Materials Science and Corporate Research

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Materials Science and human development

Handaxe
~ 1.66 million years old
Majuangou, China

Omo Kibish Point
~ 110,000 years old
Omo Kibish, Ethiopia

Bone and ivory needles
~ 25,000 years old
Xiaogushan, China

2 million years ago | 1 million years | 100,000 | 25,000

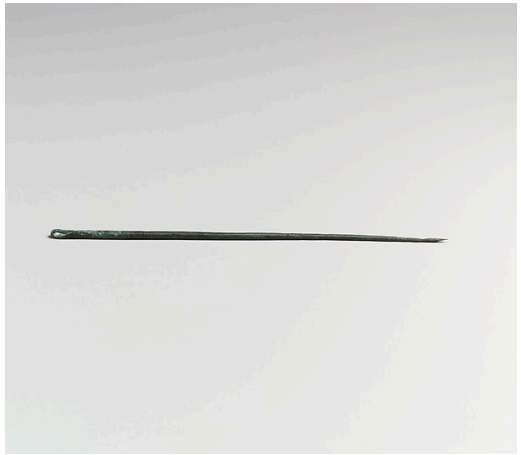
Minimal processing & basic functionality

http://humanorigins.si.edu

Metals Age- new materials, complex processing

Bronze Age Artifacts

Bronze needle,
Minoan
2000 BCE



http://www.metmuseum.org/art/collection/search/252397/

Socketed Axe
Ca. 1000 BC

http://www.weapons-universe.com/

3,000 years ago

Same application- more complex materials

Profiting from materials businesses

New, complex materials replace the old

Same performance, lower cost

- Cost of manufacture or formulation innovations
- Managing the competitive environment

Differentiated performance, same cost

- Diversified functions supporting innovation
- R&D as a means of growth-science as a business

Profiting from science as a large corporation

3 characteristics needed to enable profitable materials science

Uncertainty Management

Balanced portfolio

Absorption of failure

Knowledge Acquisition

Learn/Create

Sensing

Integrated Development

Across divisions

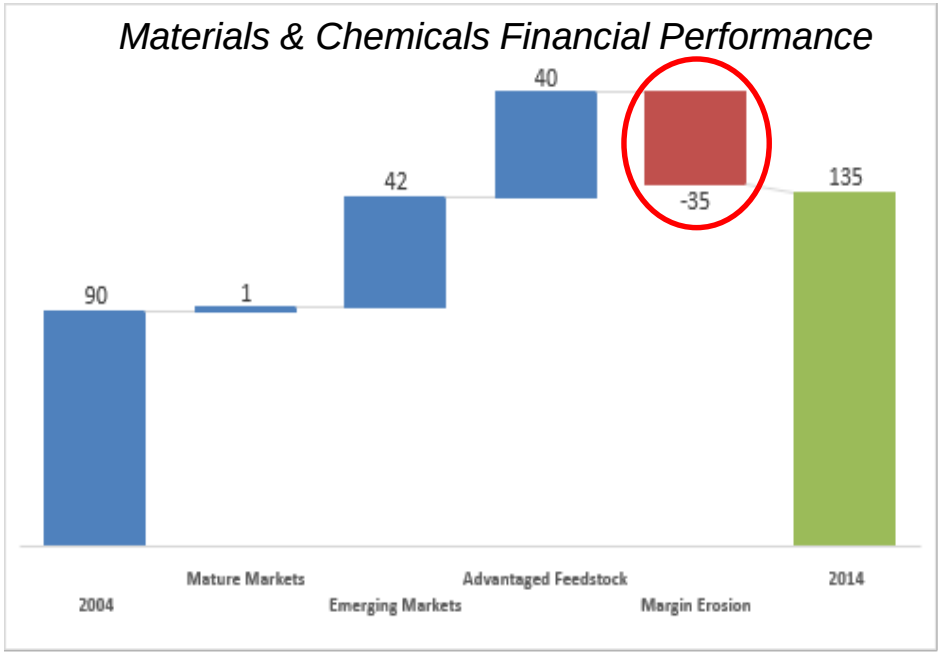
Throughout stages

Derived from Pisano, Industry and Corporate Change, 19, pp 465-482 (2010)

