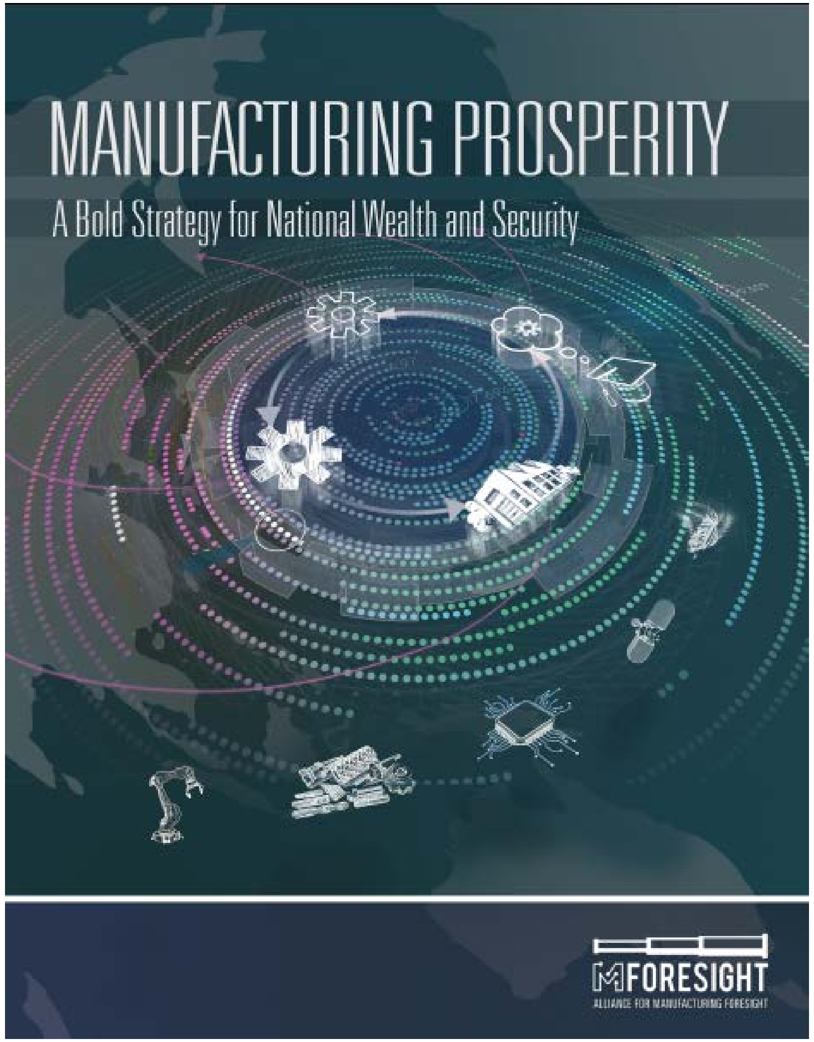
Bridging the Gap between Research and Manufacturing

Sridhar Kota, Executive Director

MForesight: Alliance for Manufacturing Foresight

Professor of Mechanical Engineering, University of Michigan



2018 NSF Nanoscale Science and Engineering Grantees Conference,

December 7, 2018

www.mforesight.org

MFORESIGHT:
Alliance for Manufacturing Foresight

A federally-sponsored consortium of national thought leaders from industry and academia focused on the future of American manufacturing.

Discover

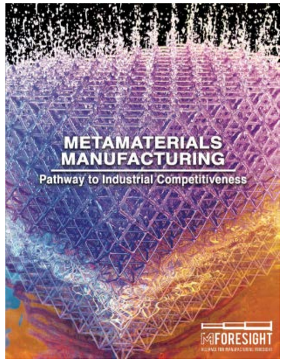
Prioritize

Develop

Disseminate

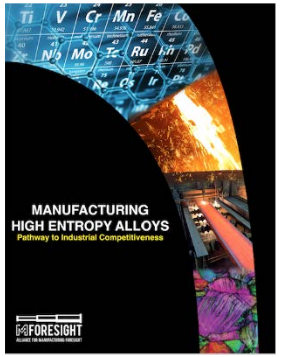
National Institute of Standards and Technology
U.S. Department of Commerce

Accelerating Technology & Manufacturing Innovation

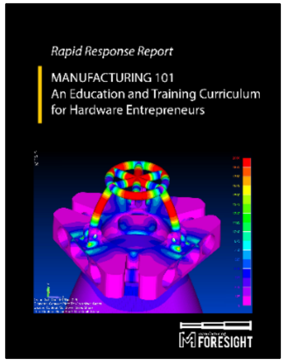


Metamaterials Manufacturing

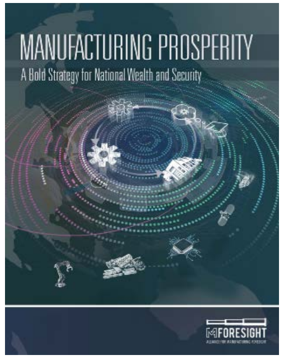
Regenerative Medicine



Manufacturing High Entropy Alloys



Manufacturing 101



Manufacturing Prosperity

Education and Skills Building

Next Generation Supply Chains

Cybersecurity for Manufacturers

Ideas worth scaling → MFORESIGHT ALLIANCE FOR MANUFACTURING FORESIGHT ← **Challenges worth addressing**

Basic Research	**Translational R&D**	**Applied R&D**	**Full Volume Manufacturing**

MForesight Leadership Council

Industry

Nonprofits

Alliance for American Manufacturing · AMT The Association for Manufacturing Technology · Association of Public & Land-Grant Universities · ASME Setting the Standard · The Brookings Institute · ITIF Information Technology & Innovation Foundation · Lift Lightweight Innovations for Tomorrow · National Association of Manufacturers · NDIA National Defense Industrial Association · NTMA · semi · sme Making the Future Together

Academia

Case Western Reserve University · Indiana University · The Ohio State University · Rensselaer · UCI University of California, Irvine · UCLA · University of Cincinnati · UNC Charlotte · University of Michigan · University of Pittsburgh

Convene diverse stakeholders

Conduct "game-changing ideas" events, deep-dive workshops and expert interviews.

