# NNI/OECD Metrics Workshop

Electronics breakout session

Results of March 27/28 discussions

# What impacts are already occurring?

- Cost per transistor dramatically reduced
- $300 billion in semiconductor industry revenues in 2011
- Quality of life, communication, education, change of culture, etc.
- Improving/preserving market share
- Return on investment
- Improvements in productivity, product life cycle time
- Use in other fields, e.g., medical, robotics, energy, etc.
- Regional impacts through well organized public/private partnerships

# Main European initiatives for promotion of Nanoelectronics

Aeneas
Association for European NanoElectronics ActivitieS

*Bringing together people with ideas to set the R&D agenda for nanoelectronics in Europe*

**AENEAS** mission is to represent R&D performers in the Joint Technology Initiative in the field of Nanoelectronics and to adopt and continue the activities of the European Technology Platform **ENIAC**. ***INL is member of the AENEAS association***

eniac
JOINT UNDERTAKING

*A PUBLIC-PRIVATE PARTNERSHIP IN NANOELECTRONICS STRENGTHENING EUROPEAN COMPETITIVENESS AND SUSTAINABILITY*

**The ENIAC Joint Undertaking (JU)** is a public-private partnership focusing on nanoelectronics that brings together Member/Associated States, the European Commission, and AENEAS (an association representing European R&D actors in this field).

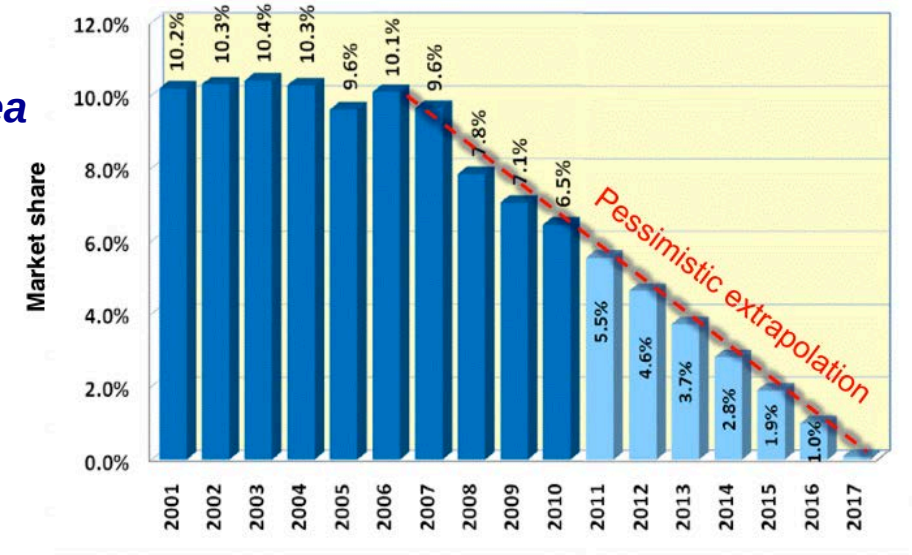
# European figures in the electronics sector.

***Europe is loosing market share in the area of Integrated Devices Manufacturers:***

-40% market share in 5 years (2006-2010)