The global market challenges materials companies

Markets rapidly commoditized

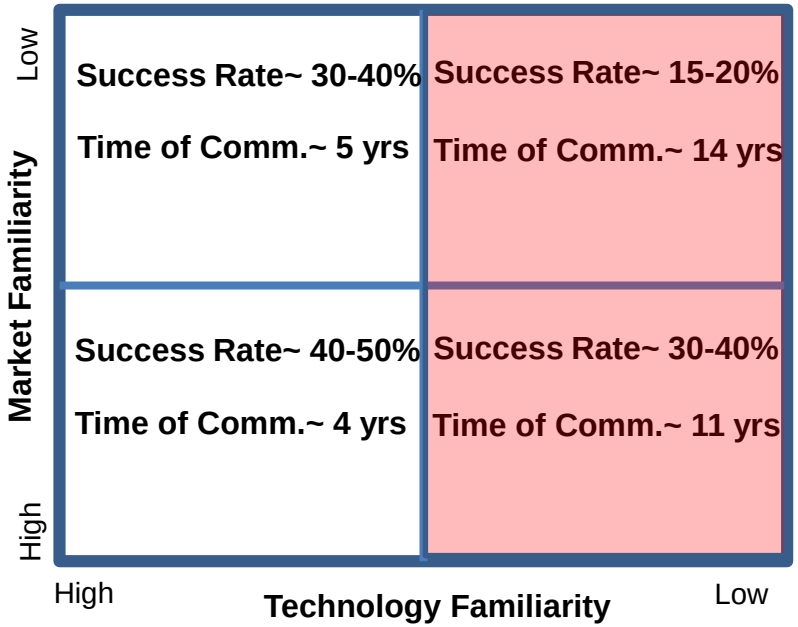
- Margins squeezed
- Research "cost" harder to absorb



J. Boringer, T.J. Simons, McKinsey, Commoditization in chemicals 12/16

Long innovation delivery times

- Requires funding by cash businesses
- Hard to absorb research investment



C. Musso *et al*, McKinsey Chemical Innovation 5/13

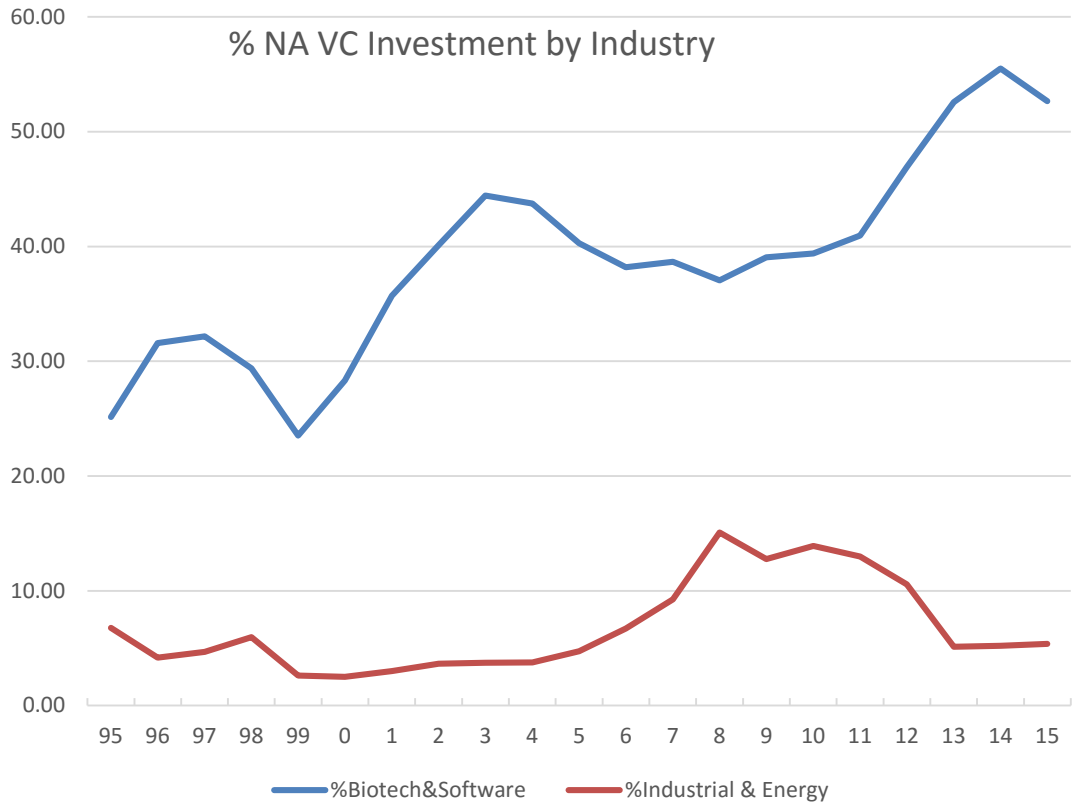
Materials businesses react to investor pressure