Access to over 40,000 subject matter experts

Develop Actionable Recommendations

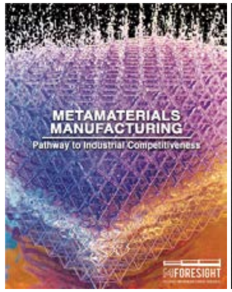
- **R&D Priorities**
- **Implementation challenges**
- **Related policies**

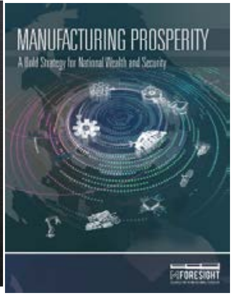
Over 2000 participants from 38 states (2017-18), ~20,000 report downloads

Disseminate

Serve as a continuous source of intelligence to Federal agencies, Capitol Hill, the White House, Private sector, and Academia

Publish Reports, Blog-posts and Community Highlights





Grand Challenges in U.S. Manufacturing

Grand Challenge: "Invent here, Manufacture there" is reaching its logical conclusion:
"Invent there, Manufacture there"

Convened 7 roundtables across the nation with **over 100 thought leaders,** spent **over 1200 hours** discussing potential solutions

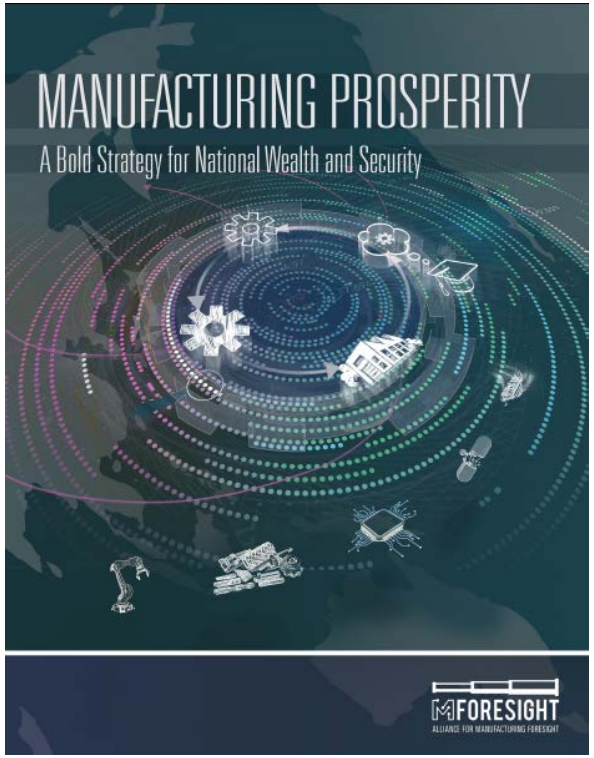
Round Tables and Partners

Boston, MA
Washington D.C.
Austin, TX,
San Jose, CA
Raleigh, NC
Indianapolis, IN
Detroit, MI

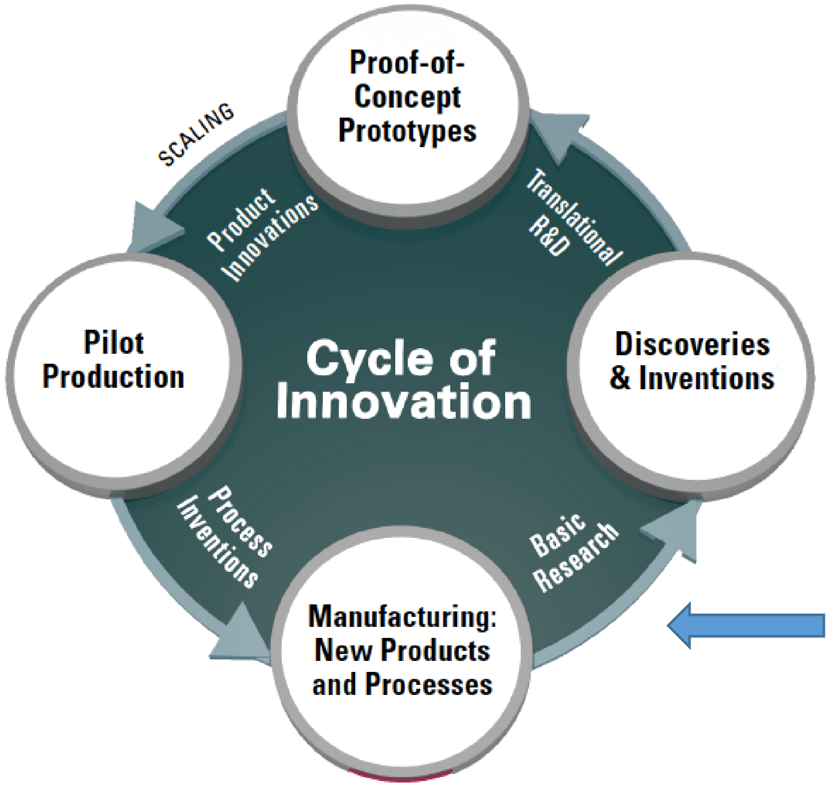
Massachusetts Institute of Technology
National Association of Manufacturers
sme
TEXAS The University of Texas at Austin
NASCENT
Boston Scientific
Cummins

