow of additive, AKA, 3D Printing

A key activity for the Industrial Hygienist because additive manufacturing is happening now!

Additive Manufacturing: a simple view

Traditional

Billet



Subtractive

Machining



Part



Scrap



Additive Manufacturing

Foil/Powder



Additive

AM



Part



Scrap



Additive Manufacturing Institute: Key Objectives

INCORPORATING 3D PRODUCTS



- Advanced/nano materials
- Growing numbers
- Exposures not well known
- Entry barriers are low

Skilled workers should be skilled in OS&H.

ADVANCING 3D TECHNOLOGY

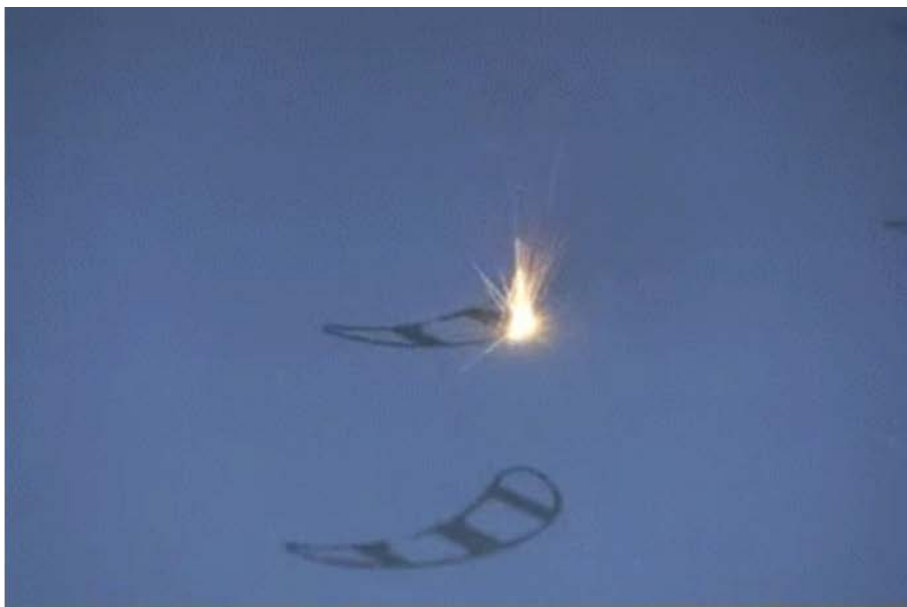


The technology is being taught, but does it include health and safety?