- Businesses become “focused”- *i.e.* less diversified with shorter-term mentality
- Shift spending from research to application development
- Eliminate functions not required for short-term strategy and sales
- Violates characteristics of science-based business
  - Breaks the connection from discovery to commercialization
  - Reduces the ability to attract new talent and ideas
  - Reduces the ability to sense and incorporate new opportunities

www.supplychain247.com

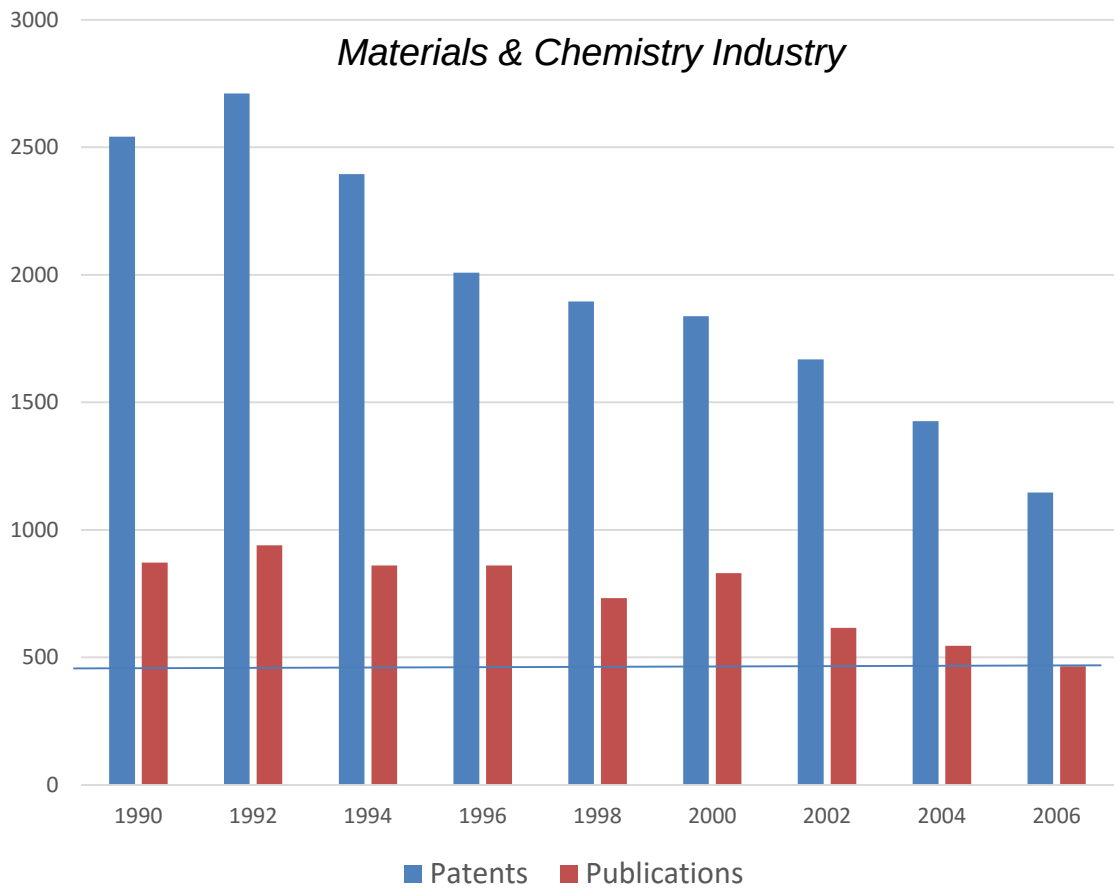
Depending on starts-up not the perfect answer

- Large materials companies lack the sensing capability and risk tolerance
- Venture money prefers 3-5 years to exit & minimal invested capital
- No one to fill the Valley of Death