Issues discussed at the roundtables

1. *Regaining America's industrial commons*
2. *Creating wealth from national R&D investments*
3. *Ensuring financing for "hardware" start-ups and scale-ups*



Invent Here, Make There: Creating Knowledge, Not Wealth



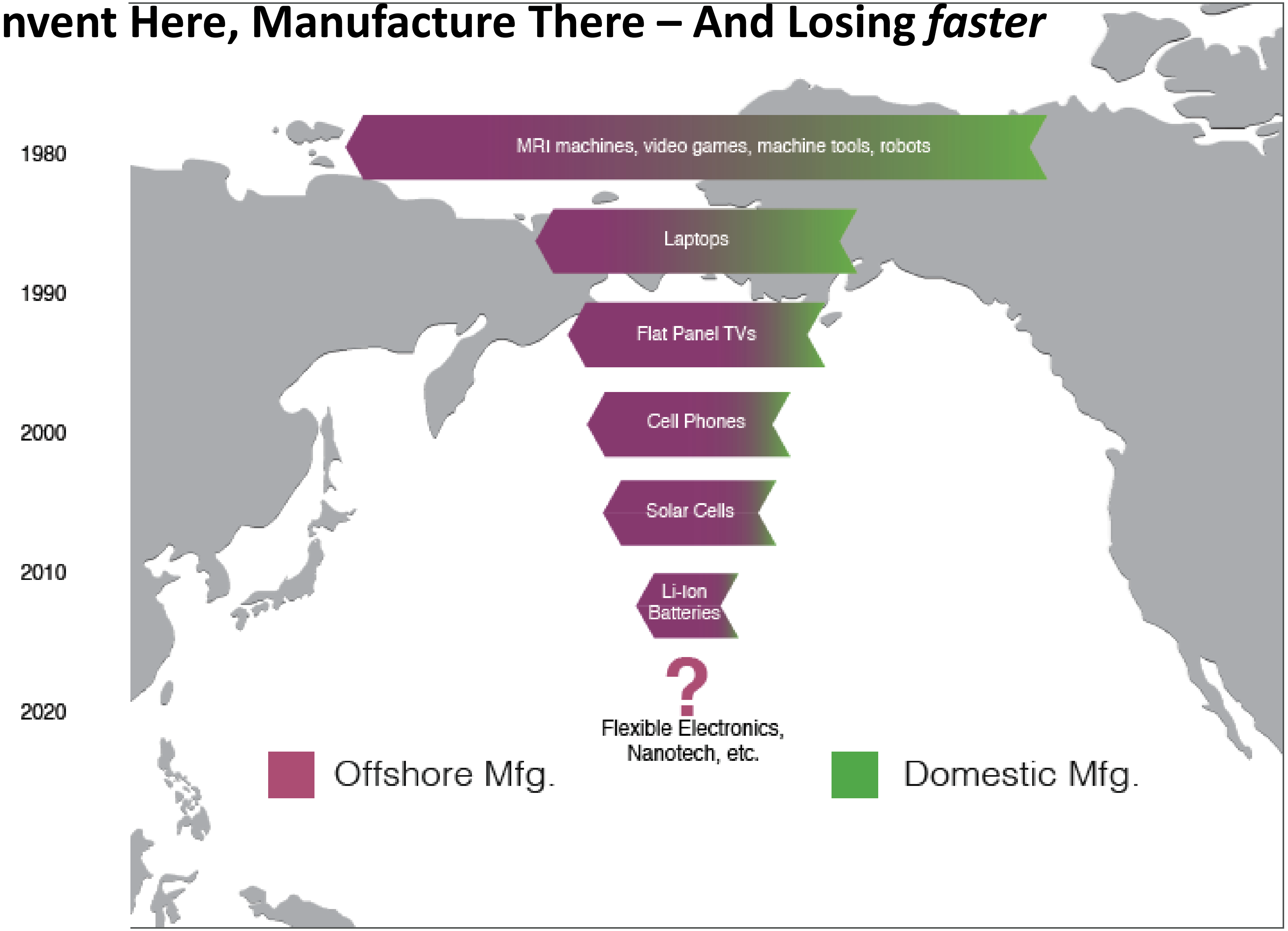
Federal S&T investment
~ $140 billion annually

Mfg. deficit ~ $800 billion
Adv. Tech. Products deficit ~ $100 billion

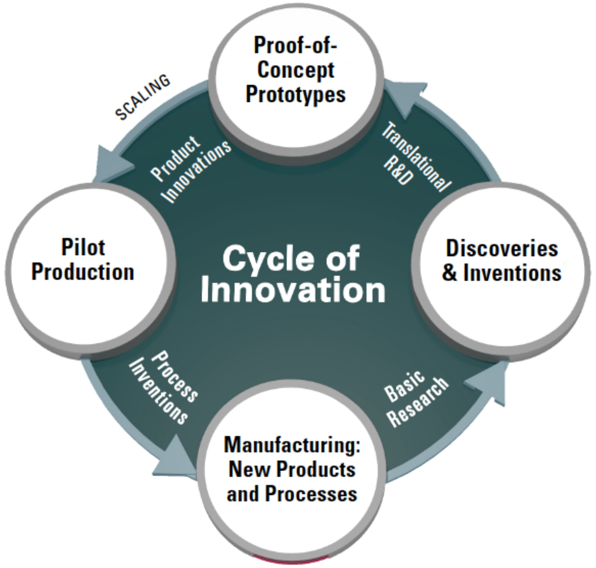
Manufacturing Innovation Gap

Leading the world in R&D is little comfort if we are simply subsidizing it for other countries

