NSF National ATE Center for Nanotechnology Applications and Career Knowledge (NACK)

Osama O. Awadelkarim, Associate Director
Center for Nanotechnology Education and Utilization &
Nanotechnology Applications and Career Knowledge Center
The Pennsylvania State University

NACK's Mission

1. *Build partnerships in nanotechnology education among Research Universities, 2-year Community and Technical Colleges, and 4-year Colleges/Universities through:*
   - *Resource sharing (courses, programs, laboratory facilities, staff)*
   - *Creating education pathways through these institutions for student development*
2. *Develop the means to enable a broad nanotechnology education in synthesis, fabrication, characterization, and applications at 2-year Community and Technical Colleges in* ***every region of the US***

3. *Educate students for careers in a spectrum of industries by advocating a knowledge base which can be used in many types of applications and companies*
4. *Insure that this broad nanotechnology education is one which students can build upon throughout their professional careers*

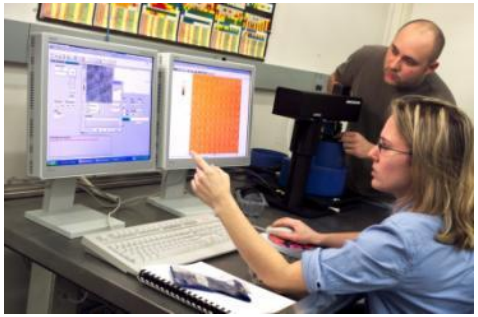
NACK CENTER
WWW.NANO4ME.ORG

Suite of Six Nanotechnology Courses

E SC 211	*Material, Safety and Equipment Overview for Nanotechnology*
E SC 212	*Basic Nanotechnology Processes*
E SC 213	*Materials in Nanotechnology*
E SC 214	*Patterning for Nanotechnology*
E SC 215	*Materials Modification for Nanotechnology Applications*
E SC 216	*Characterization, Testing of Nanotechnology Structures and Materials*

Teaching Cleanroom: Hands-On Experience

Remote Access & Control of Nano Equipment



From our lab…

…to any classroom

PENNSTATE

Center for Nanotechnology Education and Utilization

Pennsylvania's Nanotechnology Innovator!

NACK CENTER

WWW.NANO4ME.ORG

Faculty Development: Educator Workshops

Statistics

Attendees to Date

- *939 Educators*
- *30 States, DC, and Puerto Rico*

Live Monthly Webinars

Upcoming Webinars

- **Introduction to Nanofabrication: Top Down and Bottom Up**
  February 25, 2011
- **Nanotech Works - Alumni Success Stories**
  March 25, 2011
- **Nanotechnology in Medicine**
  April 29, 2011
- **Recruiting Under-Represented Minorities**
  May 26, 2011

Portal to NACK Resources

Nano4Me.org

NSF

Nanotech Academies, High School Curriculum Enhancement, and downloadable Modules

National Industry Advisory Board

- *Alcatel-Lucent; Boeing; Corning; Cyoptics; Dupont; General Electric; Imerys; Johnson & Johnson; Lockheed Martin; 3M; National Coalition for Advanced Technology Centers; Northup Grumman; Plextronics; PPG; Semiconductor Research Corporation; Strategic Polymers; Stryker; and Tyco Electronics*

Some Job Titles Held by Nanotechnology 2-Year Degree Graduates

Biological Laboratory Tech.	*Laboratory Tech.*	*Production Scientist*
Biofuels Tech.	*Lithography Tech.*	*Quality Control Tech.*
Chemical Laboratory Tech.	*Materials Science Lab Tech.*	*Research Assistant*
Cleanroom Tech.	*Medical Devices Tech.*	*SEM Operator*
Deposition Tech.	*Microfabrication Tech.*	*SPM Operator*
Device Tech.	*Nanobiotech Researcher*	*Scientist Specialist*
Equipment Maintenance Tech.	*Nanoelectronics Expert*	*Solid State Tech.*
Engineering Tech.	*Nanofabrication Tech.*	*Test Tech.*
Etch Tech.	*Nanotechnologist*	*Thin Films Tech.*
Failure Analysis Tech.	*Process Tech.*	*Vacuum Tech.*

The Perfect Storm

3 Events that have effected RSL Initiatives

1) The Great Recession Sept. 2008- Present

   Two recessions during a 10 year period 2000-2010. Investment in Nanotechnology Community during and after the Dot.com bust.

2) Venture Capital Investment in the Nanotechnology Community

3) Lack of Liquidity Exits

   IPOs and M&A activity from 2000-2012

Early Stage VC Investment

- ***Early Stage*** VC Investment and the 10-year annual return (from October 1, 2001 to September 30, 2011) is 0.9% vs 3.3% for the NASDAQ and 2.8% for the S&P 500. The risk/return world turned upside down!

NNCO
NNI Workshop RSL 2012
May 1-3, 2012

Vincent Caprio, Executive Director

www.Nanobca.org
www.Nanoevent.org
www.VincentCaprio.org

Historical Comparison

- For historical comparison, the 25-year early stage VC return is 21% vs 8% for the NASDAQ and 9% for the S&P 500, which is a more reasonable risk/return profile.

Nano.gov
National Nanotechnology Initiative

NanoBusiness
COMMERCIALIZATION ASSOCIATION

Venture Capital Investments

- Venture Capital commitments hit a peak of $105 billion in 2000 with the number of VC funds at 649. Last year, VC commitments were $18.2 billon with the number of funds at 169.

2011 Nanotechnology Exits

(Harris and Harris)

- 1. Solazyme (IPO) http://solazyme.com/
- 2. NeoPhotonics (IPO) http://www.neophotonics.com/
- 3. BioVex (acquired by Amgen) http://www.biovex.com/
- 4. Innovalight (acquired by DuPont) http://www2.dupont.com/Photovoltaics/en_US/products_services/silicon_inks/silicon_inks.html
- 5. Crystal IS (acquired but not publicly disclosed) http://www.crystal-is.com/

The Future of Exits

2012 and Beyond

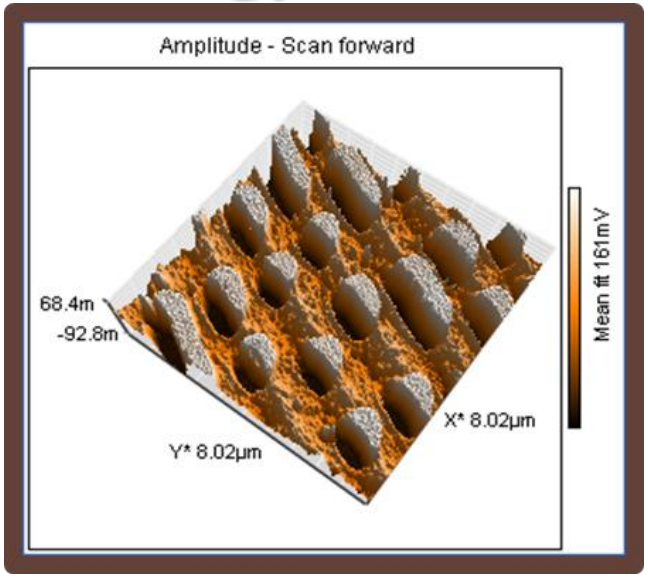
Will we have 25 liquidity exits in the next 5 years?