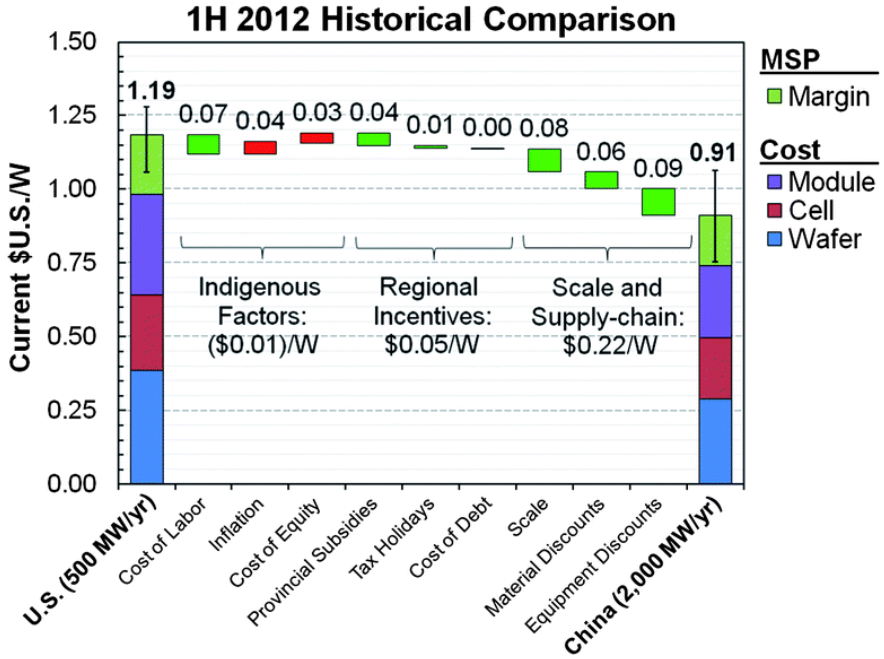
Patents, papers, relevance reduced

- Application development drives down novelty
  - Apparent in both publishing and patents
- Reduces science leadership
  - >45% top Mat Sci papers non-US
  - Implications for competitiveness, national security, & attractiveness



Golden Goose Project

Innovation can change the competitive equation



- US vs. China cost: scale & supply chain, not labor
- Can be reproduced but installed base challenges

AC Goodrich, *et.al.*, *Energy and Environmental Science,* 2013, **6,** 2811-2821

Thank you

Government role is key to optimizing the future

Tech rate of change

Low
(Mature)

Med
(Growth)

Gov. Labs, Universities

Public-private, highly directed consortia; patient capital

High
(Embryonic)