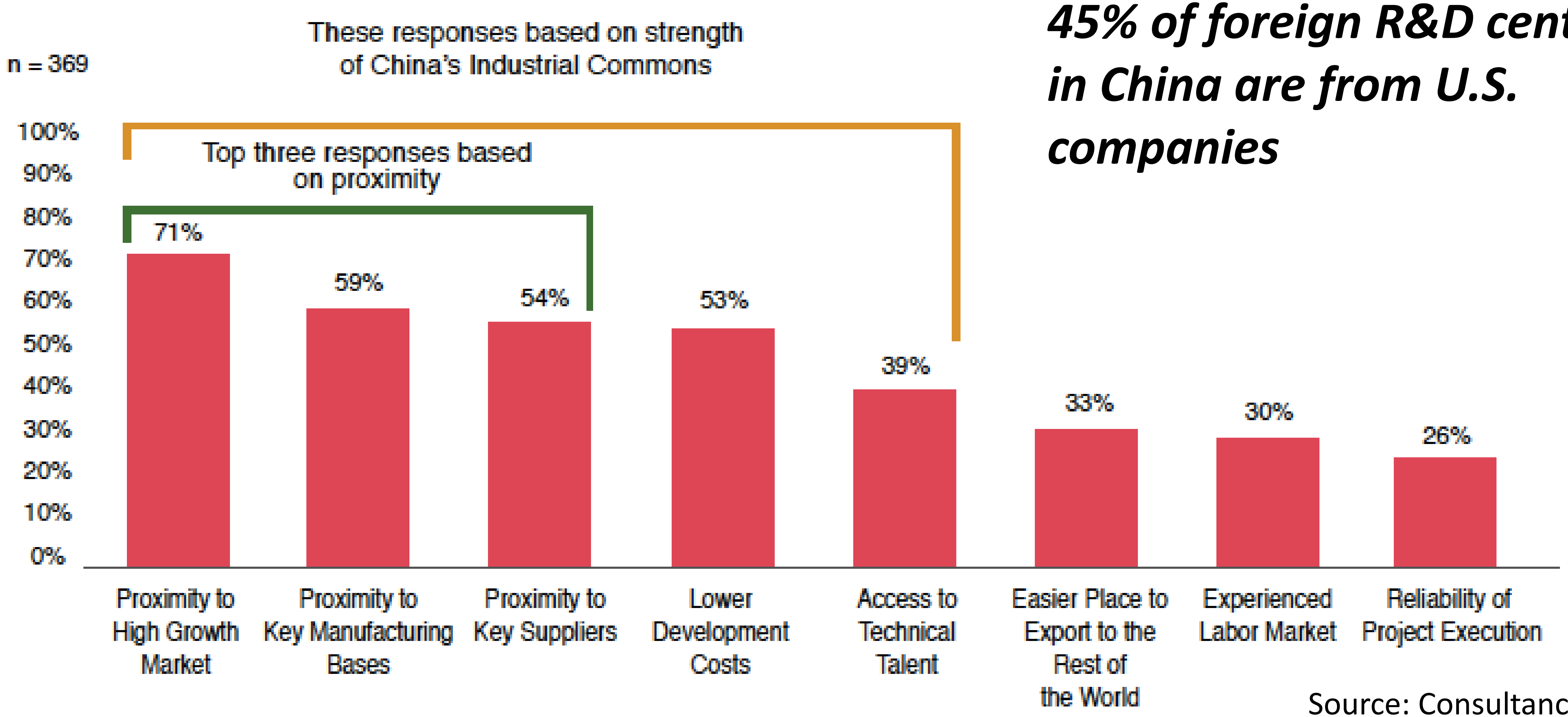
Invent Here, Manufacture There – And Losing *faster*



By not completing the cycle of innovation within our nation's borders, we are losing our ability to innovate



Factors driving manufacturing R&D to China



45% of foreign R&D centers in China are from U.S. companies

Source: ConsultancyUK, 2015

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Patents and Licenses

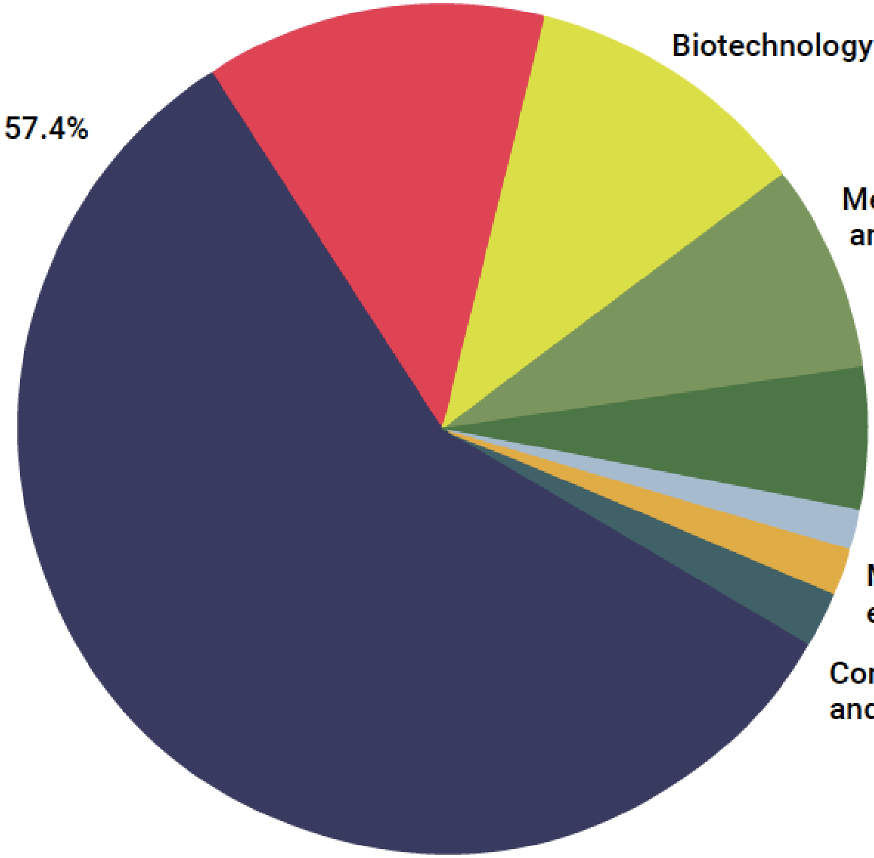
Federal labs:
For every $1B of R&D activity,
45 patents issued;
$4 million in license revenue