-11.6% in average per year

There is a pessimistic view for European Integrated Device Manufacturers

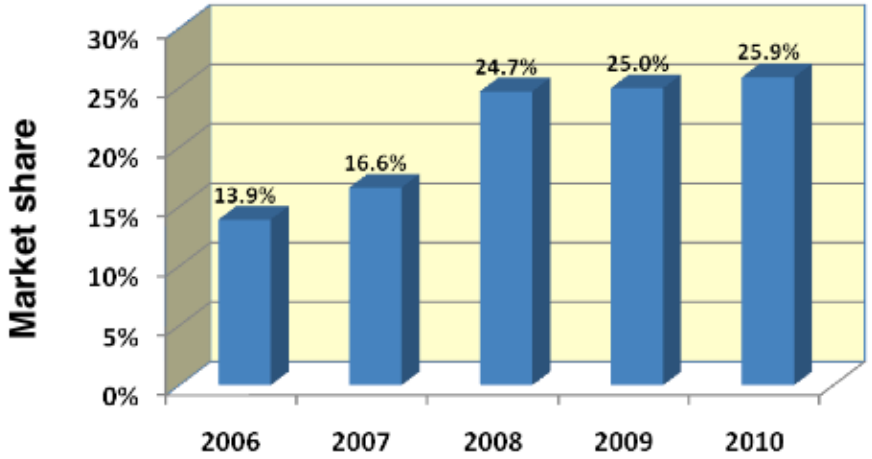



***But Europe is doing a good job in the Semiconductor Equipment Manufacturers market:***

Exceeding $10B in 2010

Compound Annual Growth Rate: > +15%

Important increase of market share




***Fabless companies*** and ***Foundries*** are also loosing market share and competitiveness against Asian and American rivals



Data Source: The European Nanoelectronics Roadmap. A. Wild (ENIAC). Micro- and Nanoelectrincs 2 Days, Rome, 30 Sep 2011

# CNSE Partnerships

**STC Center**

SMART SYSTEM TECHNOLOGY & COMMERCIALIZATION CENTER
COLLEGE OF NANOSCALE SCIENCE & ENGINEERING


7

**SUNYIT C4 Campus (Utica)**

nfrastructure

5

**Luther Forest Technology Campus**

GLOBALFOUNDRIES

4

**Watervliet Arsenal Technology Park**

3

**Albany NanoTech Complex Technology Hub**

1

**Syracuse Electronics Park**

LOCKHEED MARTIN

6

**IBM East Fishkill Fab Campus**

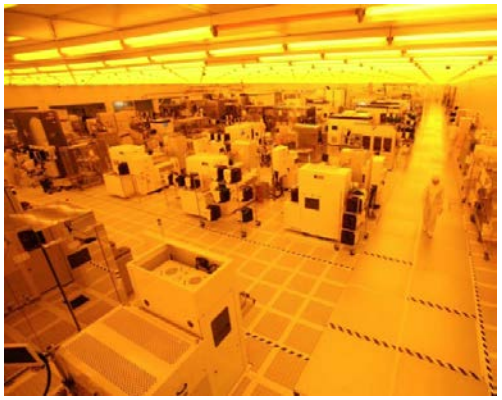
IBM

2

**Nanoscale Fabrication Requires Closer Coupling Between R&D and Manufacturing**

# Public/private Development Impact, CNSE





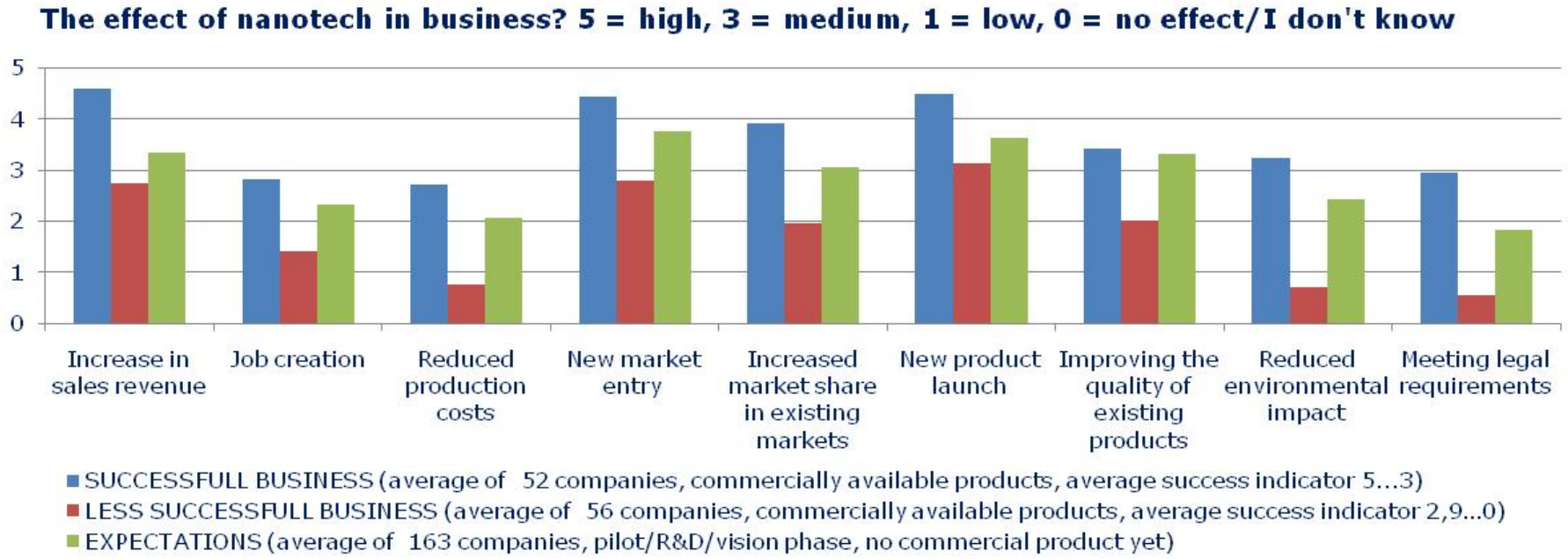
- 300+ industry partners including electronics, energy, defense & biohealth
- $14 B investments since 2001 and over 2700 R&D jobs currently on site (projected increase to 3700 R&D jobs by 2014)
- Since 2001: 12,500 jobs created/retained; $1B wages; $28B investment
- Projected by 2015: 25,000 jobs created/retained; $2.25B wages