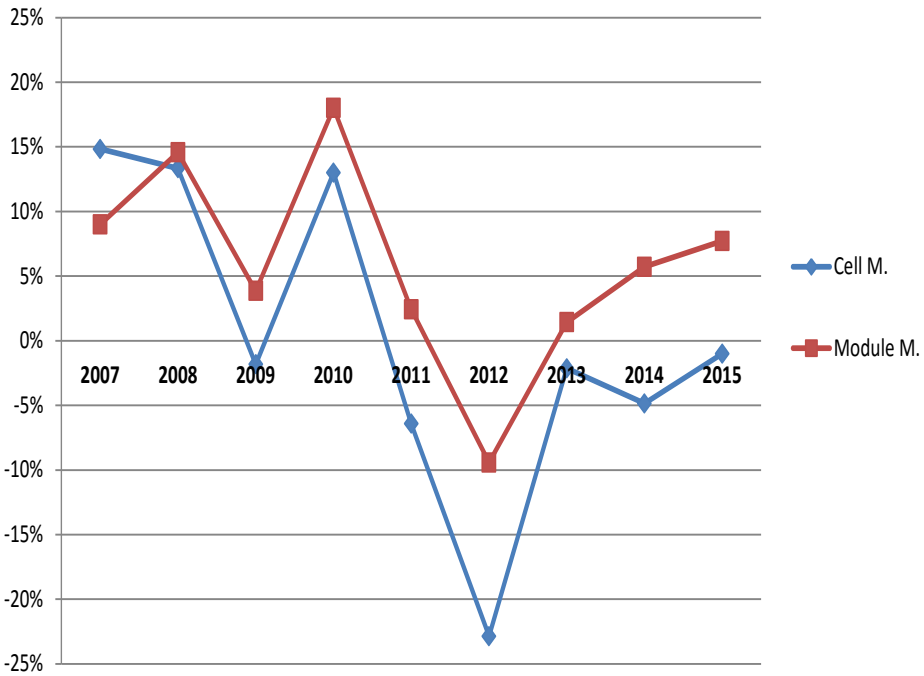
Low | Med | High

Market rate of change

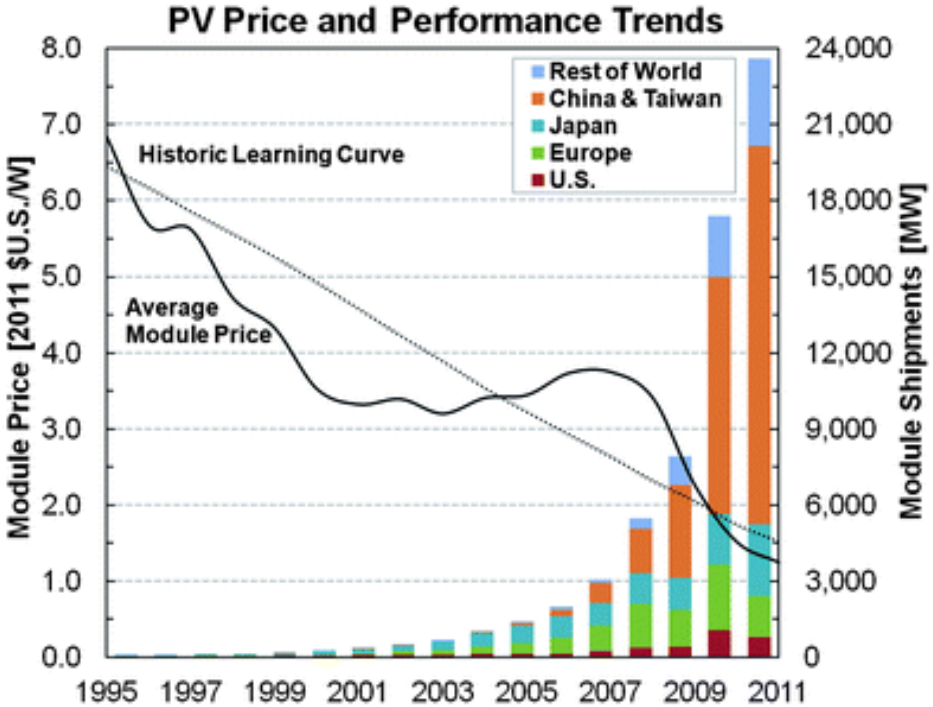
The opposite is happening

Solar energy industry driven by technology and business innovation

- Rapidly moved down the experience curve
- Focus on lowering cost of manufacturing
- Dramatic improvements in scale and supply chain