In 2015, $46 billion total spent on R&D by fed gov.
2200 patents; $193 million license revenue

Universities:
For every $1B of R&D activity,
168 patents issued
$52 million in license revenue

In 2015, $37 billion spent on R&D in S&E by fed gov.
6200 patents; $1.9 billion license revenue

VCs rarely invest in hardware



Not just how much but what we invest in matters

2016 OECD data

U.S federal R&D budget: $149 billion

Industrial Production and Technology:

$773 million (**0.52%)**

OCED definition: R&D on industrial products and their manufacturing processes.

Germany: $36 Billion

Industrial Production and Technology:

$4.34 billion (12%)

6X the amount U.S spends

Japan – 7% of its budget; 3X U.S

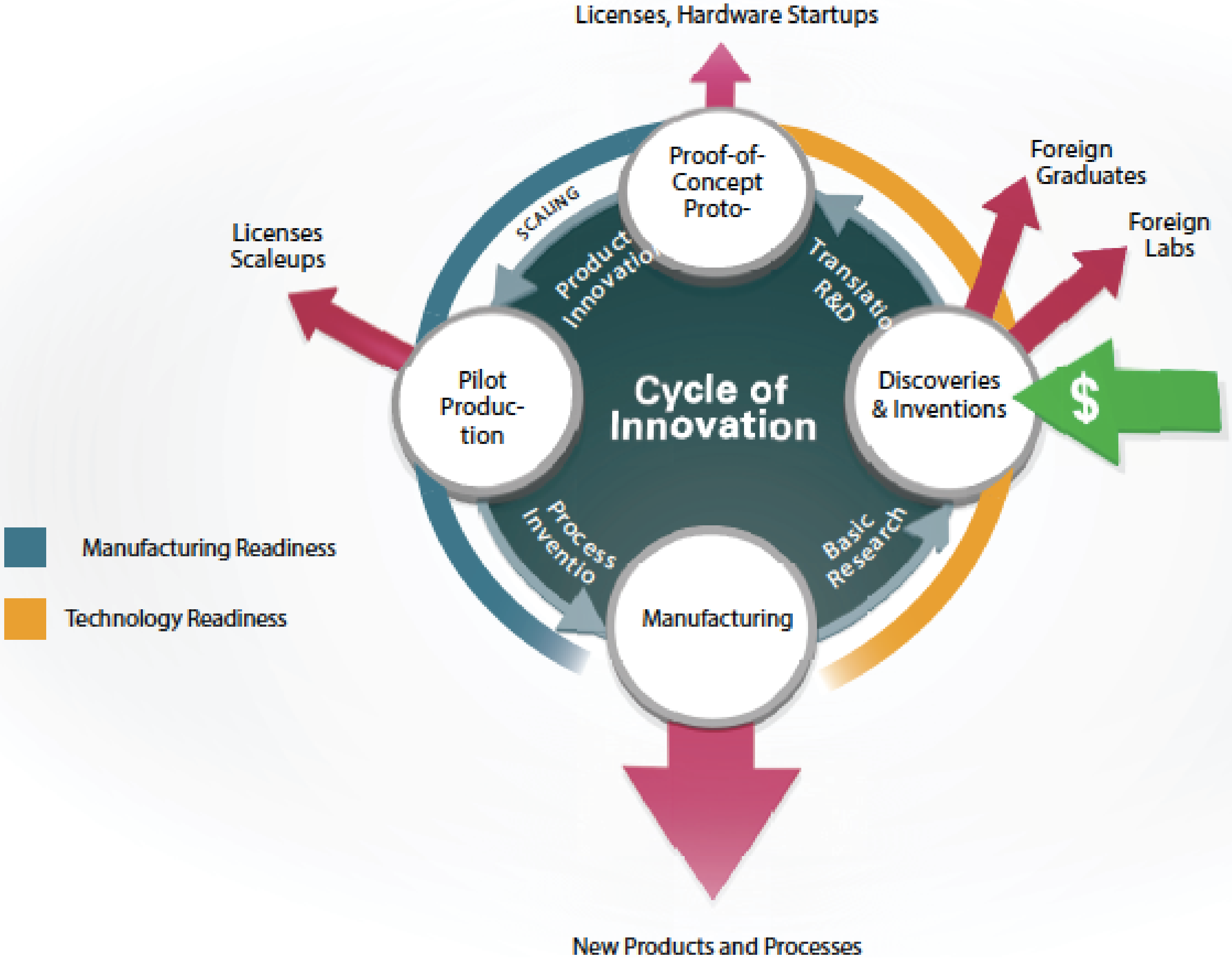
S. Korea – 30% of its budget; 8X US

Trade balance in Goods (2017)

U.S:	$ 796 billion deficit
Germany:	$ 290 billion **surplus**
Japan:	$ 25 billion **surplus**
S. Korea:	$ 95 billion **surplus**

Isn't 5% of total federal R&D a reasonable amount for the U.S to invest in this category?