ForsythTech
More Than You Know

An economic force multiplier

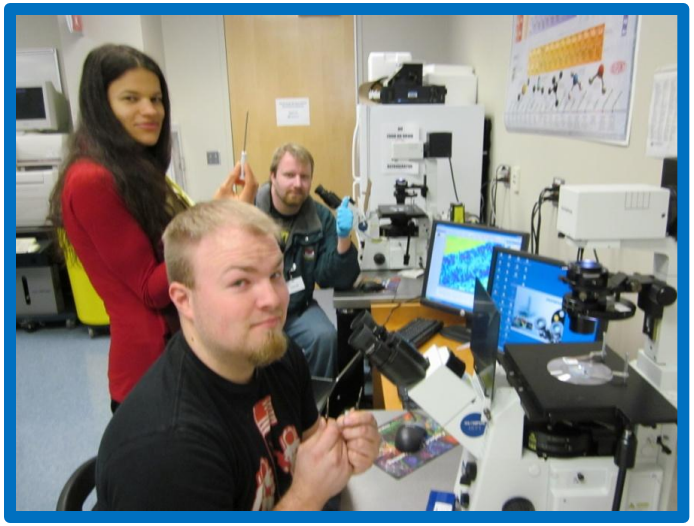
NanoElectronics

- Textiles
- Vehicles
- Energy



NanoBiotechnology

- Drug Delivery
- Pharmaceuticals
- Regenerative Medicine



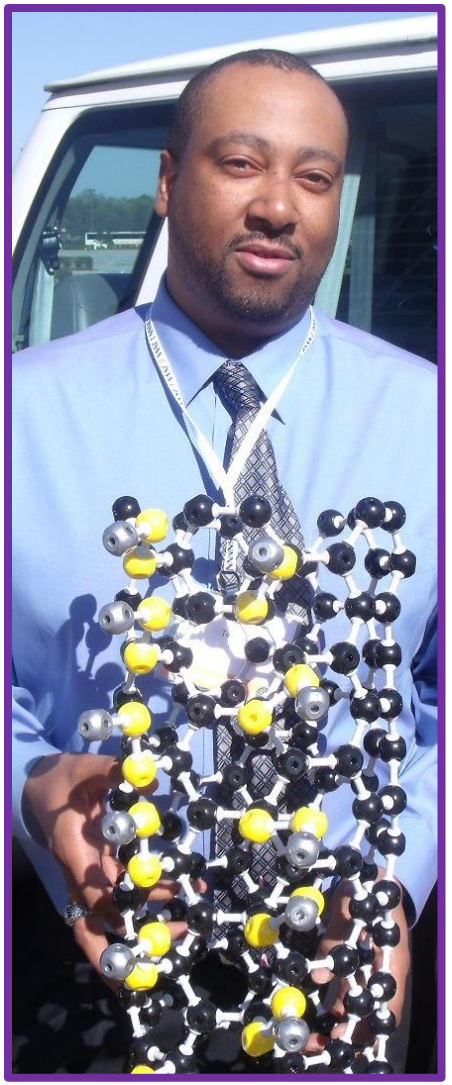
ForsythTech
More Than You Know

Zero-d, one-d, and two-d

Nanoparticle Counting <50nm

Thin-Film Spin-Coating

Nanotube Fabrication and Mixing



ForsythTech
More Than You Know

Barriers to development

1. International Competition

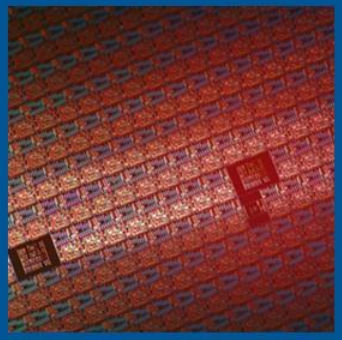
2. EHS

3. American Corporate & Workforce Integration

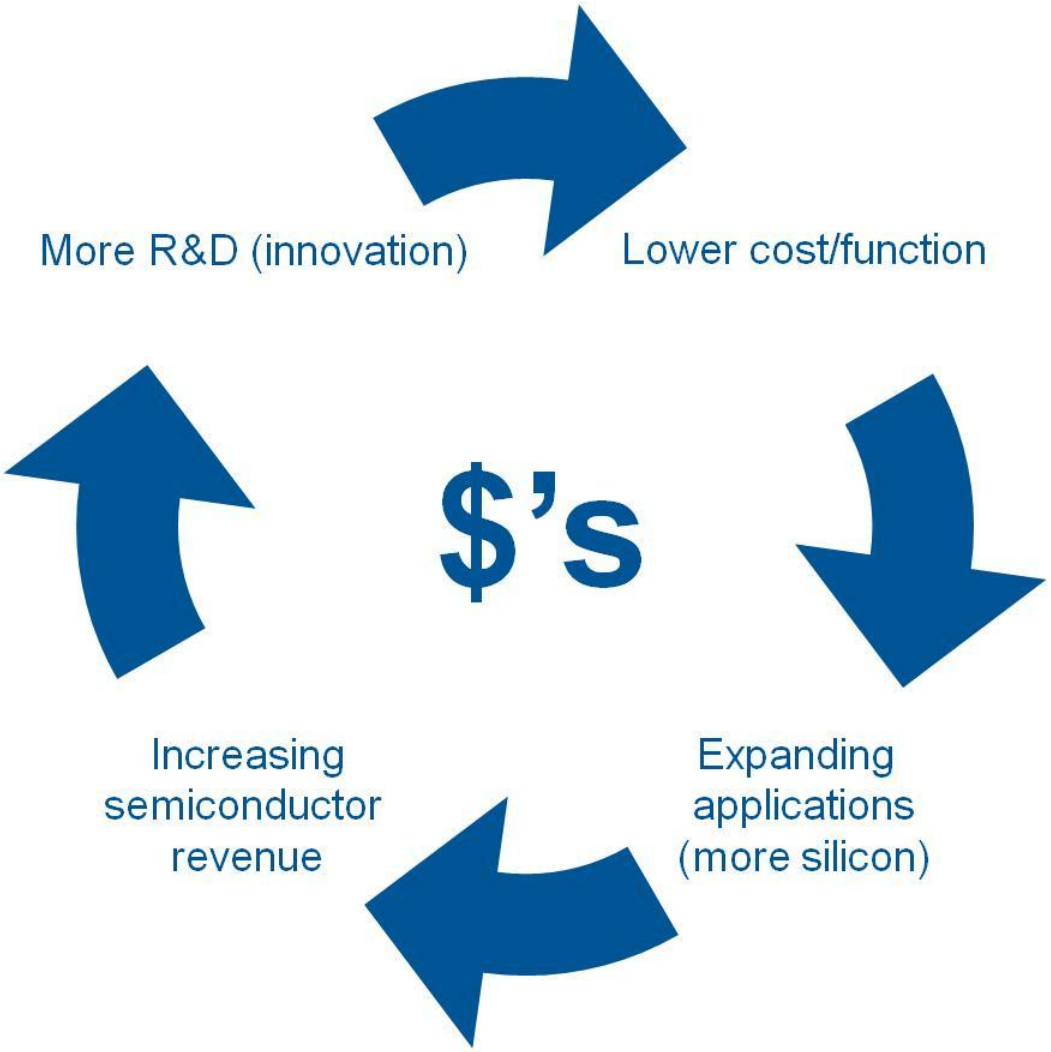
SEMATECH

Accelerating the next technology revolution

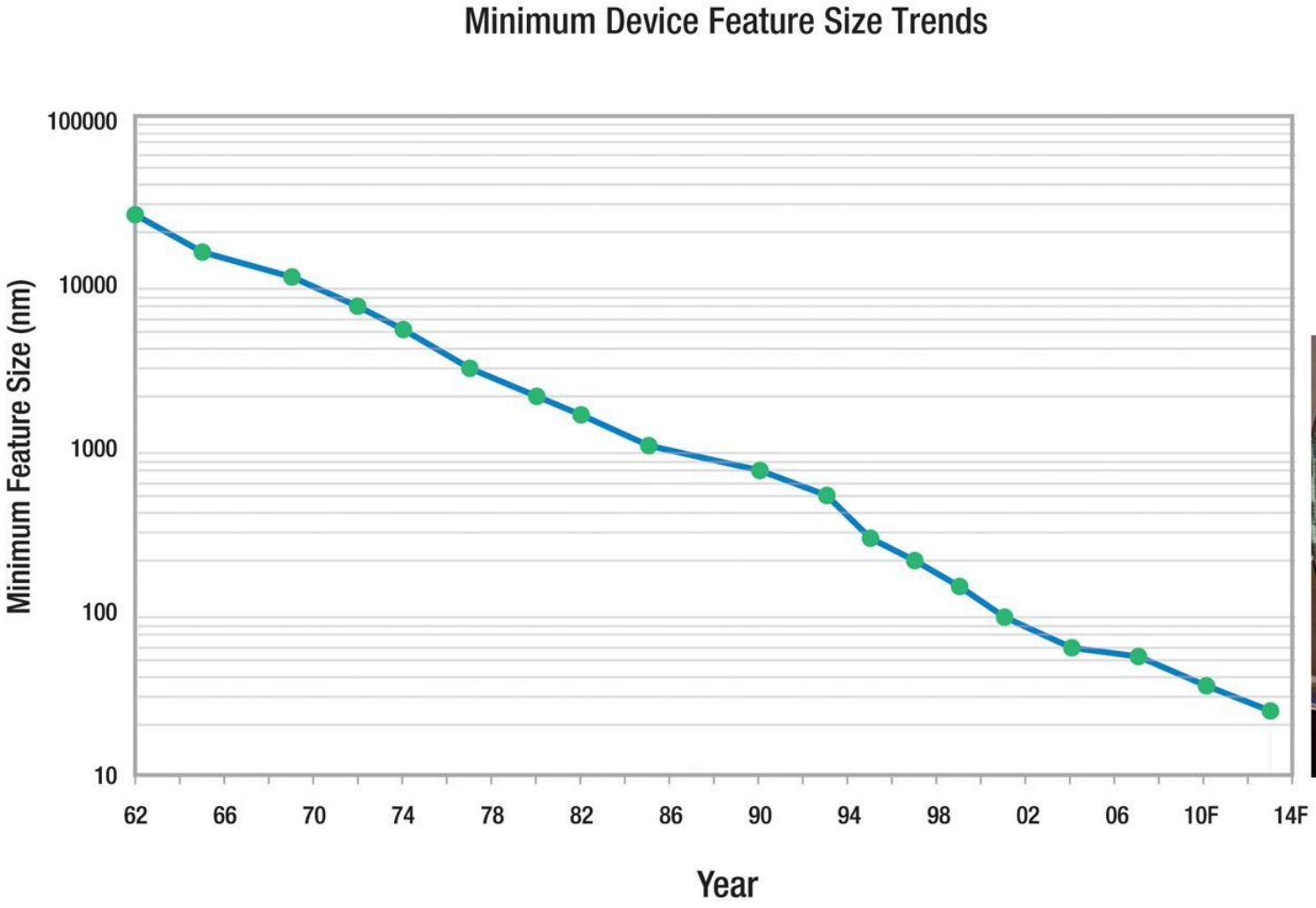
SEMATECH Overview

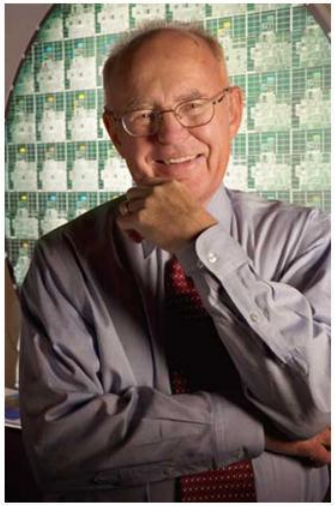


Semiconductor industry – virtuous cycle



Moore's Law



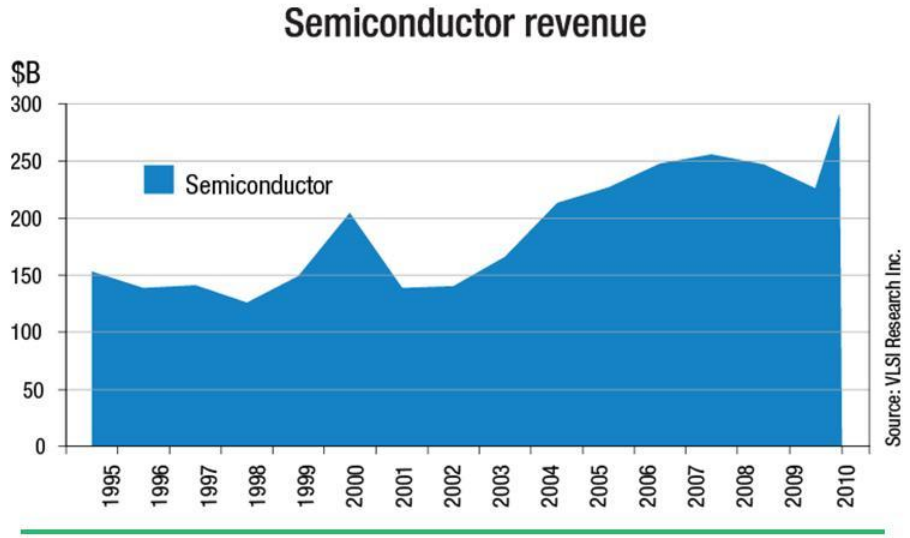


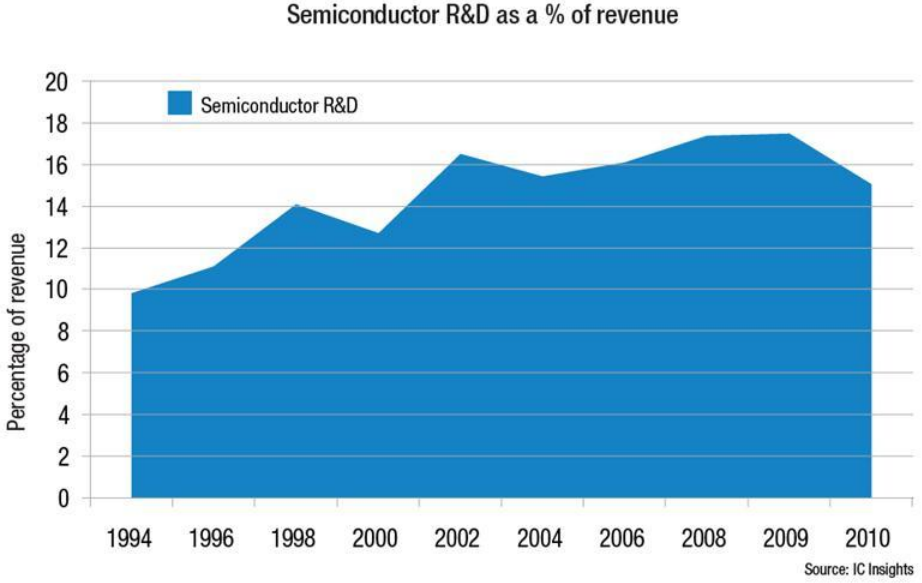
Gordon E. Moore, Co-founder, Intel Corporation.
Copyright © 2005 Intel Corporation.

Key industry trends

Trends

- Semiconductor revenue growth rate declines
- Roadmap costs and challenges increase





Growth markets

Smart Phones

37% CAGR

Cloud Computing Growth

Source: IDC, September 2009

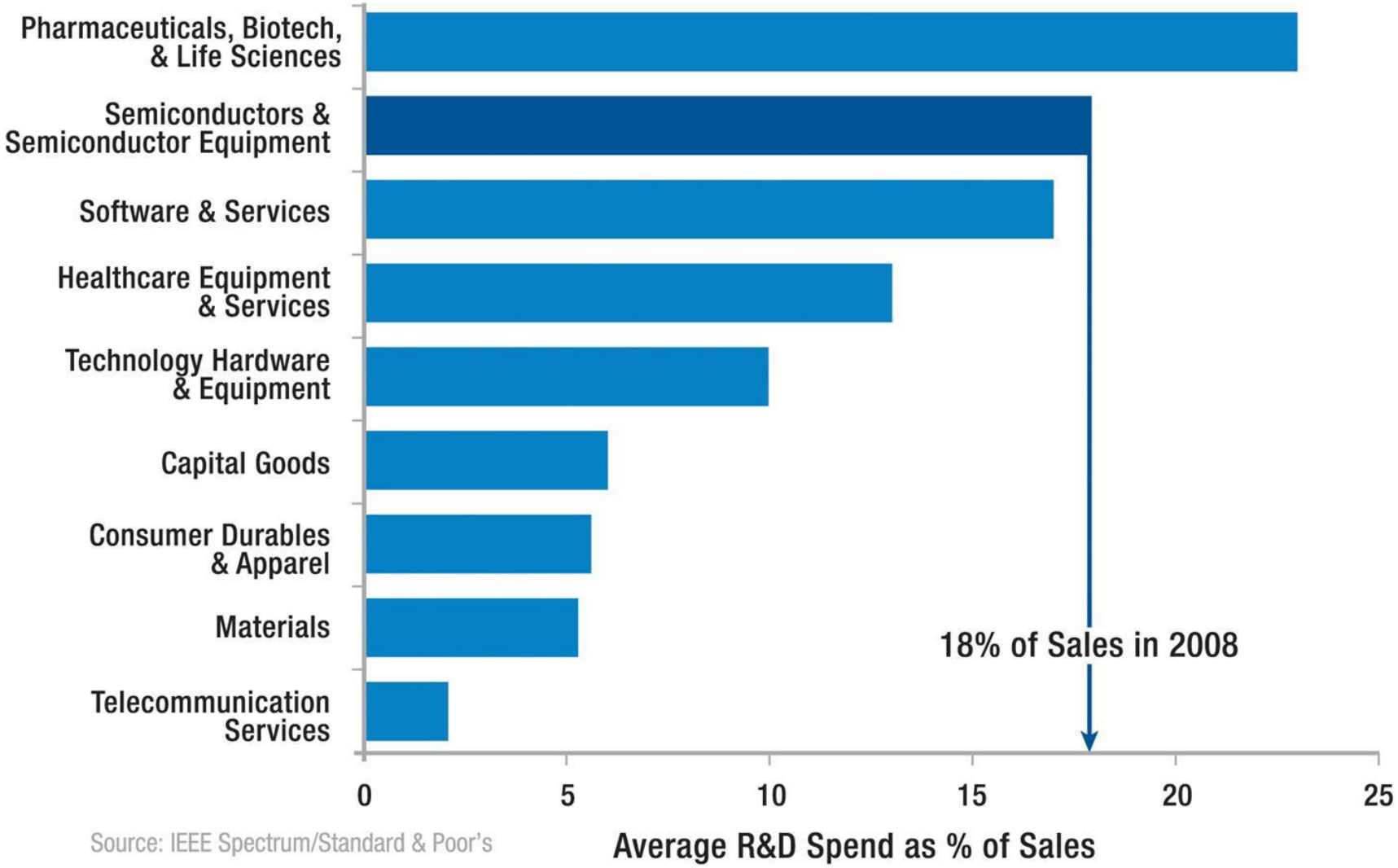
26% CAGR

Mobile Computing

19% CAGR

1 May 2012 5

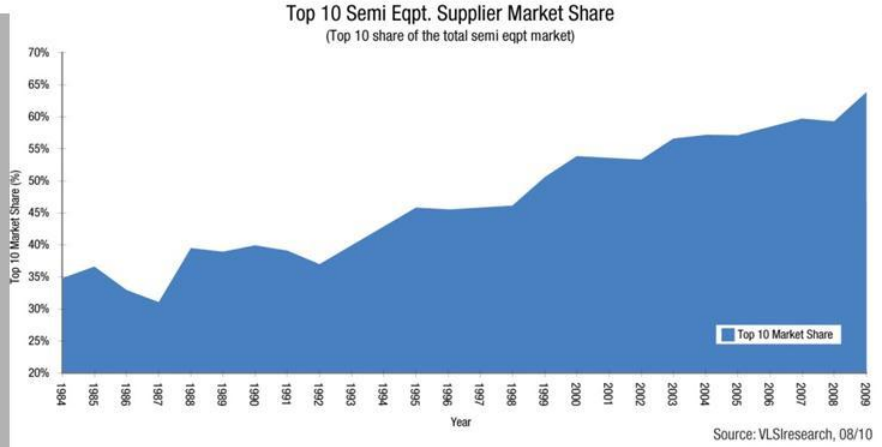
Semiconductor industry one of top R&D spenders

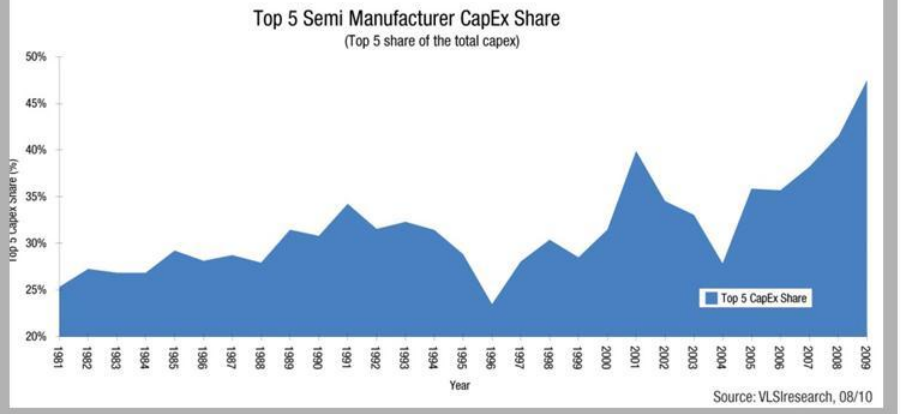


Key industry trends

Trends

- Semiconductor revenue growth rate declines
- Roadmap costs and challenges increase
- **Consolidation of suppliers and semiconductor manufacturers continues**