- Usually results in high profit margins to support further innovation
- But…….



Source: Photon International



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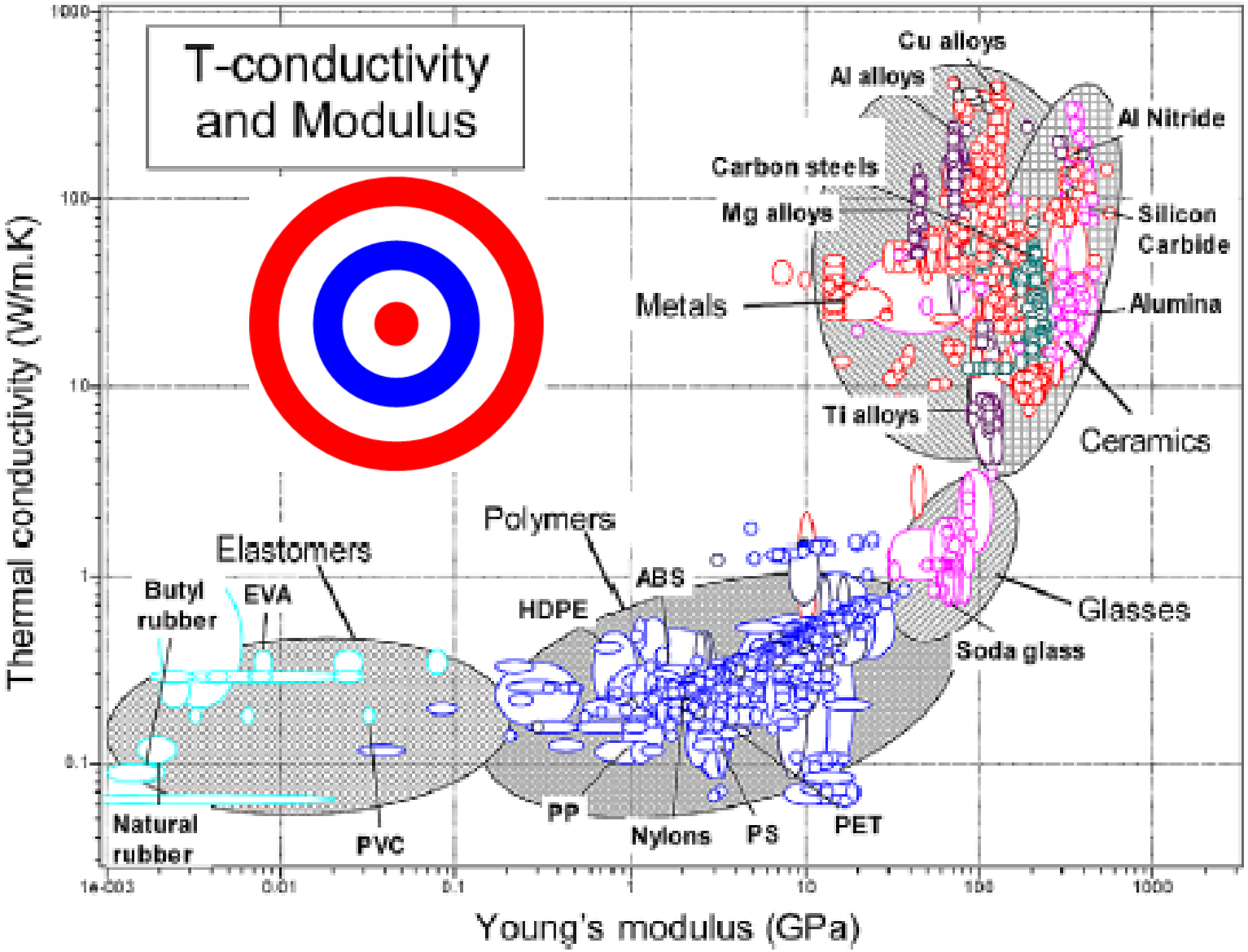
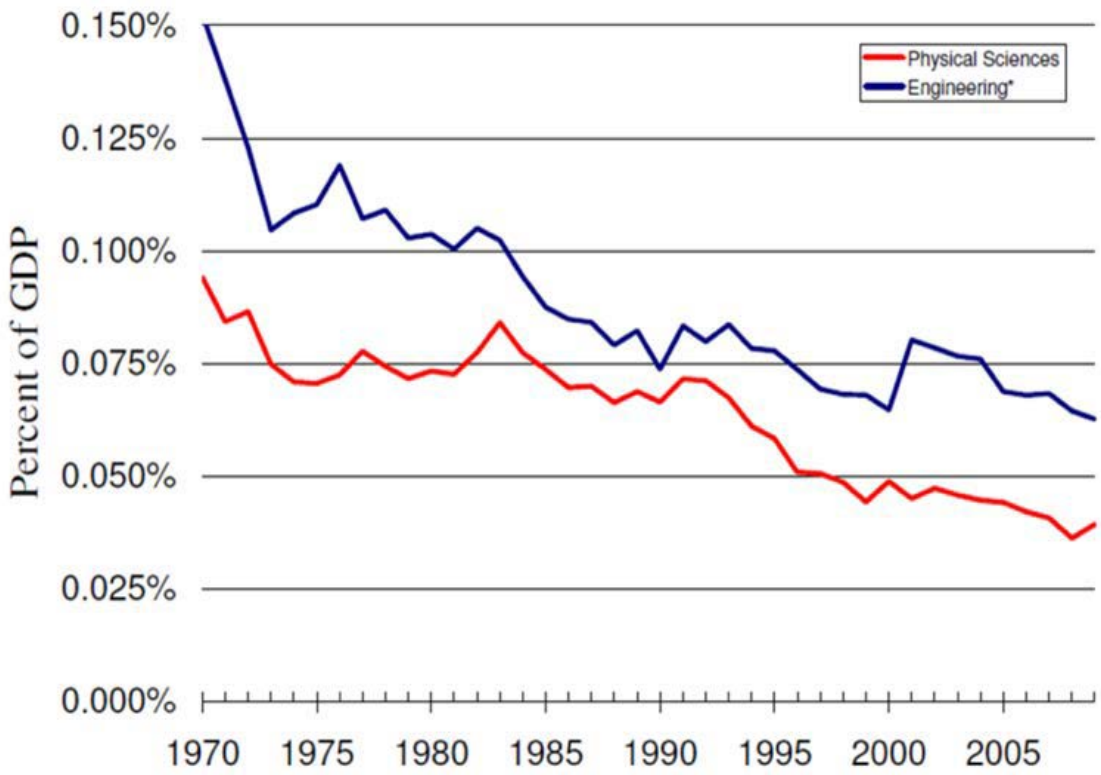
Plenty of Innovation Space Left- the Materials Paradox