NanoCom

# The success indicators – the effect of nano in business?

## The effect of nanotech is high in

- New product launch (according to 62% of the 278 companies)



# What are highest priority impacts expected in 5 years?

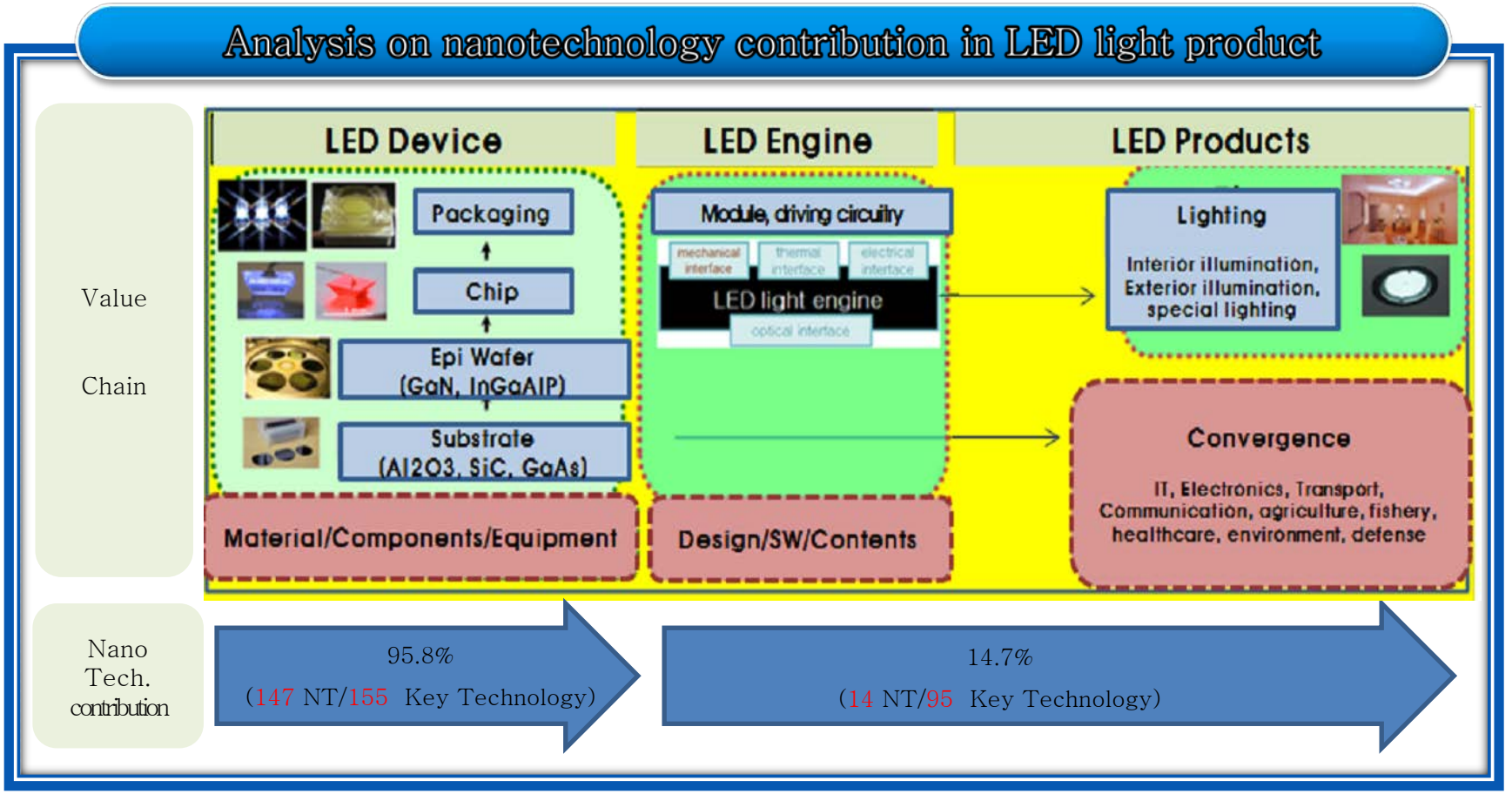
- Shorten development time
- Lowering specific investment, entrepreneurial ecosystem and culture
- Educational impact
- Regional partnerships
- Region-specific impacts (i.e., Europe vs. Asia vs. U.S.