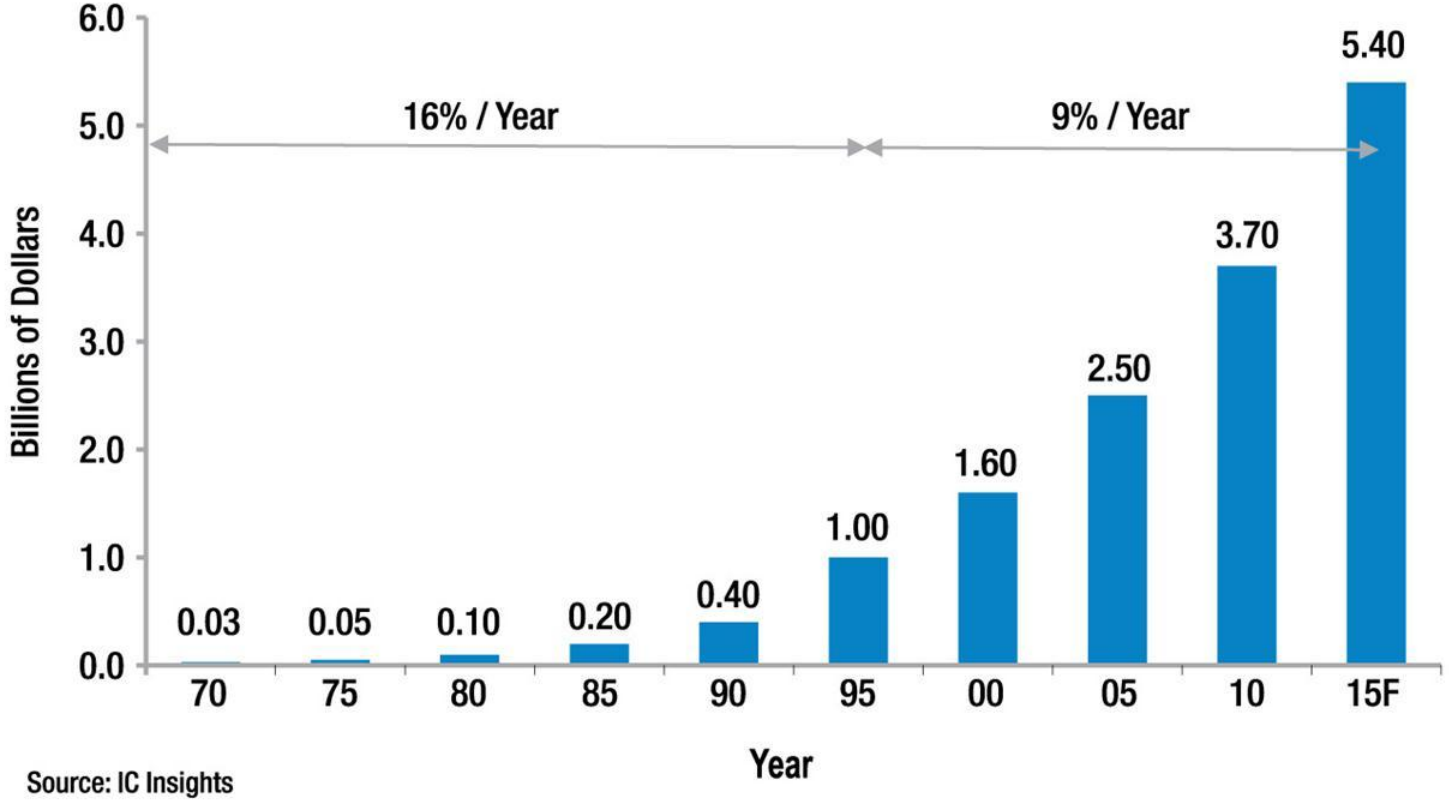




"There has been strong consolidation in semiconductor manufacturing; both in equipment supply as well as capacity. …only a very few chip makers are capable of being at the leading edge."

- VLSI Research

Semiconductor fab cost trend



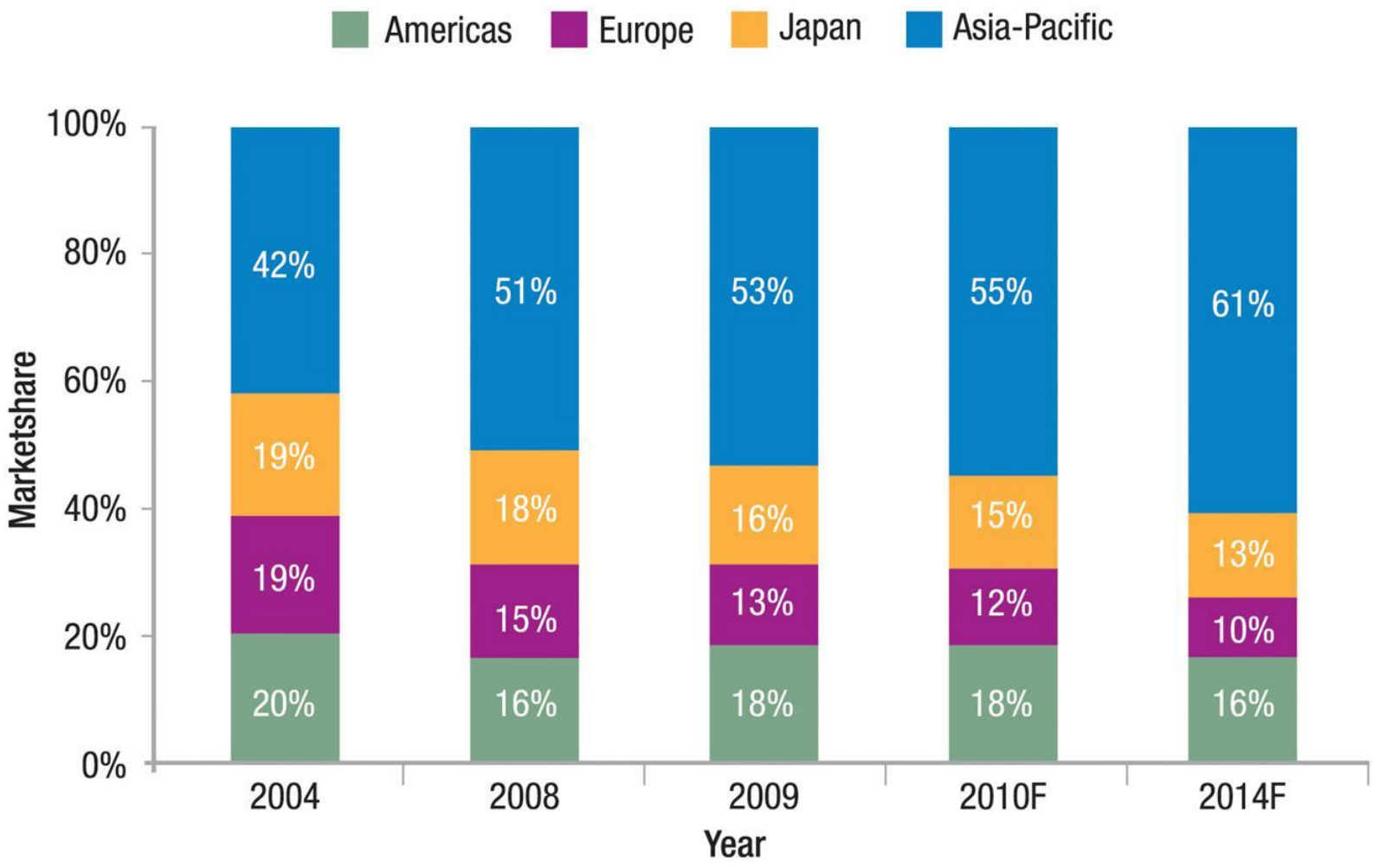
Source: IC Insights

2010 semiconductor sales leaders

Rank 2010	Device	Company	Country of origin	Revenue (million $ USD)	Market share
1	IDM/logic	Intel Corporation	United States	40	13.2%
2	Memory/IDM/Foundry	Samsung Electronics	South Korea	28	9.3%
3	Memory/IDM	Toshiba Semiconductors	Japan	13	4.3%
4	Analog	Texas Instruments	United States	13	4.3%
5	IDM	Renesas Electronics (1)	Japan	12	3.9%
6	Memory	Hynix	South Korea	11	3.5%
7	IDM	STMicroelectronics	France/Italy	10	3.4%
8	Memory	Micron Technology (2)	United States	9	2.9%
9	Fabless	Qualcomm	United States	7	2.4%
10	Memory	Elpida Memory	Japan	7	2.3%
11	Fabless	Broadcom	United States	7	2.1%
12	Logic	AMD	United States	6	2.1%
13	Logic	Infineon Technologies	Germany	6	2.0%
14	Logic/Analog	Sony	Japan	5	1.8%
15	Logic	Panasonic Corporation	Japan	5	1.7%

Source : iSuppli Corporation

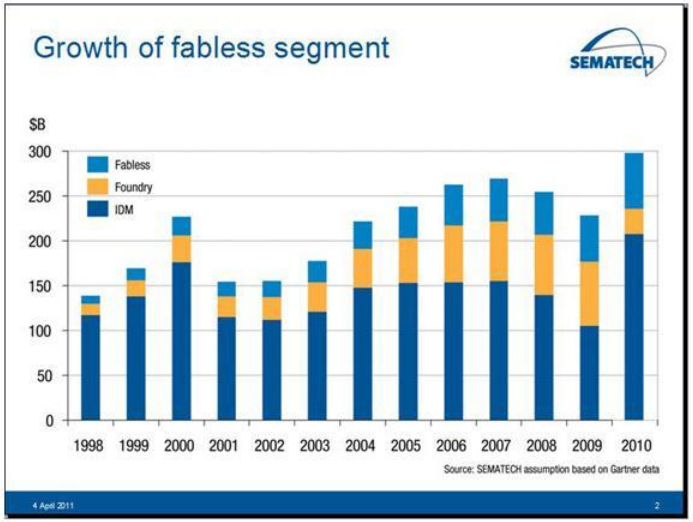
Worldwide IC market by region (2004-2014)



Key industry trends

Trends

- Semiconductor revenue growth rate declines
- Roadmap costs and challenges increase
- Consolidation of suppliers and semiconductor manufacturers continues
- **Evolving business models leading to further industry segmentation and diverging technology differentiation**

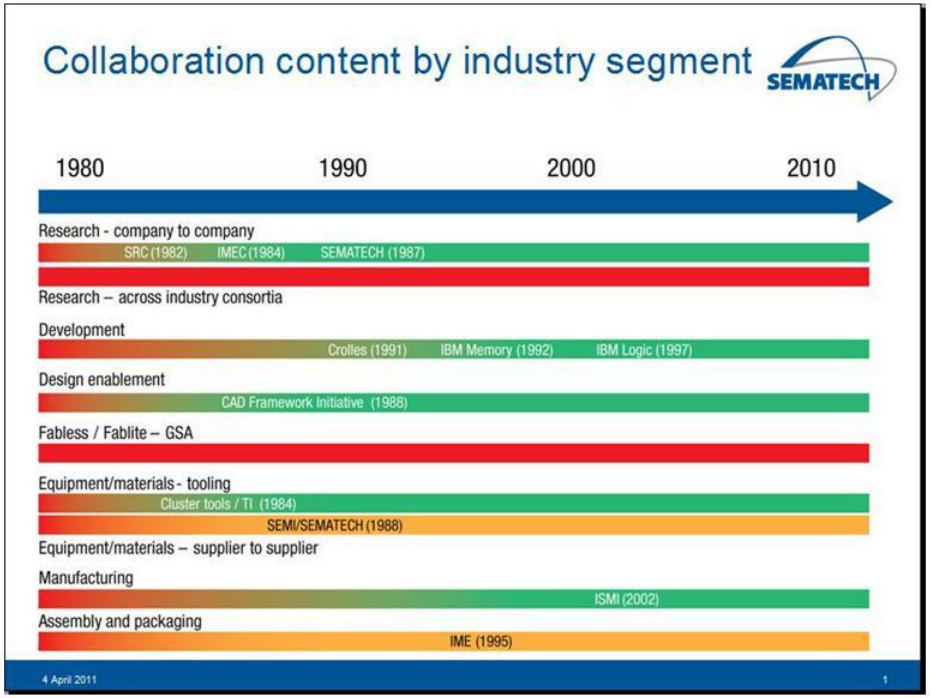


- Consumers are driving mobility/low power and increased use of analog mixed signal, sensors and MEMs

Key industry trends

Trends

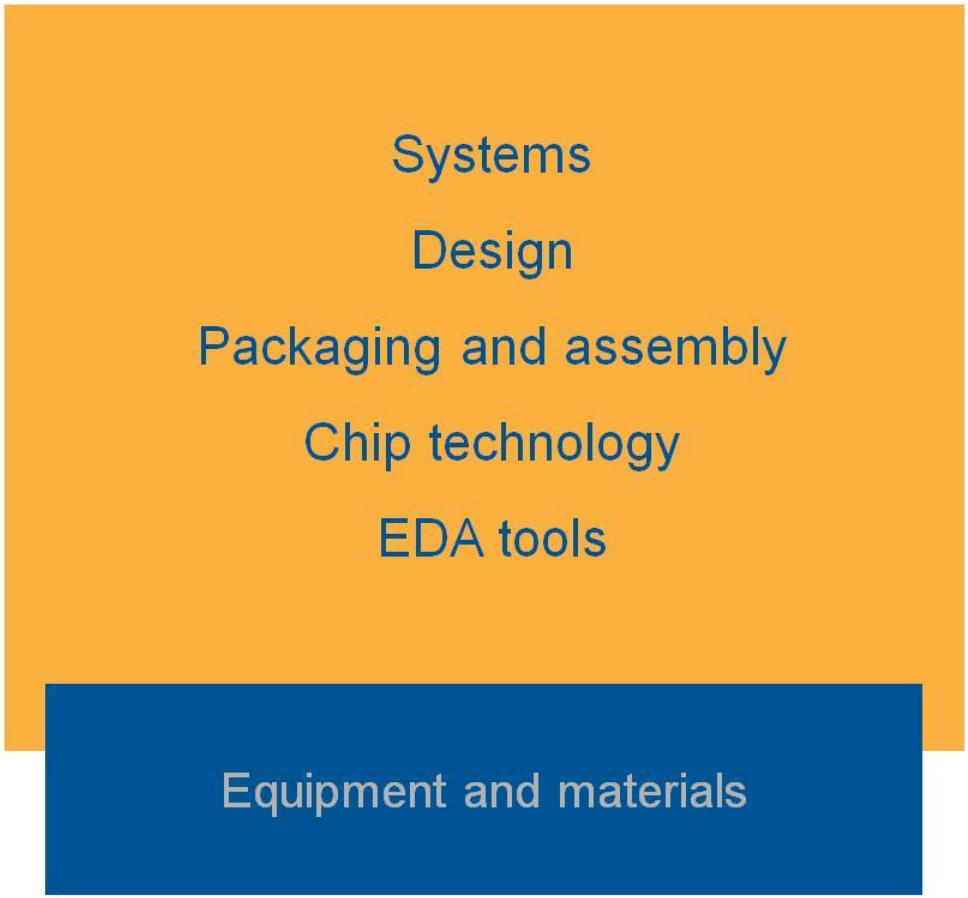
- Semiconductor revenue growth rate declines
- Roadmap costs and challenges increase
- Consolidation of suppliers and semiconductor manufacturers continues
- Evolving business models leading to further industry segmentation and diverging technology differentiation
- **Collaborations increasingly become accepted as necessary approach within many segments of the industry**