Closing Gaps in the U.S. Innovation Pipeline



Report Recommendations

Establish a **National Innovation Foundation** as a central focal point for manufacturing R&D in the federal government

1. Invest in translational R&D and manufacturing innovation
2. Invest in maturing Manufacturing Readiness Levels; Leverage govt. procurement.
3. Empower Small and Medium-Sized Manufacturers
4. Grow Domestic Engineering Talent

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Recommendations

1. Invest in Translational R&D and Manufacturing Innovation:

a. **Invest in Translational Research Centers (university-affiliated but privately run)** to translate the results of federally funded academic research into viable products. Licensing of resulting products should be restricted to U.S. production facilities only.

b. **Invest in manufacturing research**, process technologies, and systems engineering, to mature MRLs and to overcome market failures

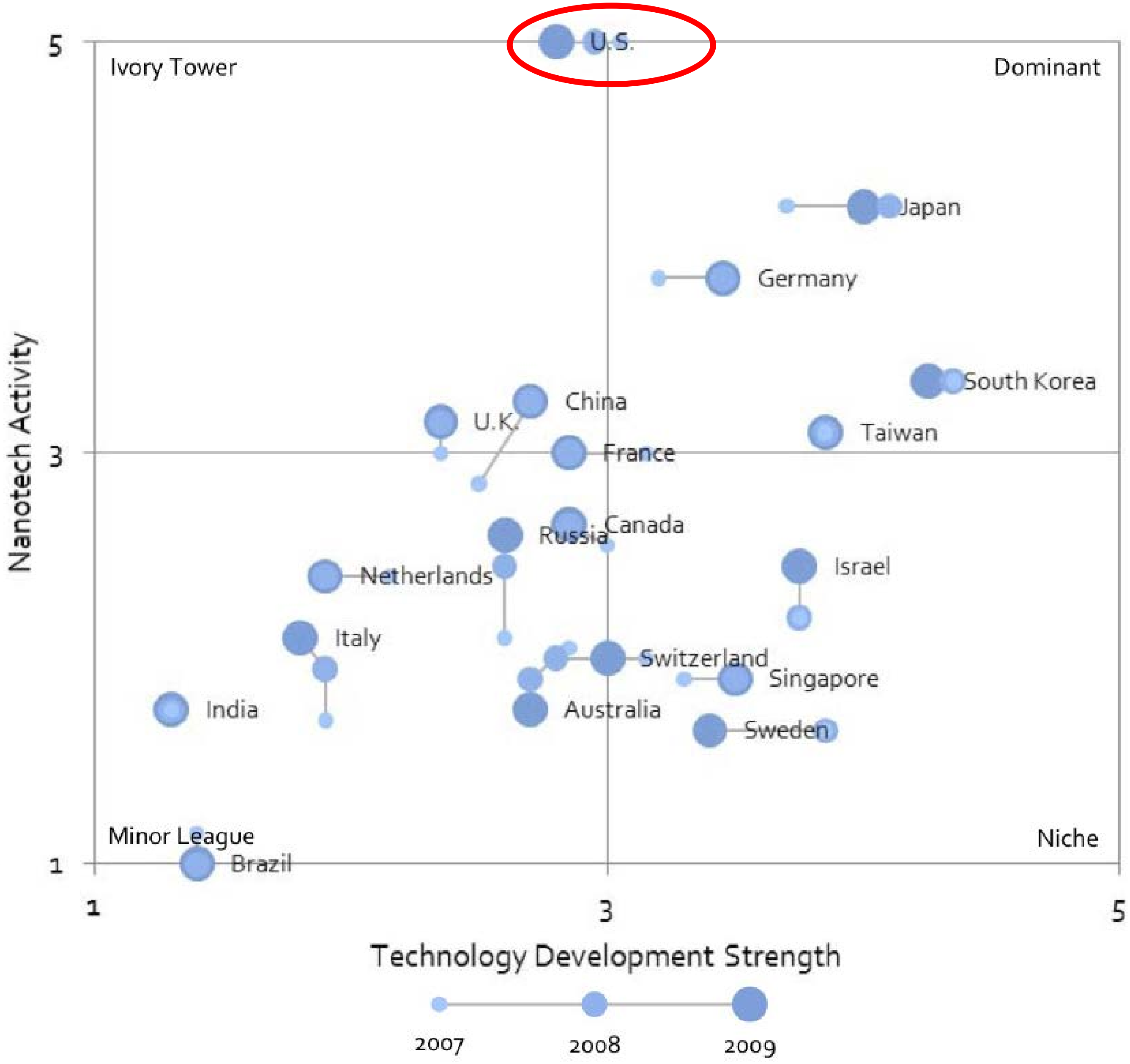
c. Establish additional **Manufacturing USA institutes in not only emerging technologies but also in foundational capabilities**.

Source: "Ranking the Nations on Nanotech"- Lux Research Report, Aug 2010

***Dominant countries** have both high Nanotech Activity (NA)* and the *Technology Development Strength (TDS)needed to commercialize it.*

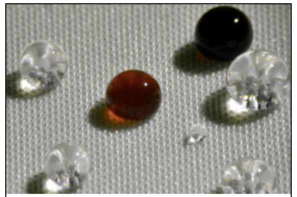
***Ivory Tower countries** have high NA, but are less likely to develop their economies based on it because of relatively poor TDS*

***Niche countries** are technology development powerhouses, scoring high on TDS, but they do not have the scale to support internationally competitive levels of NA.*

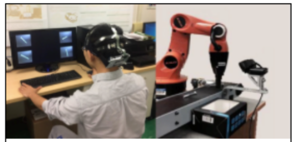


ENGAGING THE U.S. MANUFACTURING COMMUNITY TO DISCOVER, PRIORITIZE, DEVELOP, AND DISSEMINATE EMERGING TECHNOLOGIES AND MANUFACTURING NEEDS ALIGNED WITH NATIONAL PRIORITIES.