# What type of metrics most appropriate to assess high priority impacts?

- Direct:
  - Total semiconductor production $300 B/yr., 182K U.S. jobs supporting 6M other U.S. jobs, export contribution
  - Approx. 1018 transistors produced per year at reduced cost and improved performance.
- Indirect:
  - contributing to 25% of the increase in U.S. productivity between 1960-2007
  - 30-50% of growth in several other industry sectors
  - Innovation in using patents
  - Impact on manufacturing, e.g., through increased use of robotics, automation, has impact on economy as a whole (ref. Jorgenson et al., J.D. Samuels (prepub), “semiconductors and U.S. economic growth”)
  - Energy consumption efficiency: (1) less energy for same performance; (2) consistent energy use, greater performance
  - Quality of life, but how to measure? In developed and developing countries

# Contribution of Nanotechnology on Light Product

- Portion of nanotechnology in key technologies for LED lights production is estimated at 64.4%(=161 NT/250 key Tech.)
  - Technology Road Map prepared by cooperation of MKE (Ministry of Knowledge Economy), KIAT (Korea Institute for Advancement of Technology) and R&D experts is used.



# Summary of case study

## Summary Table

| | |
|---|---|
| Nanotechnology Application | - material, device, light engine |
| Effect of Nanotechnology on product | - performance improvement (electric saving, extended product life)<br>- price increase (value addition) |
| Market size of LED lights (Korea) | - 150 million$(‘11) → 1.9 billion$(’20) |
| Market share of LED lights(Korea) | - 4%(‘11) → 22%(‘15) → 60%(’20) |
| Price ratio* (LED / incumbent light) | - 2.5~130 (‘11) → 1.4~72 (’15) → 1.2~65 (‘20) |
| Producer's surplus (2011~2020) | - by LED substitution : 350 million$<br>- by LED substitution * Nanotechnology contribution ratio : 224million$ |
| Externality (2011~2020) | - by LED substitution 10.1 billion$<br>- by LED substitution * Nanotechnology contribution ratio : 6.5 billion$ |
| Carbon reduction (2011~2020) | - 68,145,112 tCO2<br>- 442,943,226 euro(6.5 euro/tCO2, price of Dec 11) |
| Other effect | - Industry growth : expansion of LED application (example of display product)<br>- Advance of industry structure (general product →higher value-added product)<br>- promotion of technology innovation |