Key industry trends

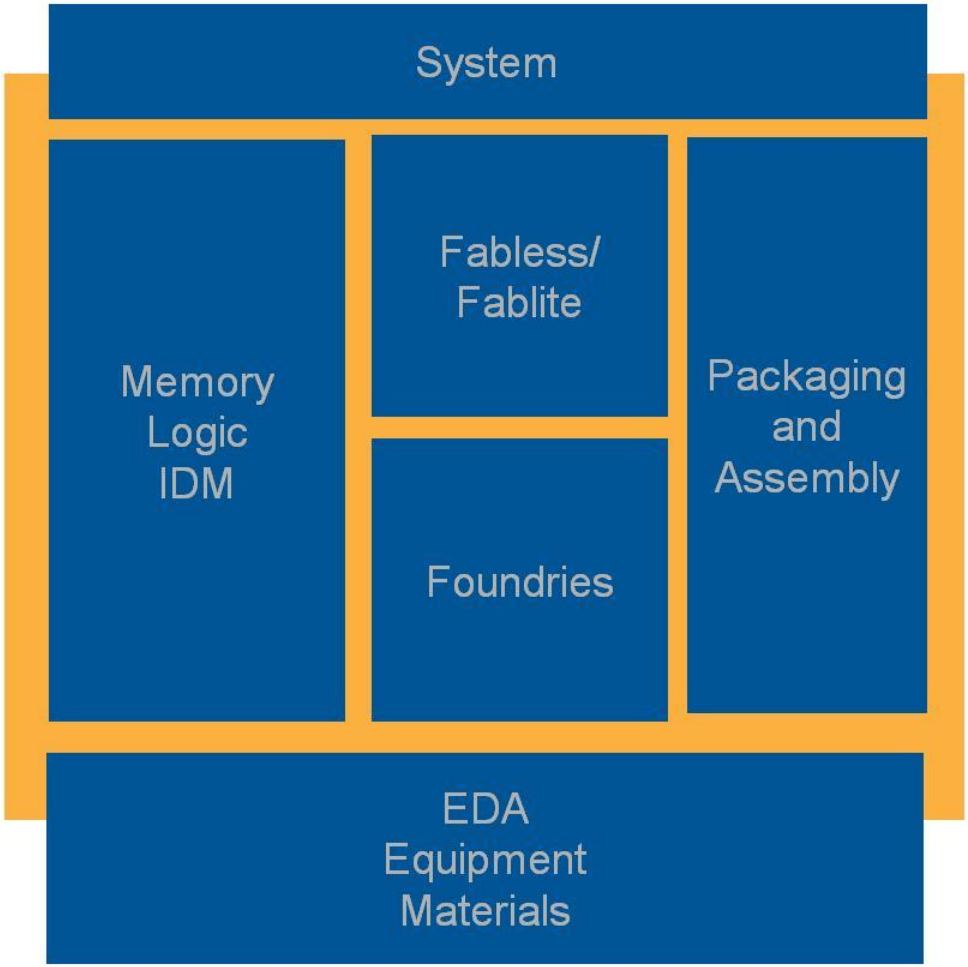
Trends	Implications
• Semiconductor revenue growth rate declines • Roadmap costs and challenges increase • Consolidation of suppliers and semiconductor manufacturers continues • Evolving business models leading to further industry segmentation and diverging technology differentiation • Collaborations increasingly become accepted as necessary approach within many segments of the industry	• R&D costs will continue to escalate • Industry will consolidate further, leaving three to four leading edge technology platforms and increasing specialization of remaining industry participants • Leadership strategies extend beyond scaling • Coordination and further innovation of collaborative industry initiatives will need to be addressed

Industry structure: then



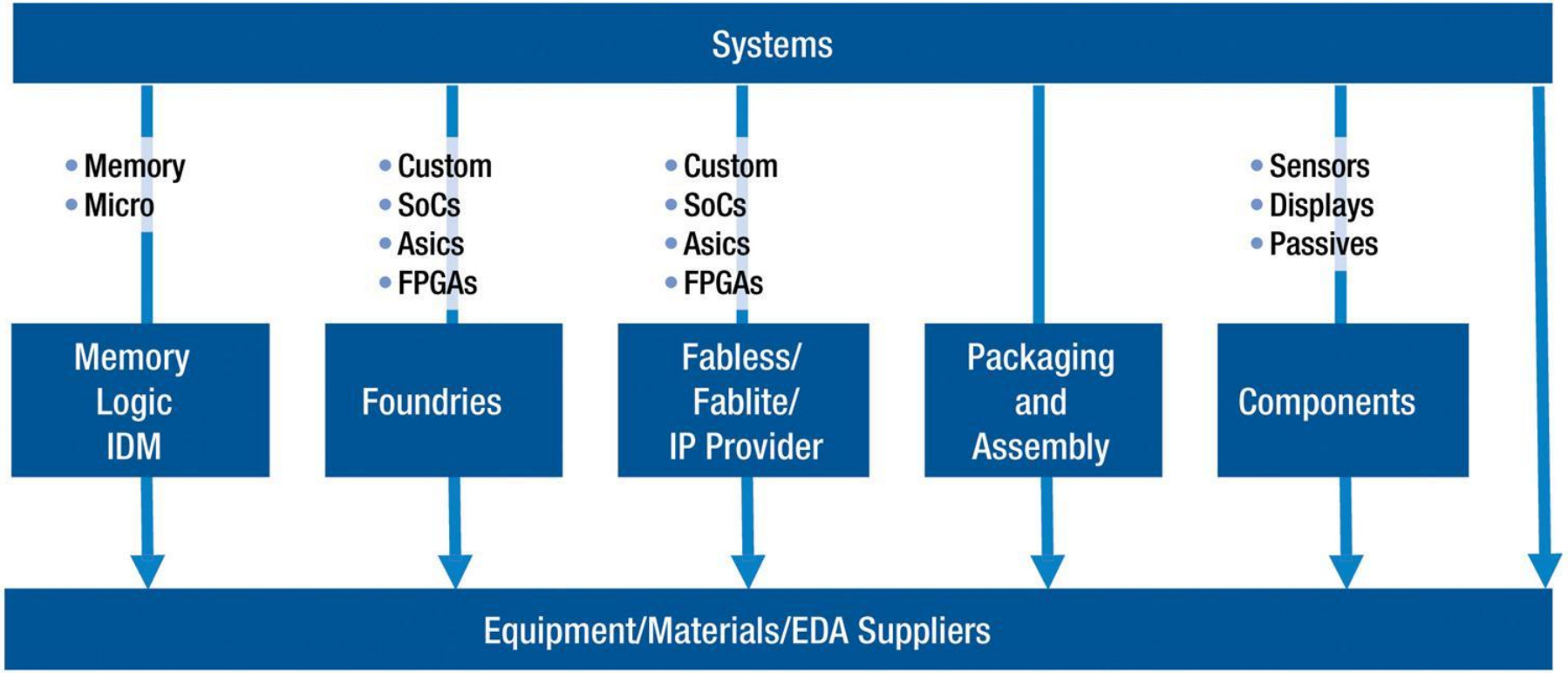
Idealized IDM

Industry structure: then and now



Idealized
IDM

Today's reality for systems companies



Industry challenges: key stakeholders

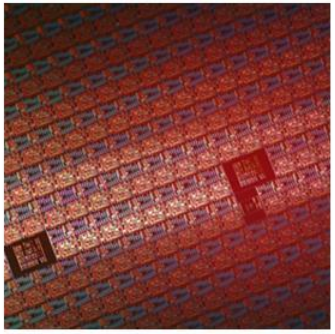
	Scaling	AMS, MEMs & Sensors	EUV	3D Interconnect	Factory Productivity	450 mm	ESH
Systems	■	■	■	■			■
Design Enablement	■	■	■	■			■
Fabless/Fablite	■	■	■	■			■
Equip/Materials Manufacturers	■	■	■	■	■	■	■
Integ. Device Manufacturers	■	■	■	■	■	■	■
Mature Fabs		■		■	■		■
Foundries	■	■	■	■	■	■	■
Packaging	■	■		■	■	■	■

■ Technology roadmap participant

Too many challenges to solve alone

- Success in semiconductors is driven by technology innovation and advances in manufacturing
- Success depends on comprehensive industry-wide collaboration
  - Challenges are global, and cut across industry ecosystem
  - Solutions require significant investment, leveraged funding

Manufacturing and technology challenges and new collaborative strategies



Major manufacturing technology transitions

Lithography

248 nm →	193 nm →	Immersion →	Double Pat →	EUV
IDM led	Consortia initiated and IDM led	IDM & supplier with consortium support	IDM led	Supplier leadership +EUV/EMI consortium across supply chain

Interconnect

Cu →	Low-k →	3D
IDM led	IDM led and collaboration across consortia	Collaborative innovation across entire supply chain

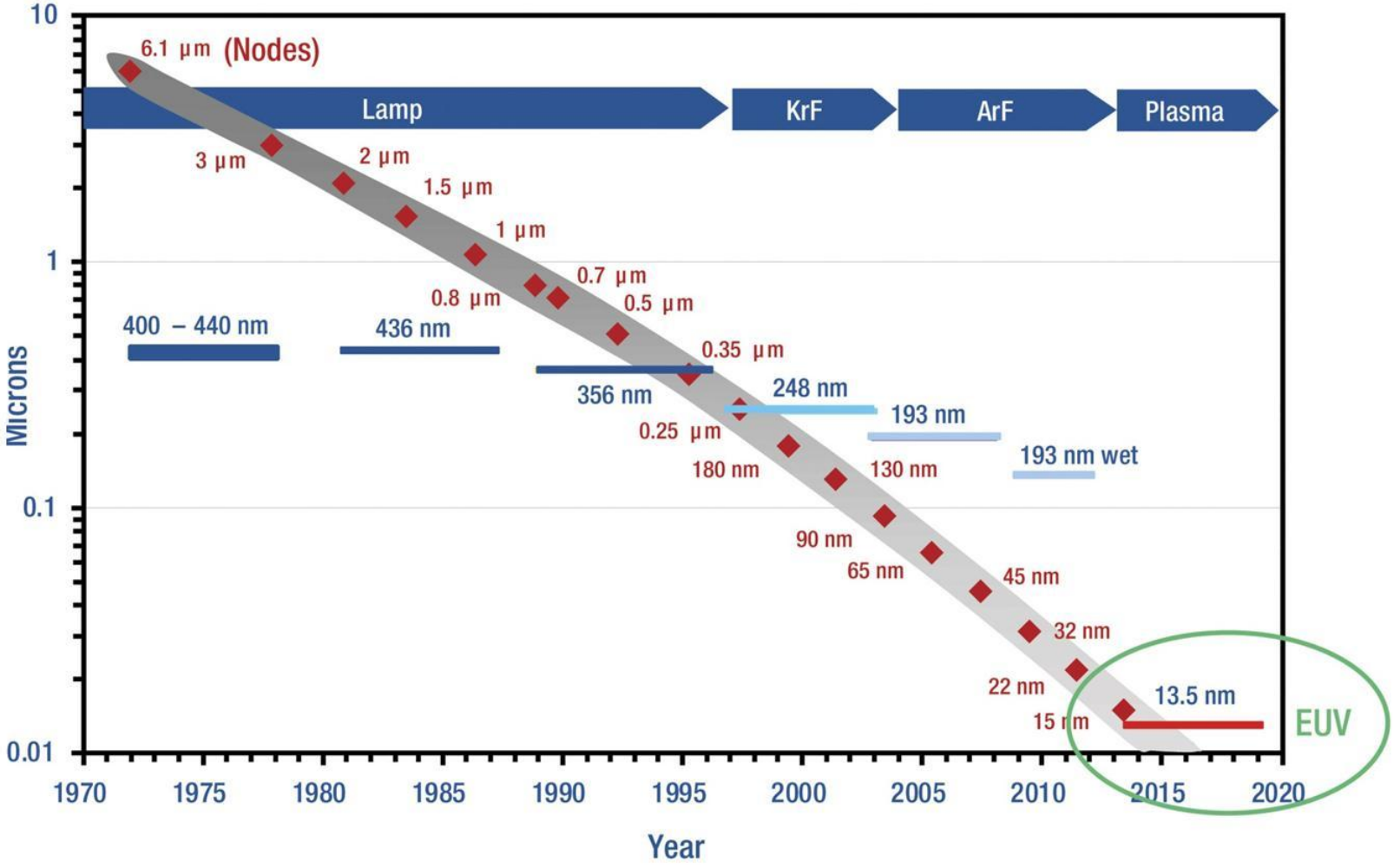
Wafer Size

200mm →	300mm →	450mm
One company	Consortium of chipmakers and collaboration with other consortia	Consortium of chipmakers and enhanced supplier role

Devices

SiON →	Strain →	High-k →	FinFETs or Ge/III-V channels or ETSOI or…
Consortia initiated and IDM led	IDM led	Collaboration across consortia (FEP Research Center) and IDM led	IDM led and collaborative innovation

Lithography scaling



EUV progress: critical enablers

First EUV tools installed in Albany & Belgium

EUV is real
BACUS, EUV Symposium

EUV Mask Consortium (EMI)

2003 2004 2005 2006 2007 2008 2009 2010

Defect -free mask

~ 100 500X defect reduction required for HVM

Source power

~ 50 W @ IF

> 100 W @ IF reliable source required

Resist resolution

Overcame 30 nm resolution brick wall

LWR needs 2 3X improvement for MPU (OK for Memory)