M.F. Ashby, Y.J.M. Bréchet, Acta Materialia 51 (2003) 5801-5821.

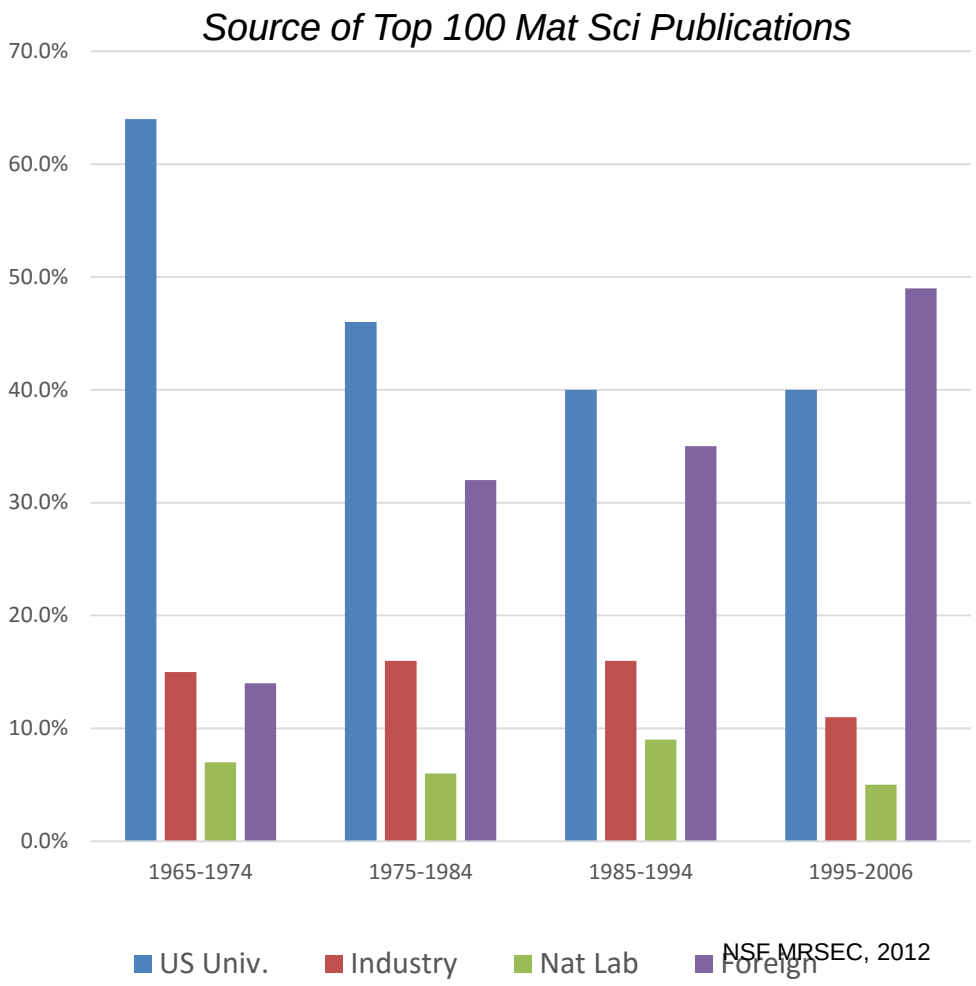
Federal investment as % GDP dropping

- Physical sciences and engineering used as proxies for materials science
- Government spending not supporting continued growth through innovation
- Significant implications on future GDP growth



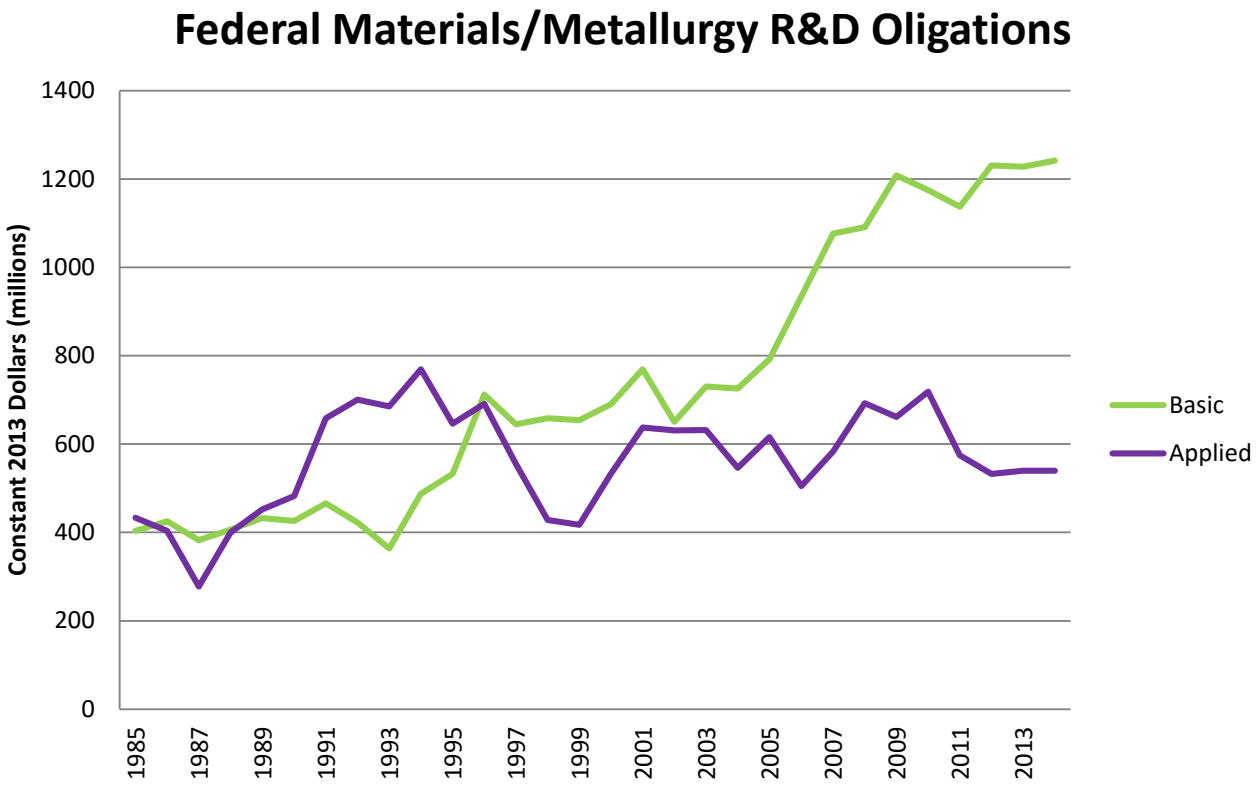
*The 2001 jump in engineering is due to reclassification of funding and is therefore artificial. Source: AAAS. Updated by the American Statistical Association Science Policy Office.