* Min~Max value by incumbent light source

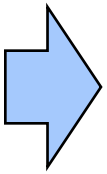
# Economic Impact Measured by Growth Accounting: Semiconductors

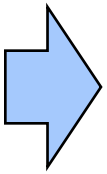
- Difference in output vs. input is due to “innovation”
- In 1960-2007 Semiconductor industry output grew 22 times faster than the US economy as a whole
- Semiconductors are largely an intermediate input to other industries (like nano)
- Semiconductor use accounts for growth in many other industries.
  - 37% of growth in Communications (1960-2007)
  - 40% of growth in Primary Metals (1960-2007)
  - 48% of growth overall (1995-2000)
  - Increased Labor Productivity in Education Services, Federal Govt, Wholesale, etc.

# SRC Numbers

## SRC Research Programs*

- ✓ Over $1.6B invested
- ✓ 3,225 contracts
- ✓ 9,195 students
- ✓ 2,025 faculty members
- ✓ 261 universities



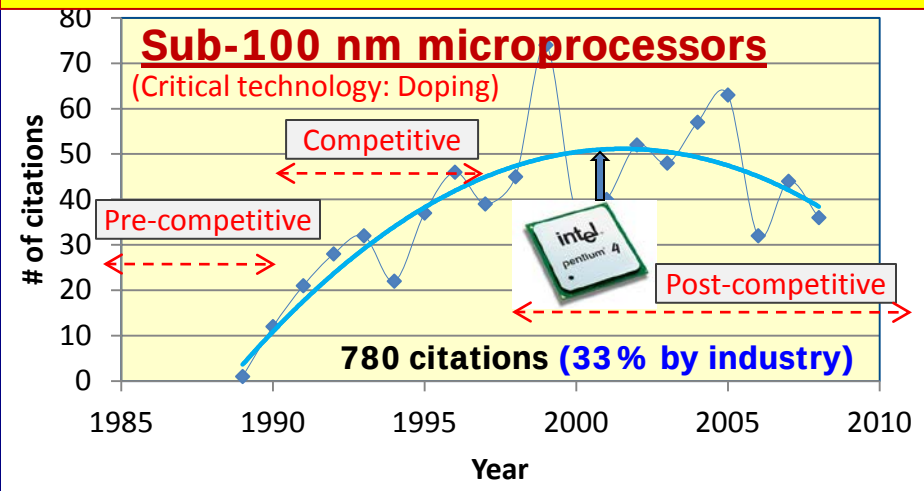


## Deliverables*

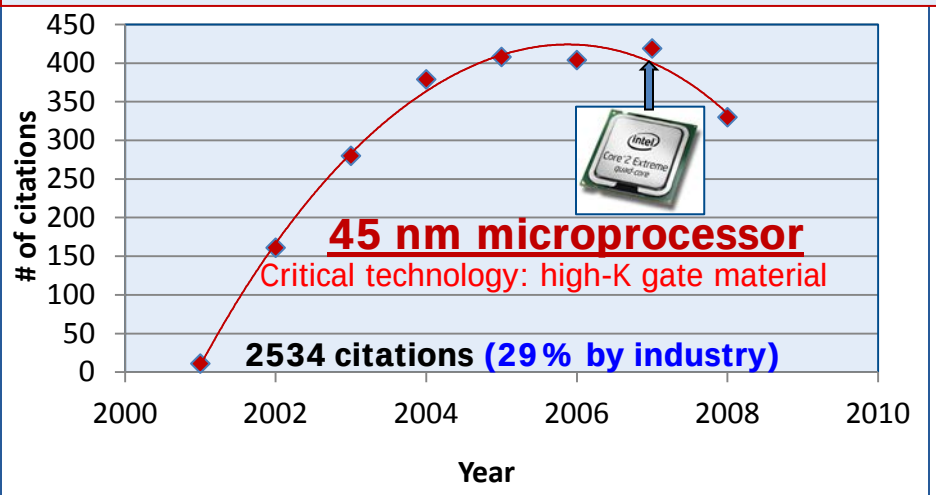
- ✓ 43,070 technical documents
  - 377 patents granted
  - 908 patent applications
  - 677 software tools
- ✓ 2,944 research tasks/themes
- ✓ 9,195 students