Reticle protection

Integrated reticle handling 0 defects

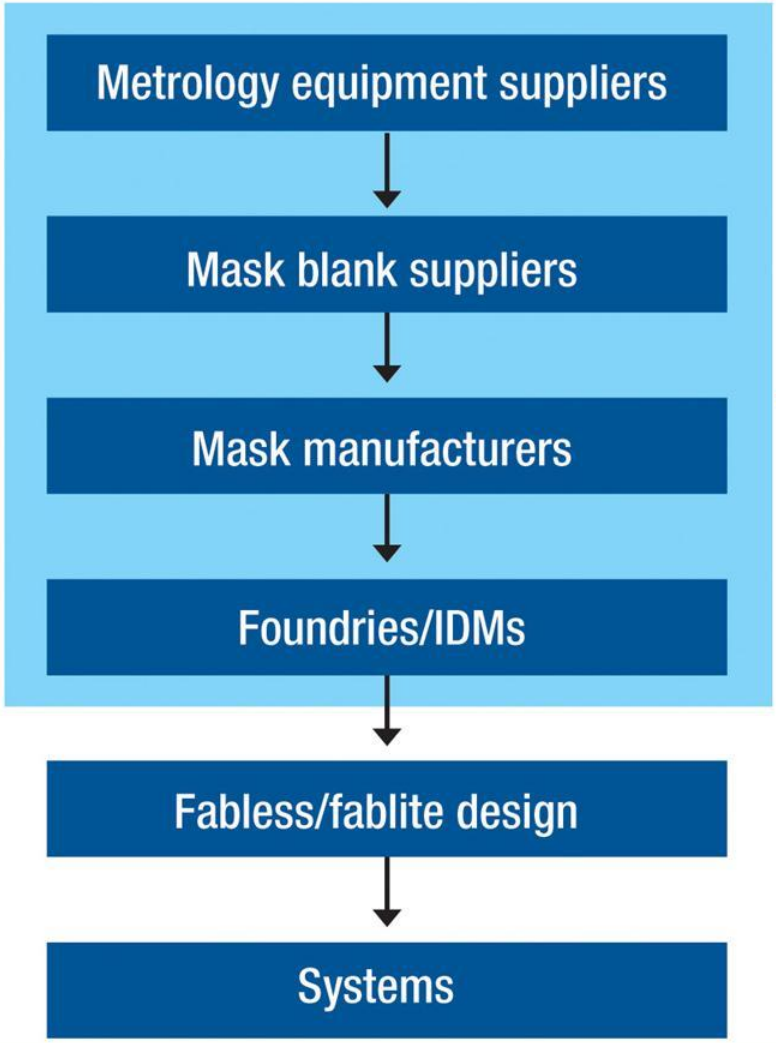
Commercial reticle handling solution available in 2010

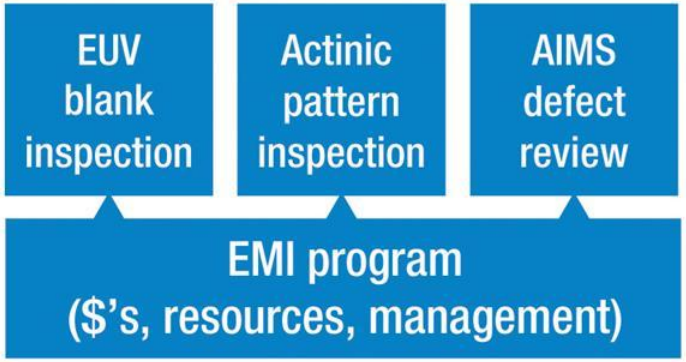
Optics quality

< 10% flare optics

PPT optics being assembled; 3300 optics in development

EUV Mask Infrastructure program

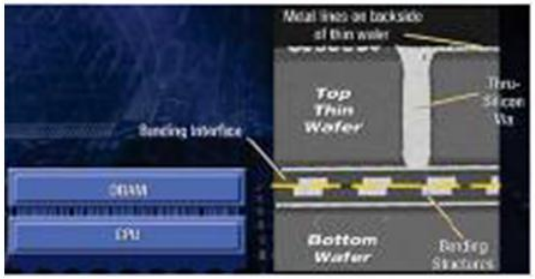




Connects multiple segments of the EUV supply chain in a partnership to collectively fund the development of needed metrology tools by equipment suppliers

3D interconnect: an industry game-changer

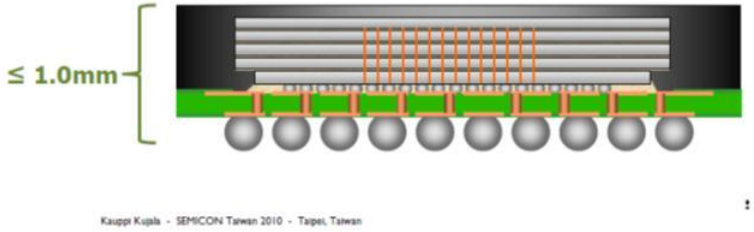
- Non-scaling alternative to improve system performance and cost
- Enables heterogeneous integration for emerging system-on-chip applications
- Diversity of approaches:
  - Via last technology requires wafer – wafer bonding
  - Via mid technology permits die – wafer bonding



Source: Intel

Driver: Performance, power
Technology: F2F Cu-Cu, Via last

Source: Qualcomm



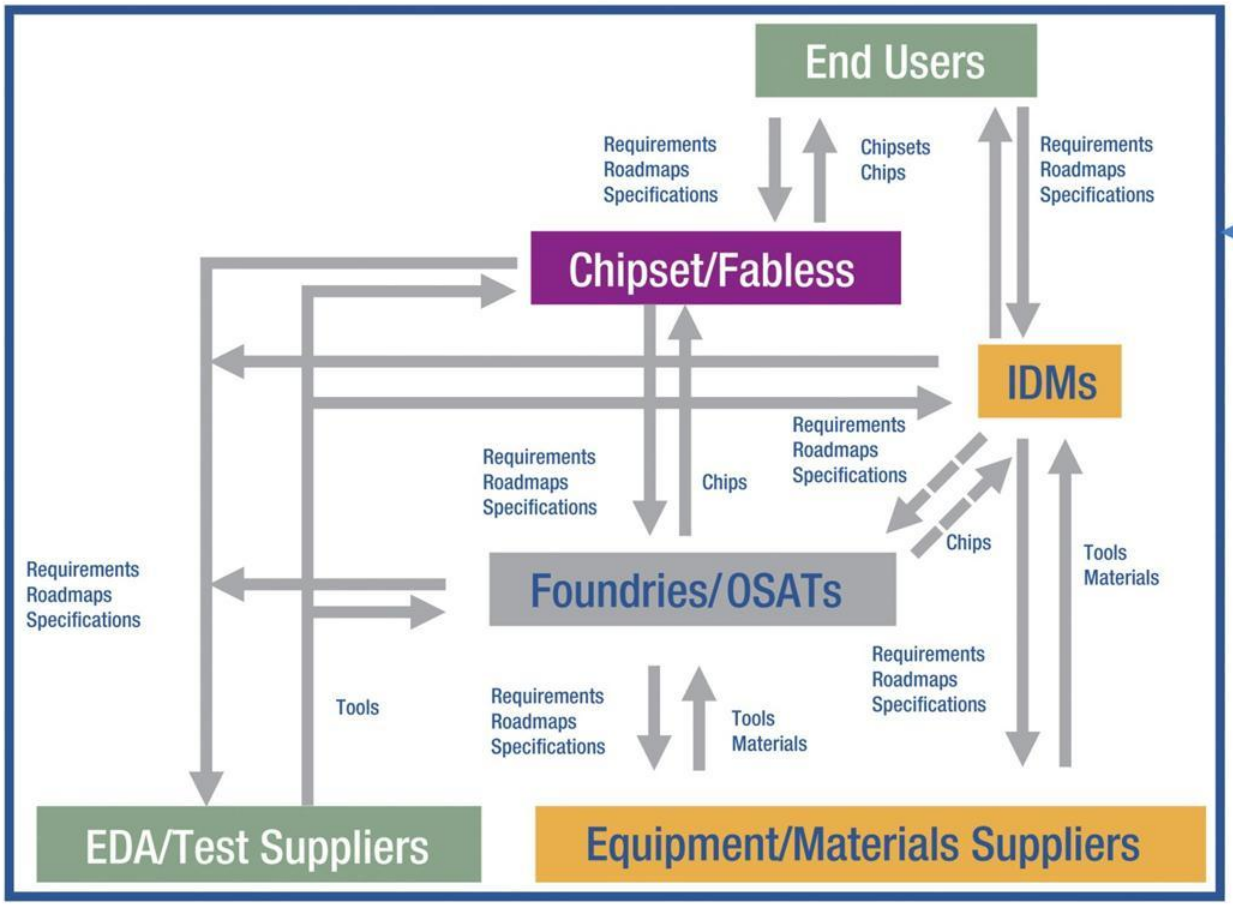
Source: Nokia

Driver: Power efficient performance, functionality
Technology: Via mid

Major industry challenges in 3D

- Immature tool infrastructure and materials
  - Numerous technology options and process flows
  - Several key tools have low productivity
  - Cost-effective solutions required for high-volume manufacturing
- Gaps in the supply chain
  - Partitioning of new processes within the supply chain
  - Standards to permit chips from multiple suppliers to work together
- Lack of convergence on infrastructure and standards delays industry success
  - Need common materials and equipment path to serve a broad industry base

3D supply chain alignment



Ecosystem needs

- Standards
- Infrastructure
- Robust tooling
- Inter-operability
- Cost models
- Supply chain co-ordination

SEMATECH workshops at 2010 SEMICON West and Taiwan

3D ecosystem development - 2010

- SEMATECH Workshops on Stress Management For 3D ICs
  - Three sessions in 2010
- SEMI/SEMATECH 3D Interconnect Challenges & Standards Workshop
  - July 13, 2010 (SEMICON West, San Francisco, CA)
- SEMATECH Workshop on 3D Interconnect Metrology
  - July 14, 2010 (SEMICON West, San Francisco, CA)
- SIA (Technical Steering Committee)
  - July 15, 2010 (San Jose, CA) kickoff
  - October 7, 2010 DARPA (Wash. DC) workshop
- 3D Executive Forum
  - September 8, 2010 (Taipei)
- Joint SEMI/SEMATECH IC Technology Forum
  - September 9, 2010 (SEMICON Taiwan, Taipei)

Ecosystem needs

Standards

Infrastructure

Robust tooling

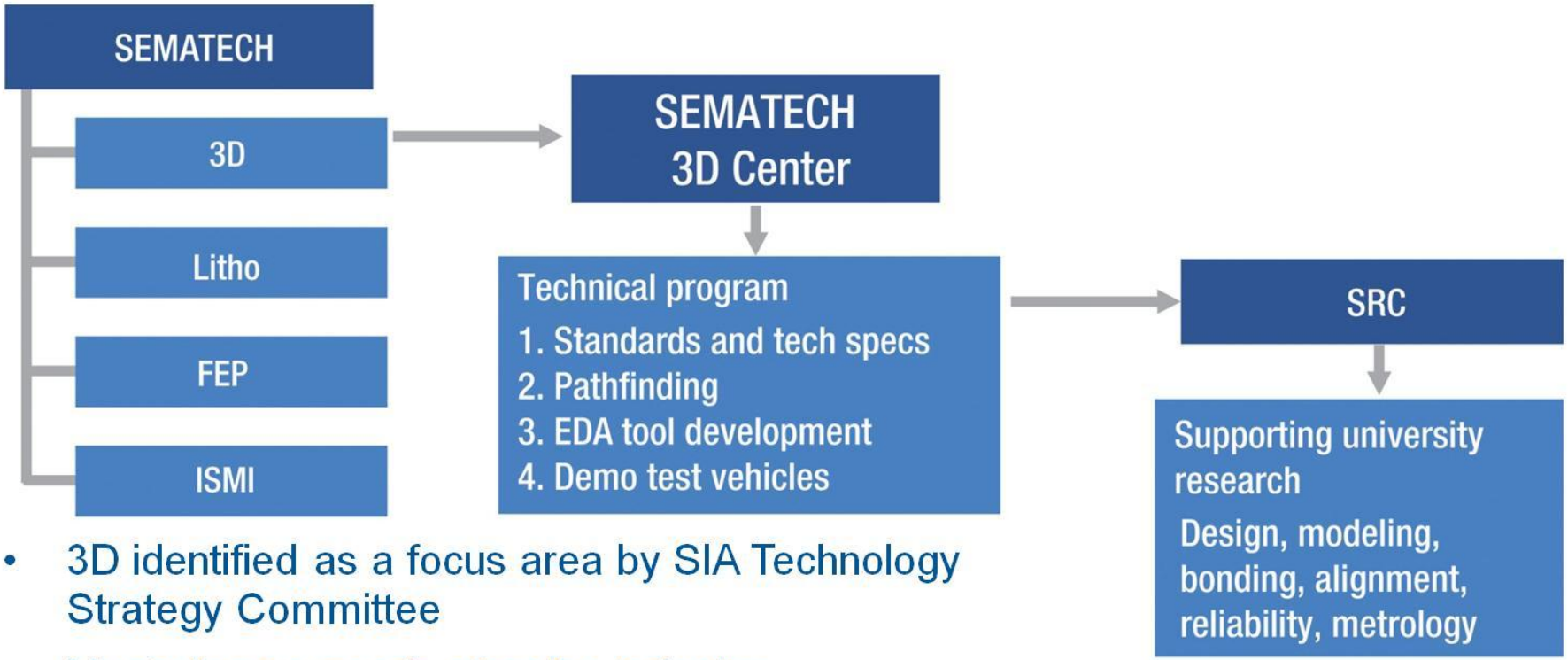
Inter-operability

Cost models

Supply chain co-ordination

- Heterogeneous stacking of wide IO DRAM on logic is a key application
- 3D is only way to support bandwidths >12.8 GB/s
- 2013 is benchmark year for volume production

3D enablement program: SIA-SEMATECH-SRC



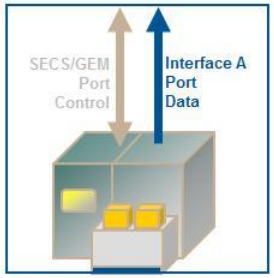
- 3D identified as a focus area by SIA Technology Strategy Committee
- Meet diverse needs of entire industry
  - High performance, mobile, analog, mixed signal, MEMS, fabless, fablite, IDMs
- Initial two-year program, 10-15 companies
- Program announced December 8, 2010

Improving manufacturing productivity through SEMATECH ISMI

- Addressing the manufacturing needs and requirements of both leading-edge and mature/mainstream fabs, through tailored opportunities for benchmarking and shared learning
- Developing new environment, safety, and health technologies for resource conservation and manufacturing sustainability
- Coordinating with the industry to drive early standards, guidelines, and infrastructure for a cost-effective transition to the next wafer size