- Reduced science leadership in both industry and universities
  - Industry not challenging universities
  - US less attractive to top students



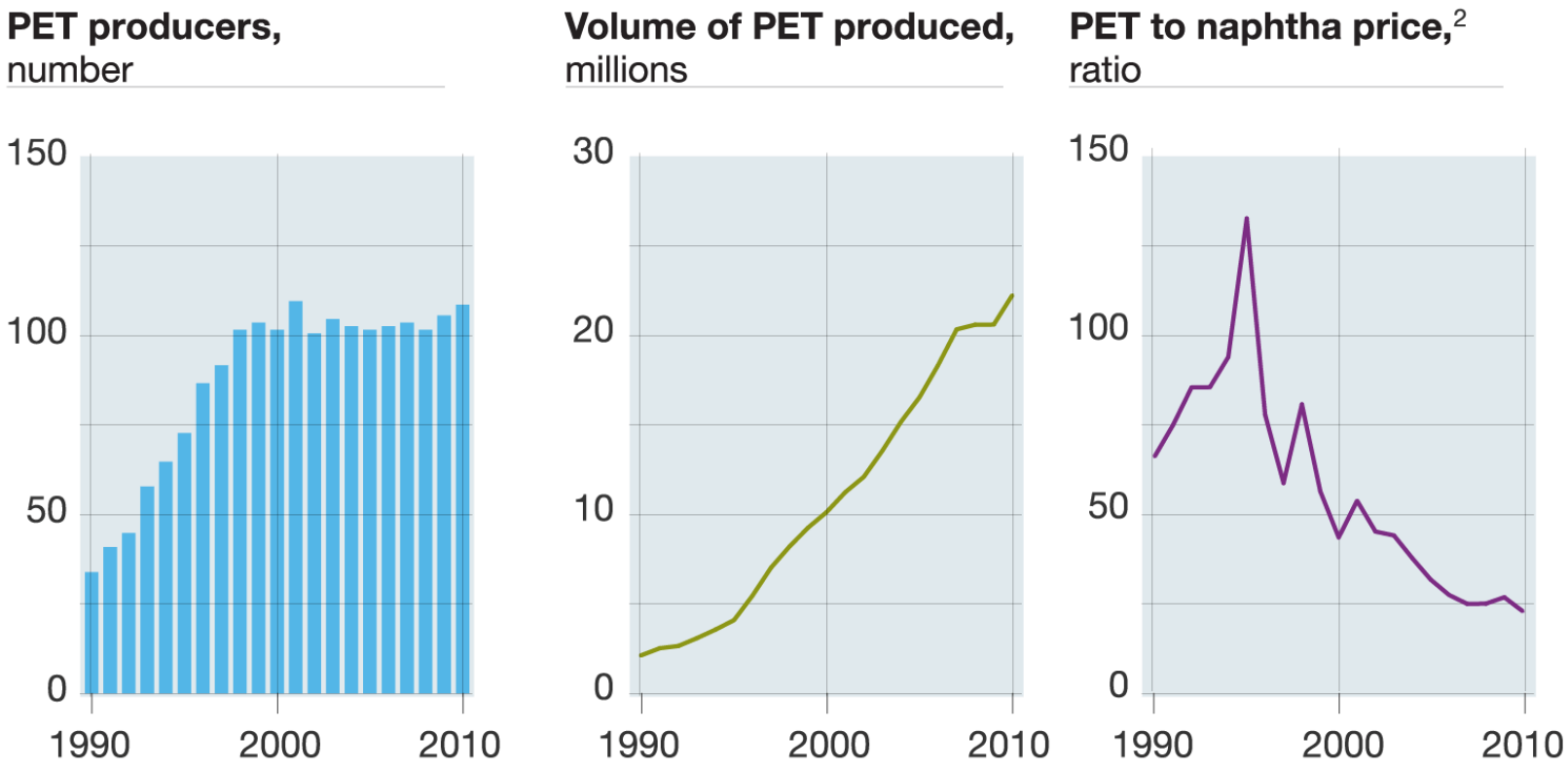
NSF MRSEC, 2012

Federal spending in Materials Science



Increase is fundamentals almost entirely due to NNI

The example of PET[1] shows how rapidly commoditization of a product can progress.



[1]Polyethylene terephthalate.
[2]Using naphtha as a proxy for PET raw materials.

Government intercession