# Citation trajectories peak about time of product introduction

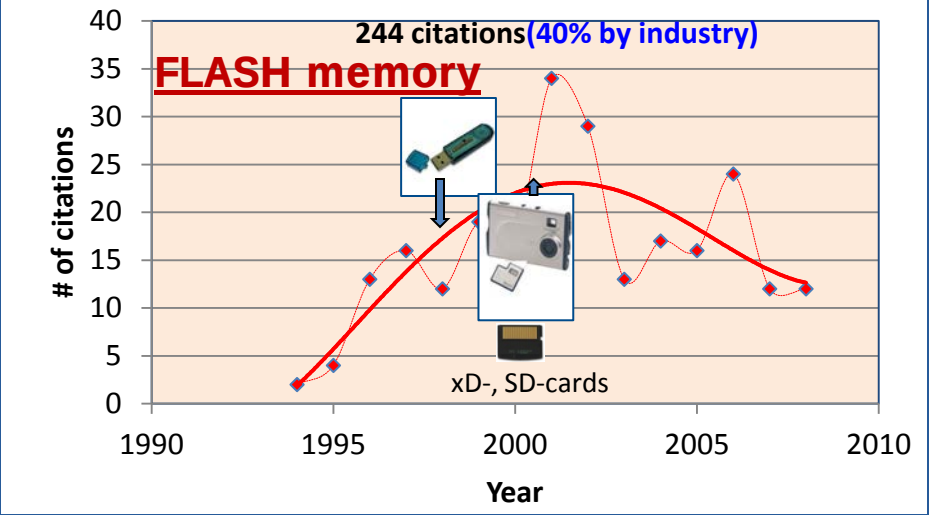
"Point Defects and Dopant Diffusion in Silicon", by Plummer et al. (1989)



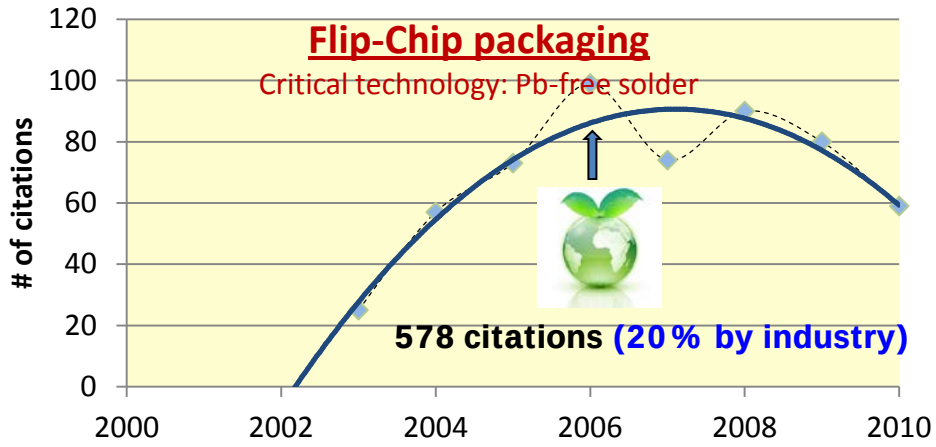

"High-k gate dielectrics: current status and materials properties considerations" by Wilk, Wallace and Anthony (2001)