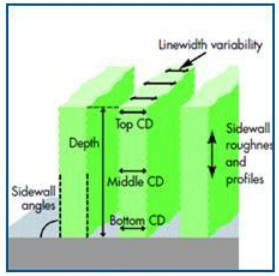

Councils and Forums


Mature Fabs

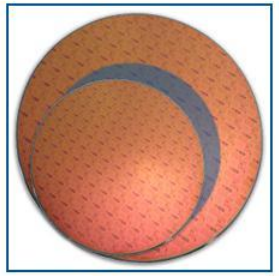


Manufacturing Capabilities

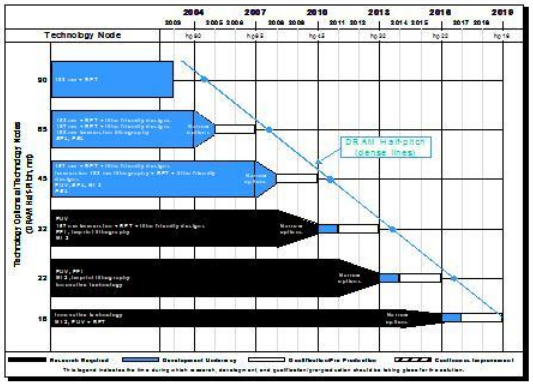

ESH Technology



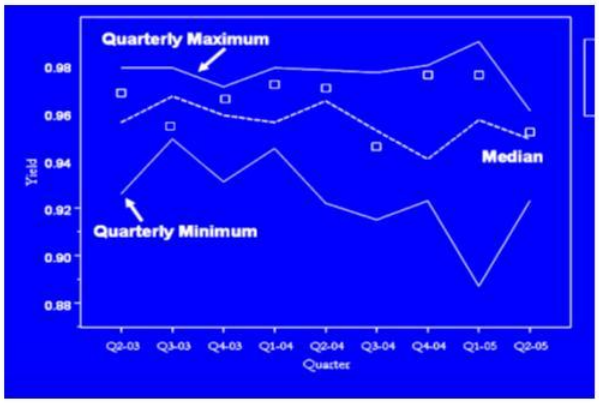
Metrology Technology


450mm Transition

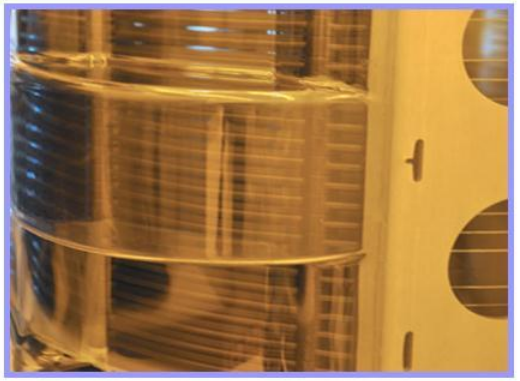
Core competencies



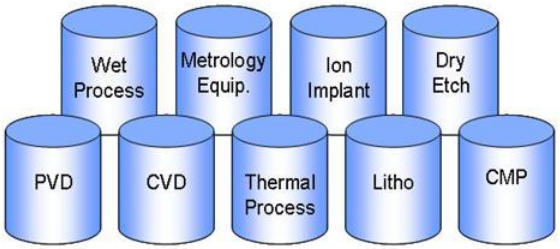
Roadmaps



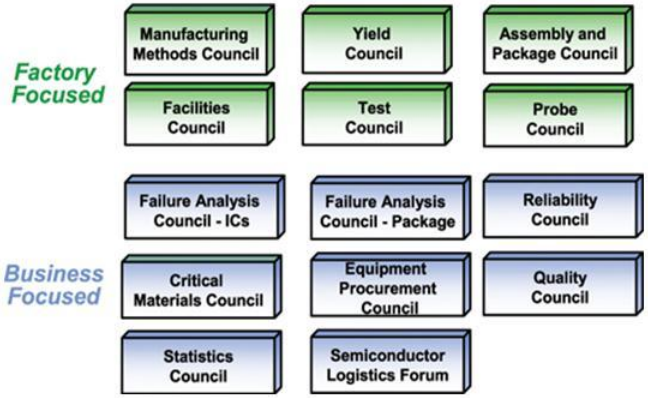
Benchmarking



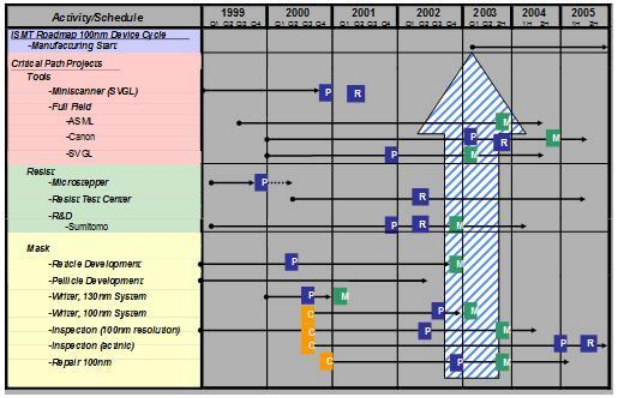
Standards



Equipment Productivity Forums



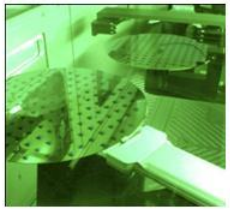
Manager Forums/Councils



Project Management

NanoHealth and Safety Center (NSC)

- New Center announced
- Formation of the New York NanoHealth and Safety Center (NSC)
  - Announced February 15th by SEMATECH & CNSE
  - A significant development offering broader industry engagement
  - Funding of at least $10 million over the next five years



COLLEGE OF NANOSCALE SCIENCE & ENGINEERING
UNIVERSITY AT ALBANY

ISMI

SEMATECH

For Release: Immediate – Tuesday, February 15, 2011

Contact: Steve Janack, Vice President for Marketing and Communications, CNSE
(phone) 518-956-7322 (cell) 518-312-5009 (e-mail)
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Erica McGill, Media Relations Manager, SEMATECH
(phone) 518-649-1041 (cell) 518-487-8256 (e-mail)
erica.mcgill@sematech.org

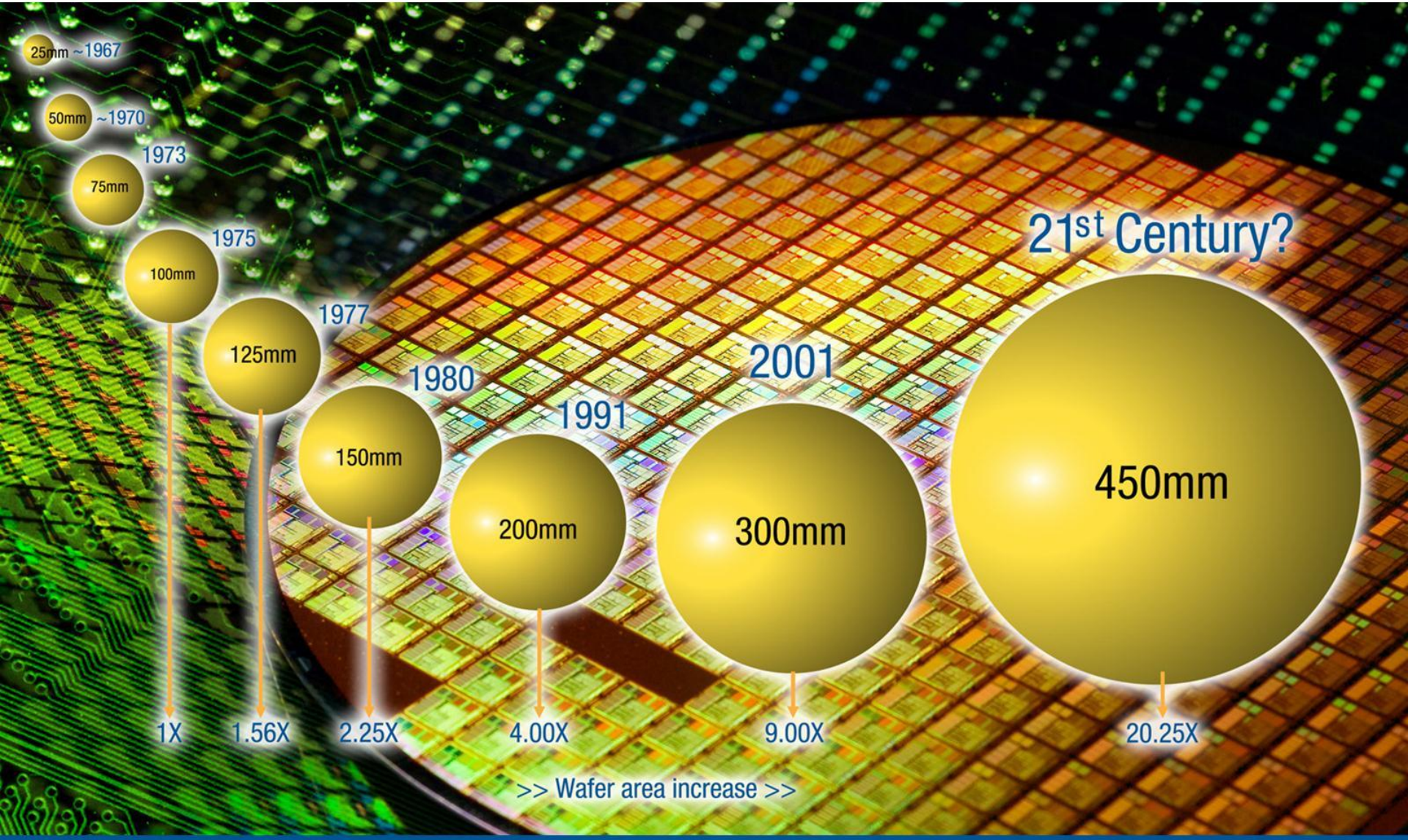
SEMATECH, ISMI AND UALBANY NANOCOLLEGE PARTNER TO LAUNCH GROUNDBREAKING NANOHEALTH AND SAFETY CENTER

Pioneering global consortium will proactively explore occupational and environmental health and safety for nanoelectronics research and manufacturing

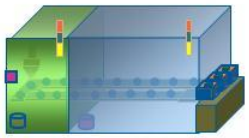
Albany, NY – Demonstrating an unparalleled commitment to the development and implementation of innovative protocols and procedures to conserve resources and safeguard occupational and environmental health and safety (EHS) in the nanoelectronics industry, SEMATECH, a global consortium of chipmakers, its subsidiary, the International SEMATECH Manufacturing Initiative, Inc. (ISMI), and the College of Nanoscale Science and Engineering (CNSE) of the University at Albany today announced the creation of the world's first NanoHealth and Safety Center (NSC), headquartered at CNSE's Albany NanoTech Complex.

As the first and only comprehensive partnership of its kind in the world, the NSC will align both ongoing and new programs and initiatives of SEMATECH, ISMI and CNSE, along with a host of global corporate partners, to form the world's leading nanotechnology health and safety research and development enterprise. With funding of at least $10 million over the next five years, this international center is expected to catalyze the creation of more than 100 high-tech EHS jobs at the

Progress in silicon wafer substrates



450mm: coordinating industry convergence



Equipment readiness

2007

Early design

Requirements Guidelines

Early prototypes

Interoperability Test Bed (ITB)

Equipment Demonstrations

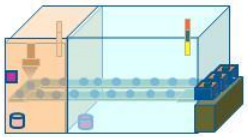
INTERNATIONAL SEMATECH ISMI MANUFACTURING INITIATIVE

2010+

Mechanical Wafer Bank

2008

Technology intercept node defined



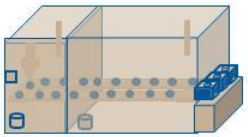
Equipment prototypes

Test plans

Test Wafer Generation

Single Crystal Wafer Bank

25 wafer FOUP



Metrology & process equipment development

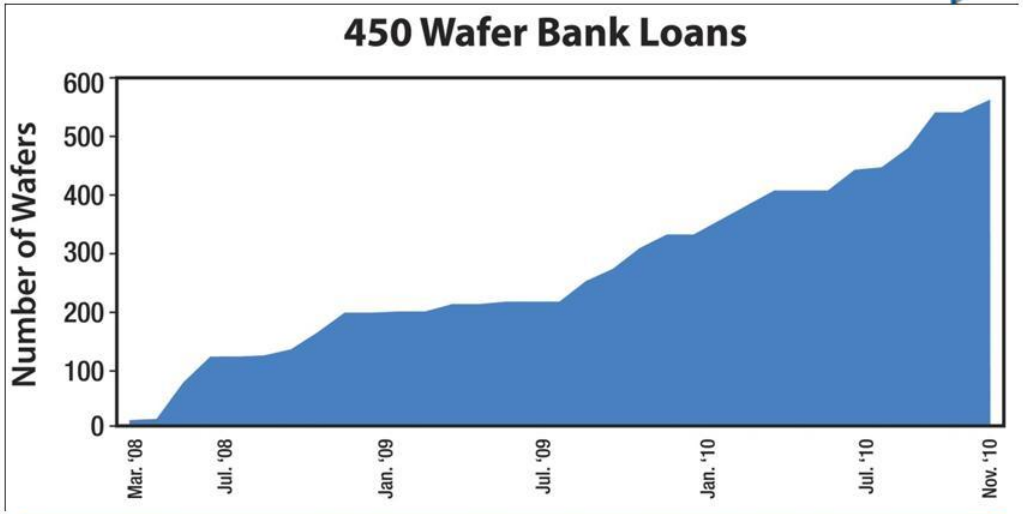
Equipment Performance Metrics (EPMs)

2009

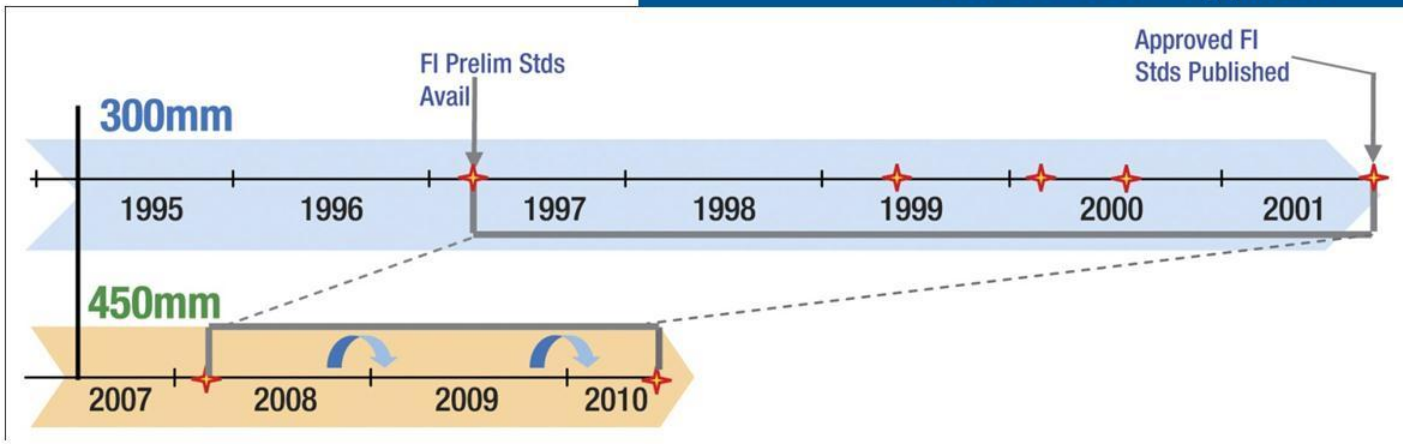
Carrier & loadport interoperability

450mm progress

- Interoperability Test Bed established
- 450mm wafer bank established (300 wafers)
- 450mm equipment developed
- Guidelines, metrics and test plans defined
- 450mm standards completed through SEMI