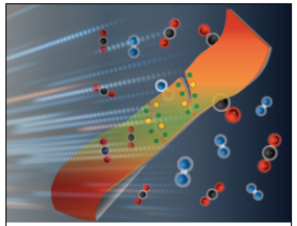
MANUFACTURING IDEAS TO WATCH



CHEMICAL VAPOR DEPOSITION OF WATERPROOF COATINGS ON NATURAL FIBERS

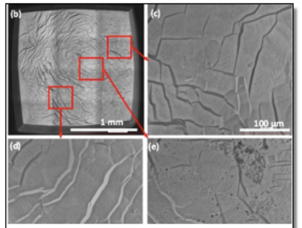


MIND-READING QUALITY CONTROL

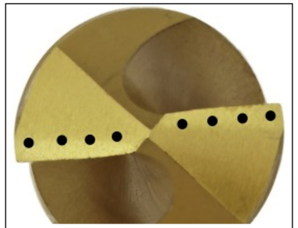


SELF-HEALING POLYMERS MOVING FORWARD

TITANIUM AND CARBON FIBER ULTRASONIC BONDING

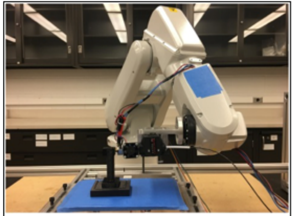


TOWARDS LOW-COST DIAMOND ELECTRONICS

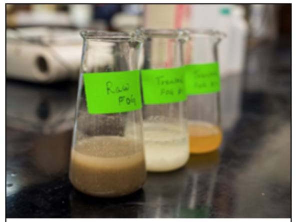


REAL-TIME DRILL BIT HEALTH MONITORING

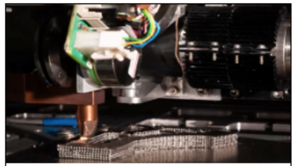
“WRITING” GRAPHENE ON ORGANIC MATERIALS



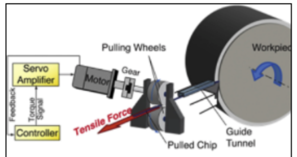
SIX-AXIS ADDITIVE-SUBTRACTIVE MANUFACTURING



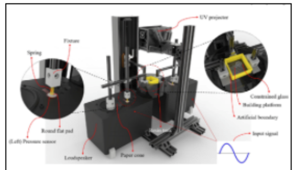
TURNING FOOD PROCESSING WASTE INTO USEFUL BIOGAS



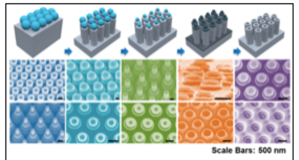
FAST, LOW COST, HIGH DENSITY METAL 3D PRINTING USING JOULE HEATING



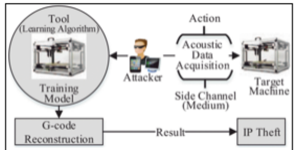
CHIP-PULLING FOR REDUCED CUTTING ENERGY AND TOOL FORCE



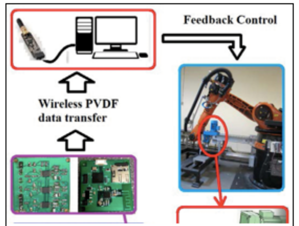
IMPROVING STEREOLITHOGRAPHY SEPARATION USING VIBRATIONS



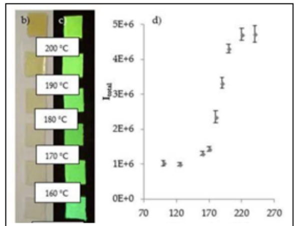
SCALABLE THREE-DIMENSIONAL NANOSTRUCTURE FABRICATION



INTELLECTUAL PROPERTY THEFT USING ACOUSTICS OF ADDITIVE MANUFACTURING



WIRELESS FORCE SENSORS IMPROVE ROBOTIC MILLING ACCURACY



THERMOCHROMIC POLYMERS FOR EARLY DETECTION OF THERMAL DAMAGE IN COMPOSITES

CONTINUOUS MANUFACTURING OF HIGH QUALITY GRAPHENE – *John Hart, MIT*

This scalable production method produces graphene membrane filters, with applications including biological separation, desalination, and gas permeable barriers, and more.

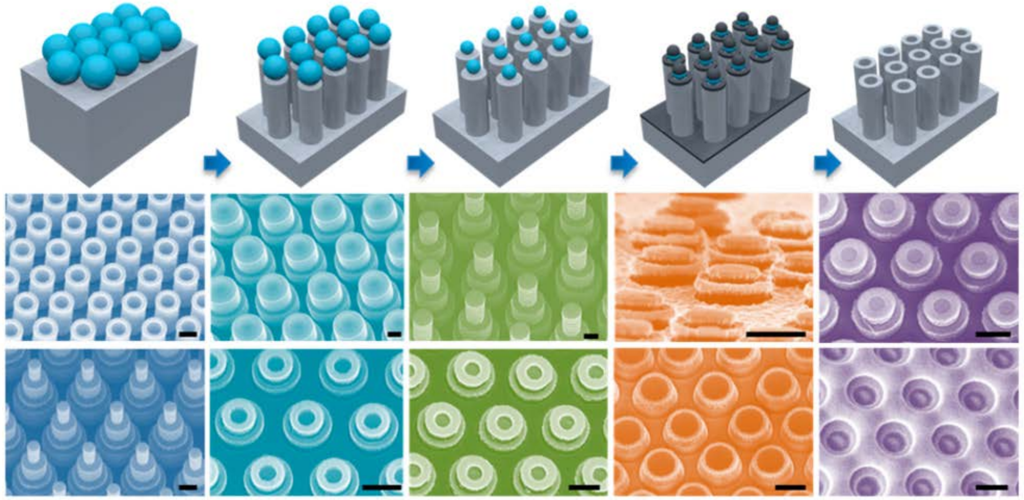
The process employs a scalable, roll-to-roll approach, depositing the graphene on thin foils using a two-zone chemical vapor deposition system. The graphene is then taken up by a second spool, where it is post-processed to create functional devices.