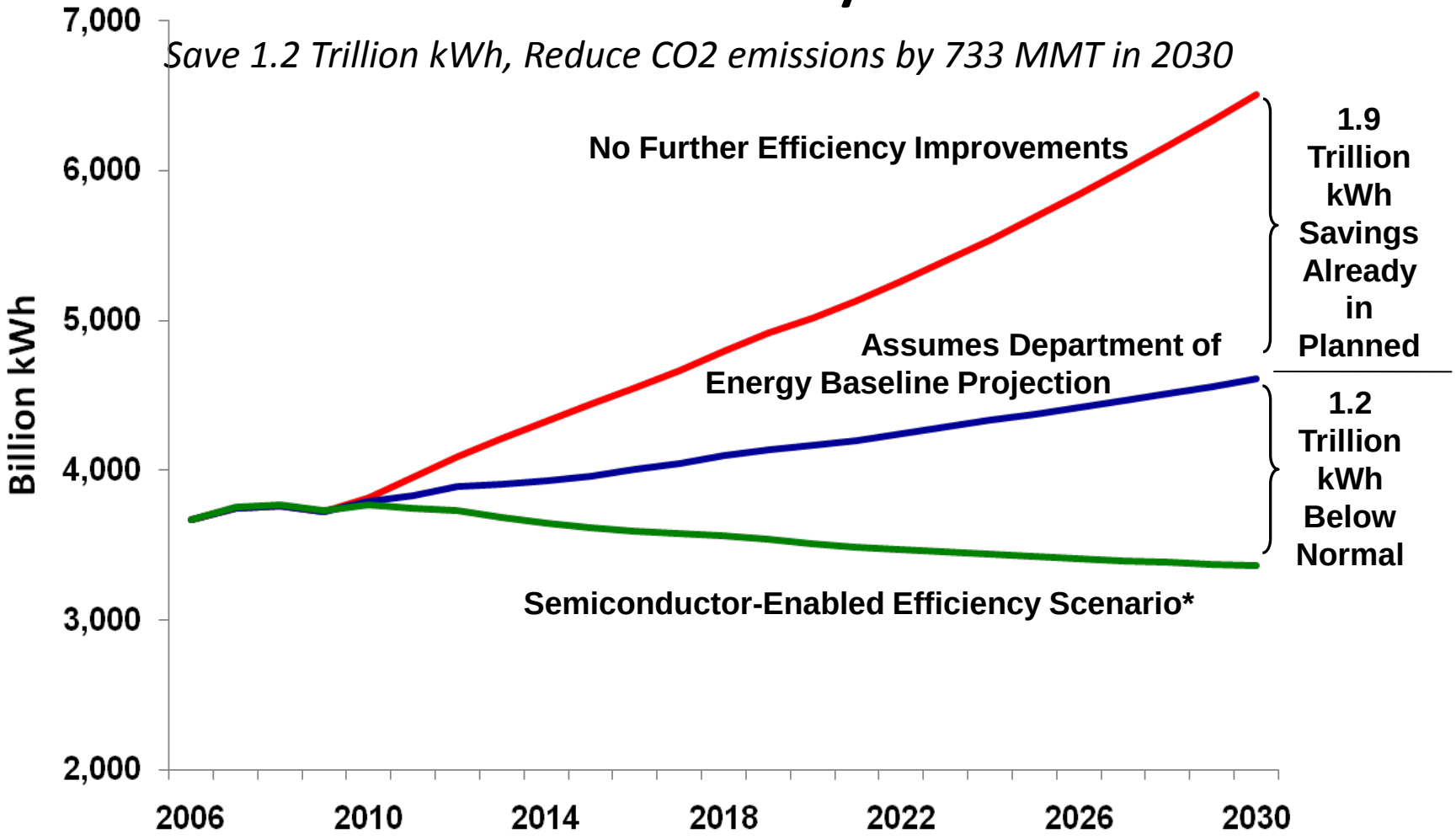

"Hole injection SiO2 breakdown model for very low voltage lifetime extrapolation" , by Schuegraf and Hu (1994)




"Six cases of reliability study of Pb-free solder joints in electronic packaging technology", by Zeng and Tu (2002)



# Semiconductors Enable Broad Energy Efficiency




*Note: Accelerated investments in semiconductor-related technologies stimulated by smart policies.
Source: American Council for an Energy-Efficient Economy, "Semiconductor Technologies: The Potential to Revolutionize U.S. Energy Productivity," (2009).