ISMI's wafer bank has loaned >550 wafers – at no cost to suppliers



ISMI's Test Bed helps enable a 60% reduction in time to standards versus 300mm

ISMI 450mm program expansion

Oct. 2010: $20M from New York accelerates ISMI's 450mm program

- Increase supply of 450mm silicon
- Broaden equipment base to generate additional 450mm test wafers
- Factory infrastructure to support increased operational scope

2011: Opportunity to align industry timetable and increase scale

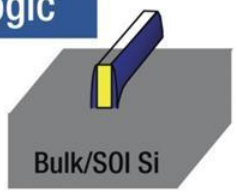
Logic and memory roadmap

Focused on materials and nanostructures

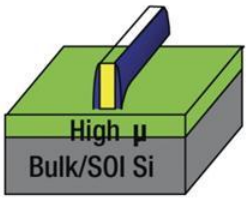
SEMATECH

Advanced materials | **Advanced structures** | **Beyond CMOS materials/structures**

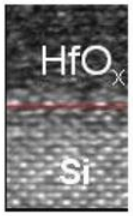
Logic

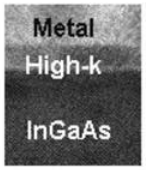


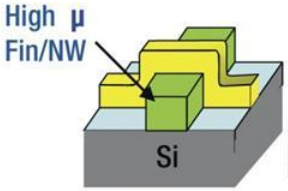
Gate stack



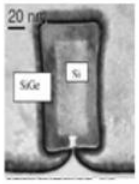
Channels, contacts, USJ

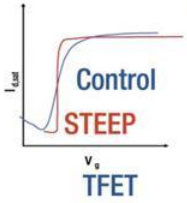






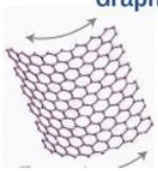
High mobility Fins/Nanowires





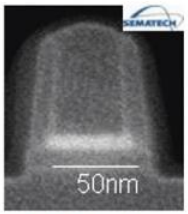
NEMS

Graphene

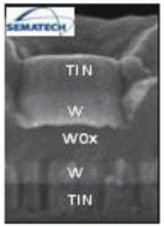


2010 → 2020

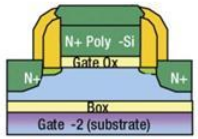
Memory



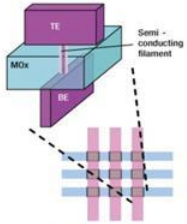
CT Flash



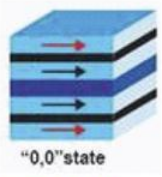
ReRAM



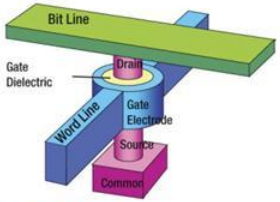
1T DRAM



<20 nm ReRAM

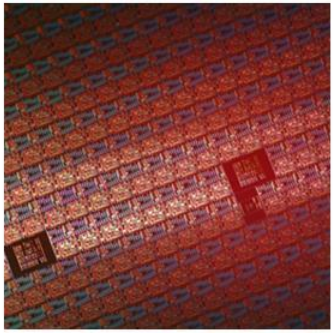


STTRAM

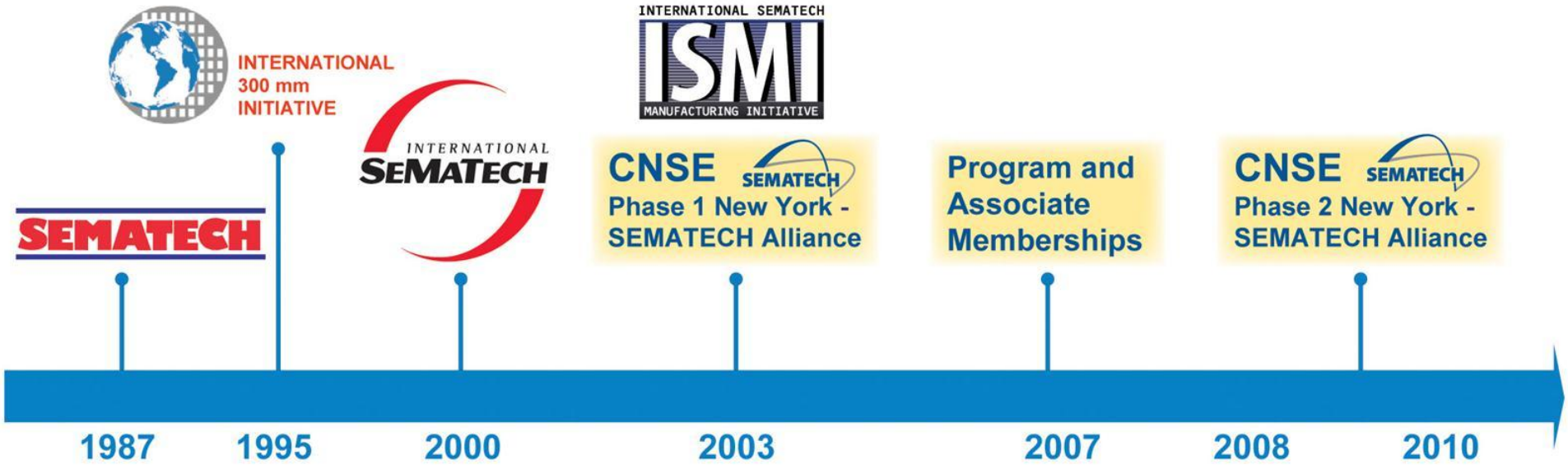


ReRAM/Nanowire 3DArray

About SEMATECH

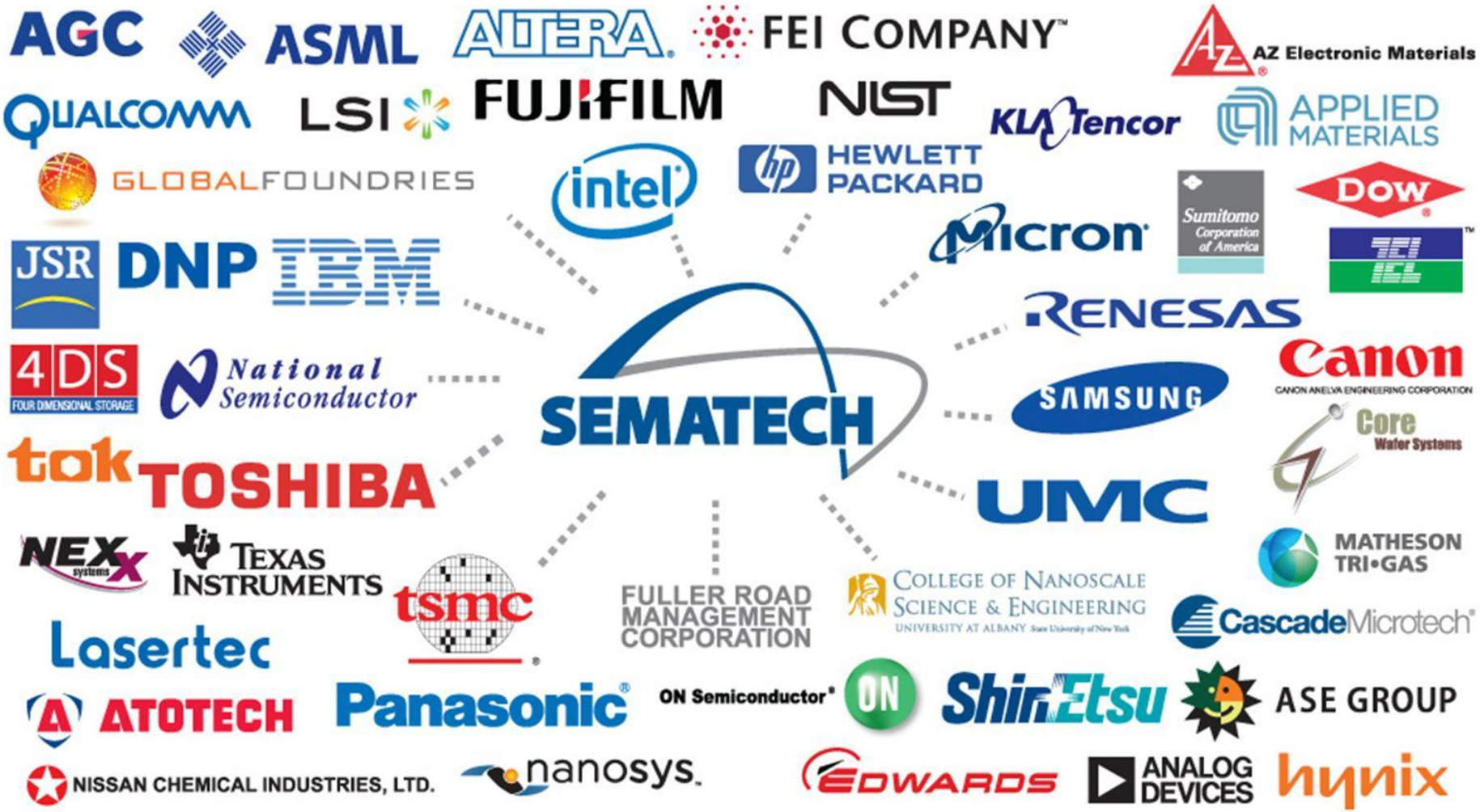


SEMATECH: a dynamic industry consortium



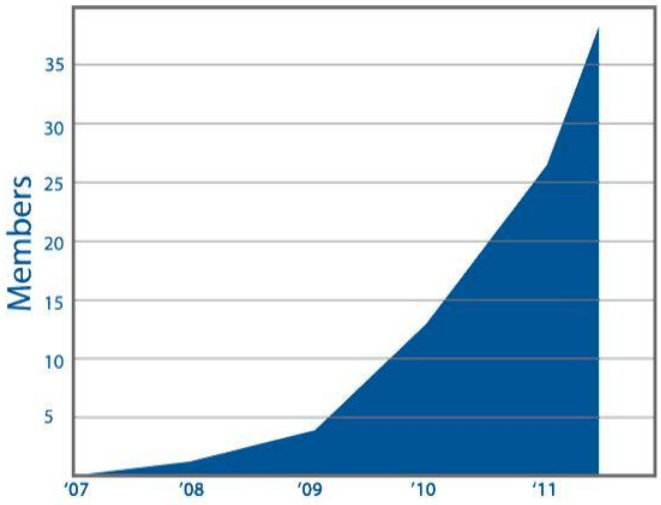
- Helped recapture US lead in semiconductor manufacturing
- Successfully managed $870M in federal funding, ramping up membership, transitioning to self-sufficiency
- Led industry-wide initiatives to enable industry transitions (next-generation patterning, next wafer size, novel materials and device structures)
- Catalyst for technology commercialization and economic development

SEMATECH members



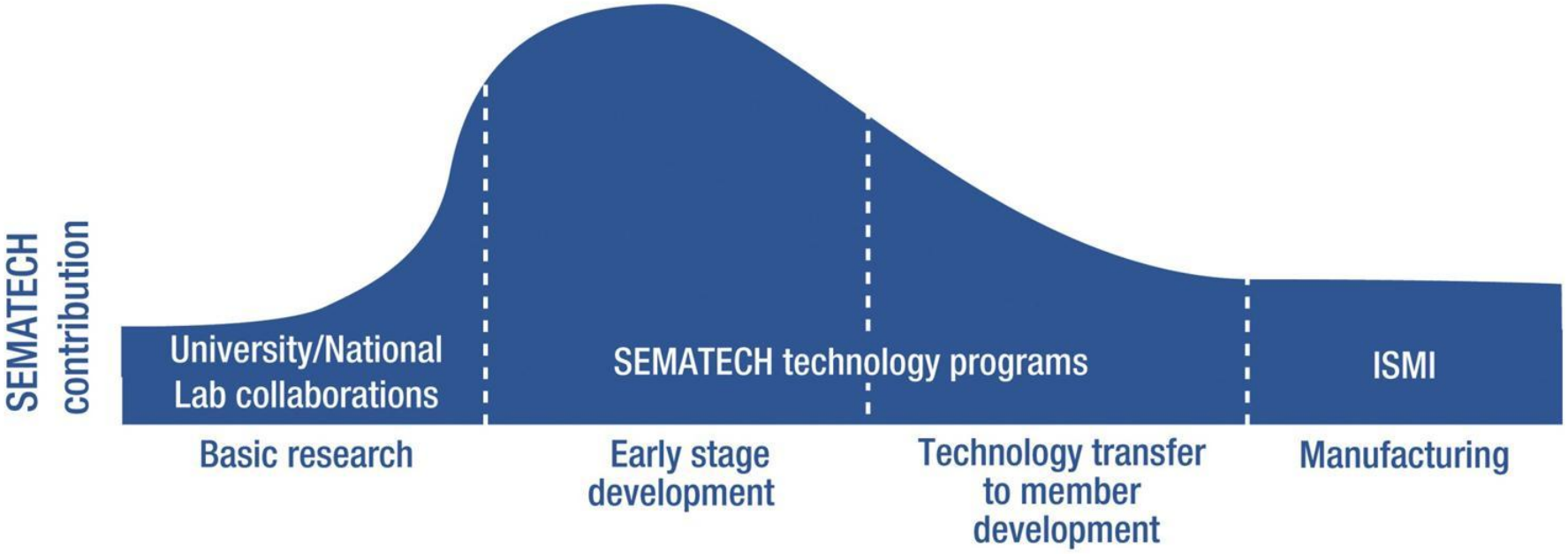
Program membership growth

2007	2008	2009	2010	2011 (ytd)
TEL – 3D	Accretech – 3D	NEXX – 3D	TEL - Litho	Qualcomm – 3D
1	Asahi Glass -Litho	Atotech – 3D	DOW – Litho resist	Altera – 3D
	Rudolph - Met	Rudolph – 3D	AMAT - ESH	On – 3D
	4	TEL – FEP	ASML - Litho	LSI – 3D
		Metrosol – FEP	JSR – Litho resist	Hynix – 3D
		Canon Anelva - FEP	AZ Elec. – Litho resist	Fujifilm – Litho Resist
		TOK – Litho resist	Qualcomm	ADI – 3D
		Shin Etsu – Litho resist	Edwards - ESH	ASE – 3D
		FEI - Met	Lasertec – 3D	4DS – FEP
		Core Wafer - FEP	DNP - Litho	Matheson – ESH
		SUSS - FEP	Panasonic - Mature	NIST – 3D
		13	Nanosys - FEP	KLA-Tencor – Litho
			Sumitomo - Litho Resist	38
			Nissan Chemical - Litho Resist	
			26	