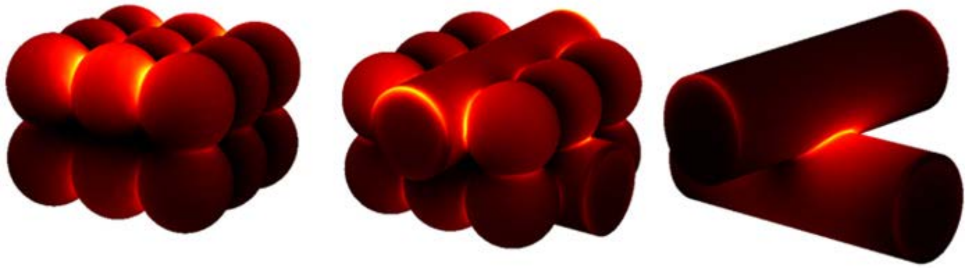
Controlling the temperatures and feed rates of the process enables precise control over the graphene properties, and the creation of seamless, endless sheets.

http://meche.mit.edu/news-media/graphene-roll-out

SCALABLE THREE-DIMENSIONAL NANOSTRUCTURE FABRICATION – *Paul Weiss, UCLA*

Researchers have developed a fabrication method that enables high-throughput lithography. By etching array of nanospheres as resists at each step to create the desired resist pattern for the subsequent step, the process can generate complex 3D patterns.





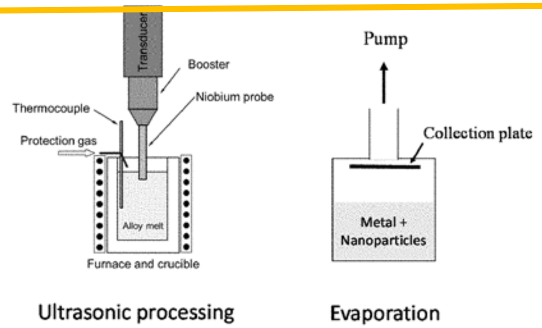
SCALABLE AND COST-EFFECTIVE MANUFACTURING OF THIN FILM DEVICES

The “intense pulsed light sintering” method uses high-energy light over an area nearly 7,000 times larger than a laser to fuse nanomaterials in seconds.– *Michael Dexter & Rajiv Malho*

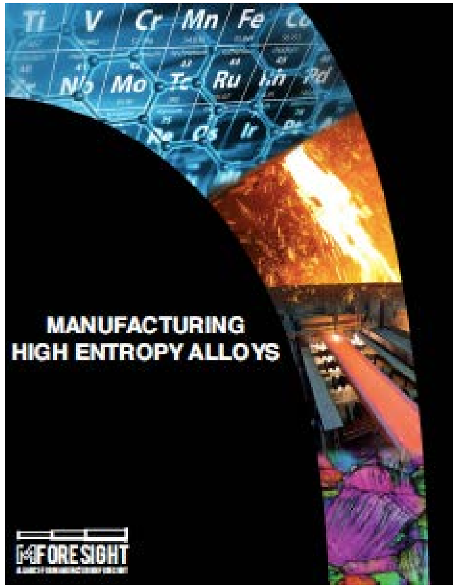
Brunswick

METAL MATRIX NANOCOMPOSITE PROCESS INNOVATIONS

Researchers at UCLA developed a novel evaporation-based method to concentrat nanoparticles in Metal matrix nanocomposites (MMNCs) by partially evaporating th carrier metal from the carrier and matrix mixture.– *Xiaochun Li, University of Californi Los Angeles*



From Nanoscience to Nanomanufacturing



High entropy alloys often use nano-scale powders; maintaining quality during scale-up is challenging, especially for powders with multiple elements. The speed, cost, and yield, as well as the precision and control of alloy composition, surface quality, size distribution, and purity are some of the hurdles that must be overcome to manufacture at scale.

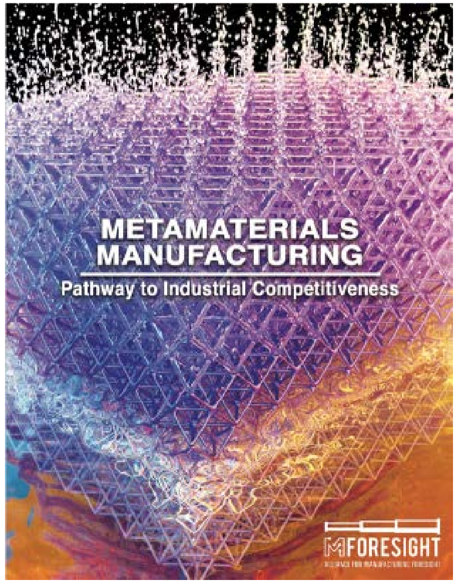


Image courtesy of HRL Laboratories, LLC

Manufacturing process technologies must be able to reliably and affordably produce multi-scale architectures with ~1 million repeated unit cells per layer

We need to develop process technologies that provide high-throughput solutions and enable precise alignment of small unit cells in three dimensions across large volumes.

- Being the world’s best in nanoscience is critical but *not sufficient* – we also need to excel in nano-engineering and nano-manufacturing

- Leading the world in nano-science is little comfort if we don’t transition great discoveries/inventions into products enabled by nano-manufacturing process innovations