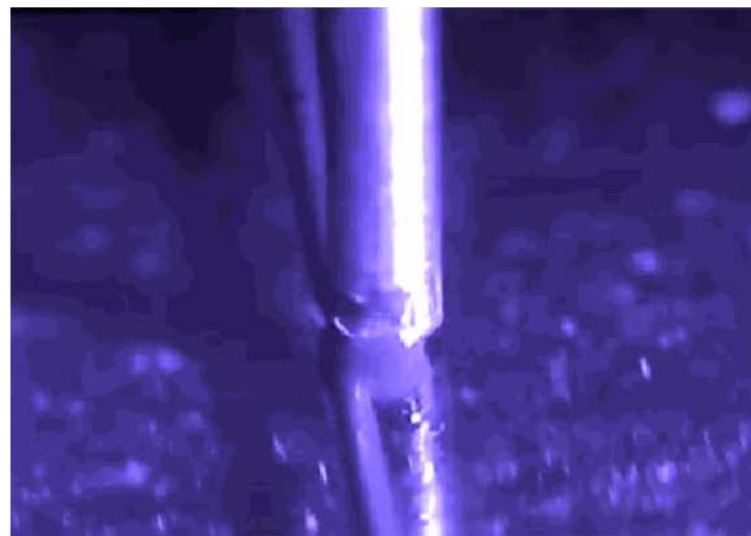
GROWING THE 3D WORKFORCE



Additive Manufacturing: Now

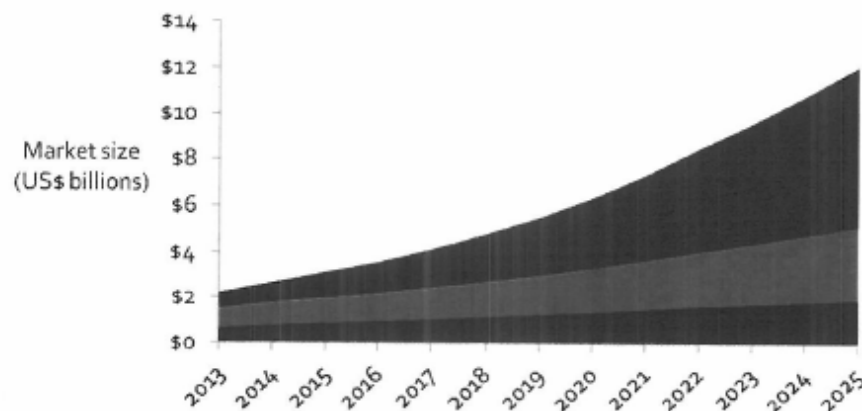


GE scientists are devising new ways to put sensors in hard-to-reach places through Direct Write technology.



GE Aviation was looking for alloys to 3-D print jet engine parts. They found them in alloys that are used for joint replacements and dental implants.

Advanced Materials: Total 3D printing market will reach \$12 billion in 2025



Key takeaways:

- Suppliers focused on prototyping will find their profit margins challenged by falling prices and rising competition.
- Expansion into manufacturing applications will be necessary to sustain growth from \$2.2B in 2013 to \$12B in 2025.
- Traditional design tools are unwieldy and inadequate, but emerging intuitive, efficient versions combined with emerging printers enable improved parts.



Source: Lux Research report "[How 3D Printing Adds Up: Emerging Materials, Processes, Applications, and Business Models](#)"

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Additive Manufacturing

- In use today and growing
- Seen as an adjunct to advanced materials
- Likely to transform manufacturing
- Now an element of the Public-Private initiative to accelerate manufacturing

Advanced Composites Institute Profile

IACMI, The Composites Institute
Knoxville, TN
Launched June 16, 2015

Agency sponsor: DOE
Startup funding: \$70M public,
\$159M co-investment

+344,000 square feet in five core regions –
composite manufacturing, laboratory,
instructional and collaboration space



Example Institute: Composites Manufacturing

10 months

Building the Network

✓ Jan 2015

President Obama, VP Biden announce IACMI

✓ June 2015

18 | Inaugural IACMI Members Meeting with >350 attendees

23 | Purdue breaks ground on \$50M composite facility

✓ Sept 2015

4 | IACMI announces Call for Projects

✓ 9 | IACMI team presentation to over 700 attendees at SPE & Automotive Composites Conference

✓ 17 | VP Biden announces IACMI's scale-up facility in Detroit

October 2015

✓ 16 | MOU announcement with CPC in NY establishing IACMI satellite in the Northeast



Institute of Advanced Composites Manufacturing Innovation

ICAMI: Strong Private-Public Partnership

Each Institute is operated by a consortium; serving a partnership of Industry, Academia and government

A partnership of world-class companies including:



Top universities including:



Economic Development Council
to leverage state support and investment



Lightweight & Modern Metals in Manufacturing



6 Pillars of Technology Development

-  Melt processing
-  Powder Processing
-  Thermo-mechanical processing
-  Novel/Agile Processing
-  Coatings
-  Joining and Assembly

Many of the metals and processes were under the NNI as a private-public partnerships.

- Full EHS characterization?
- Exposure and risk potential?
- Safe practices?

Digital Manufacturing

A new interface between the worker and the intelligent supply chain and the intelligent workplace



How will the worker deal with:

- Distributed manufacturing
- Direct interface with supply chain
- Advanced interface with manufacturing processes

The OS&H challenges are not new and are likely a blend of material and process safety, work organization, and stress.

Thank you!



Charles L. Geraci, Jr, Ph.D., CIH

Associate Director for Nanotechnology

CGeraci@cdc.gov

www.cdc.gov/niosh/topics/nanotech



Finally, always wear the appropriate PPE for the task!