Bridging research, development, and manufacturing

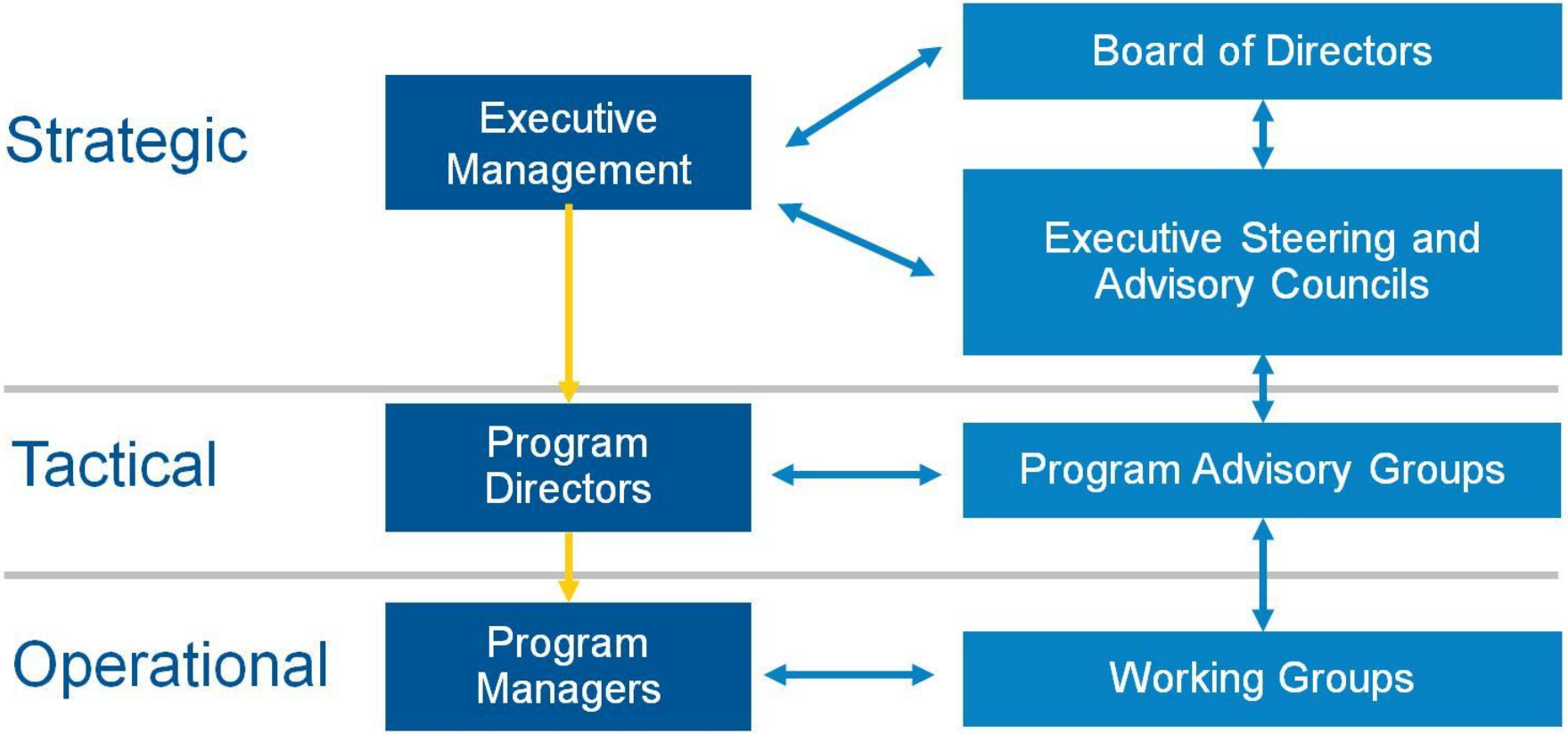
- A membership driven global consortium
- Driving technical consensus for the industry
- Pulling research into the industry mainstream
- Leading major programs to address critical industry transitions
- Focus on manufacturability



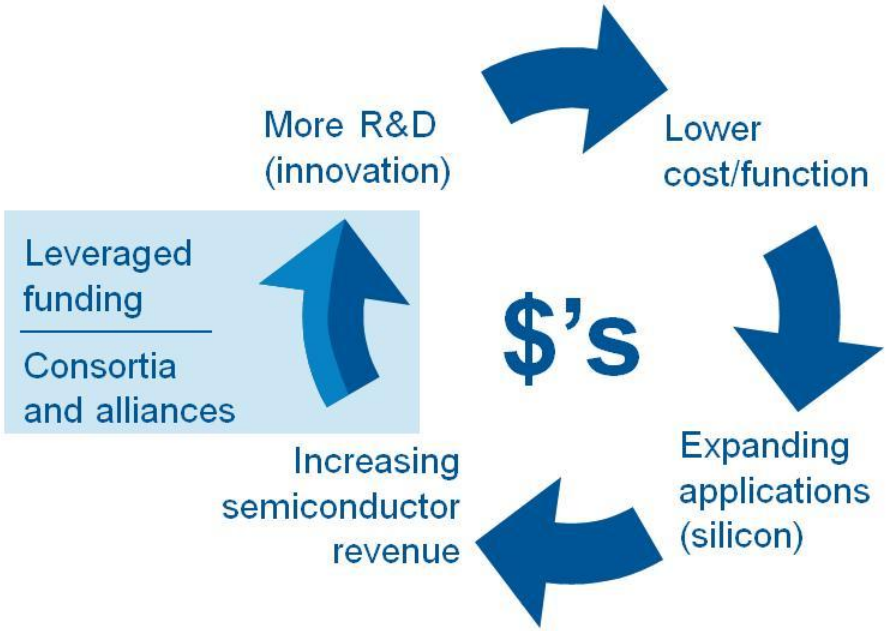
Industry/university/government collaboration in Albany

What collaboration is really all about

- Assignees make up ~35% of the technical workforce
- Members are involved at all levels of decision-making



Bringing the industry together

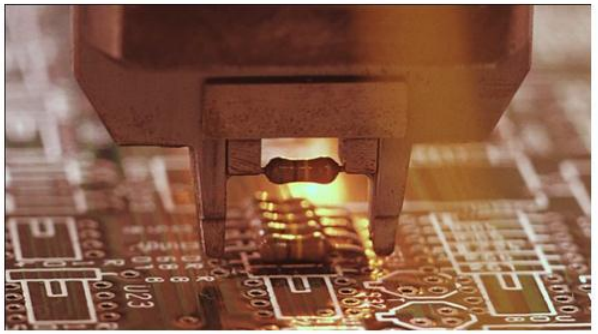


- Economics remain the driving force for change in the semiconductor industry
- We must improve our collaboration to sustain technology momentum
- Consortia will continue to innovate globally and lead major transitions
- New sources of leveraged funding will be needed to successfully introduce new technologies

Accelerating the next technology revolution

Research

Development



Manufacturing

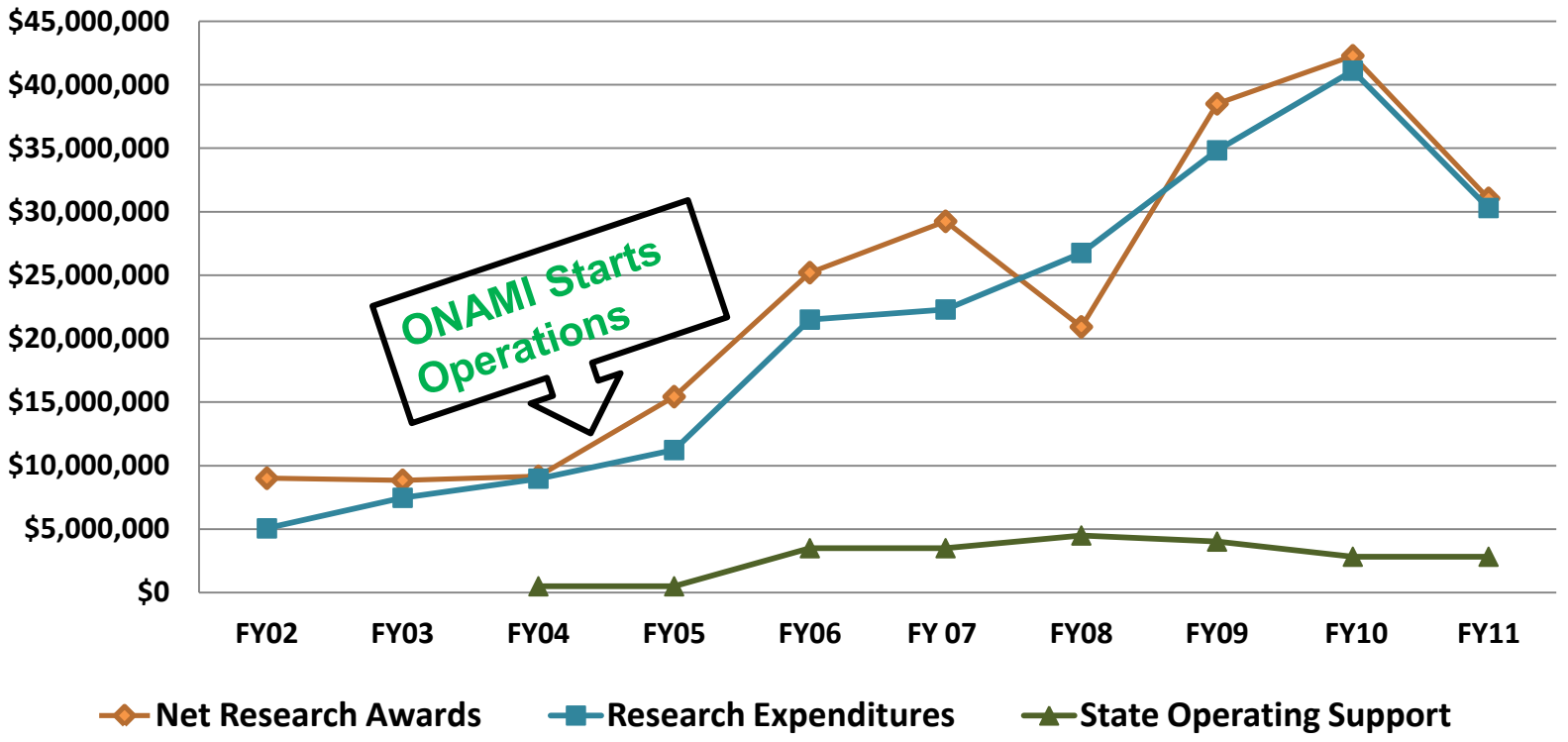
ONAMI CHALLENGES
and
SUCCESSES

Robert D. “Skip” Rung
President and Executive Director

ONAMI's Mission and Metrics

- Grow Materials Science and Device R&D *(award/contracts $$, growth rate)*
- Provide High-Tech Facility Access to Business *(# clients, $$ billed)*
- Enable Oregon tech startups to raise capital *($$ private capital, $$ leveraged grants)*

ONAMI Research Award History



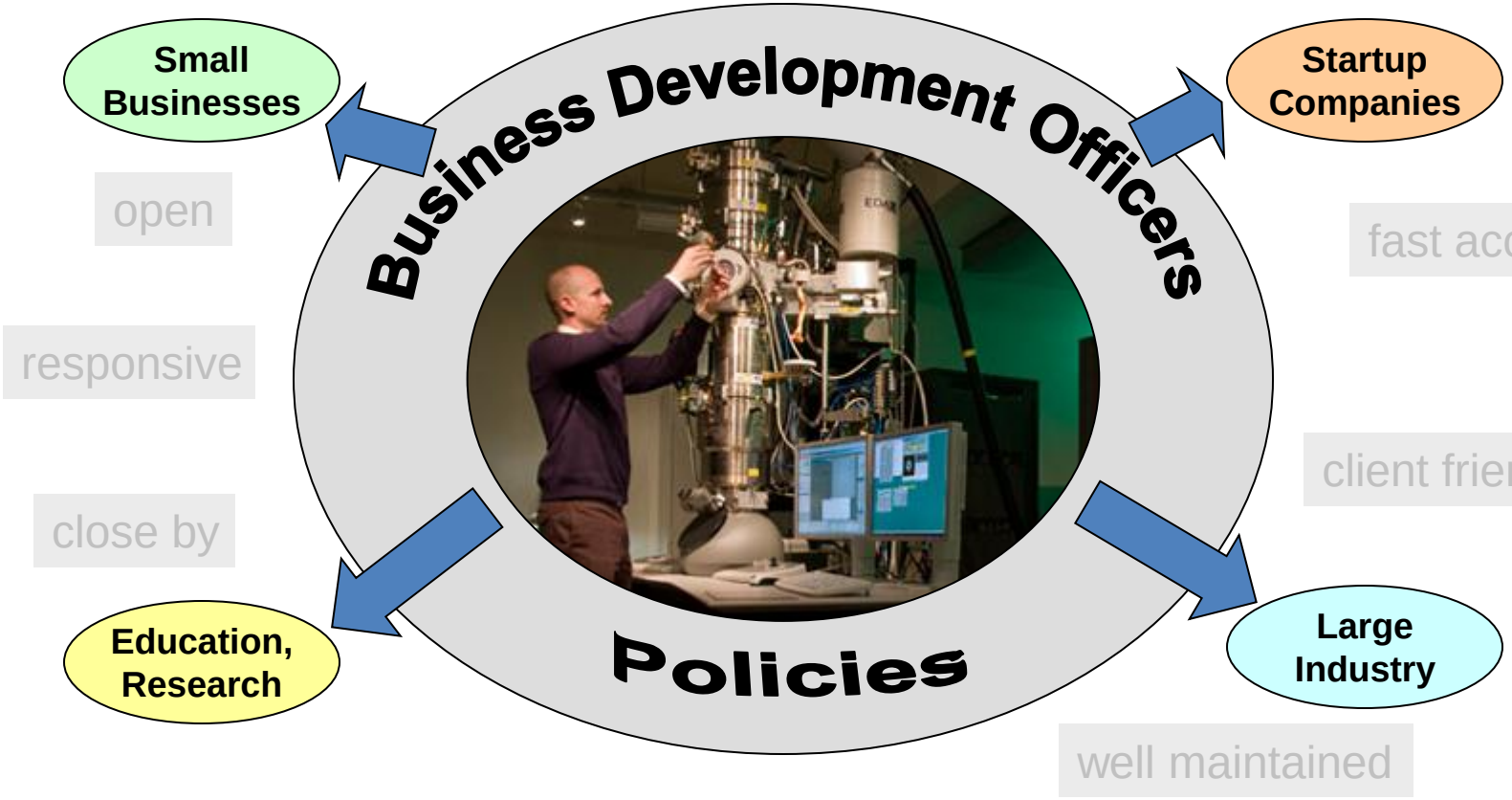
Latest Highlights:

$21.5M NSF Center for Sustainable Materials Chemistry (Keszler/Johnson)

$2.0M DoE B-N liquid H2 storage material (Liu, UO)

$1.9M NIH Nanomaterial's biological effects (Harper, OSU)

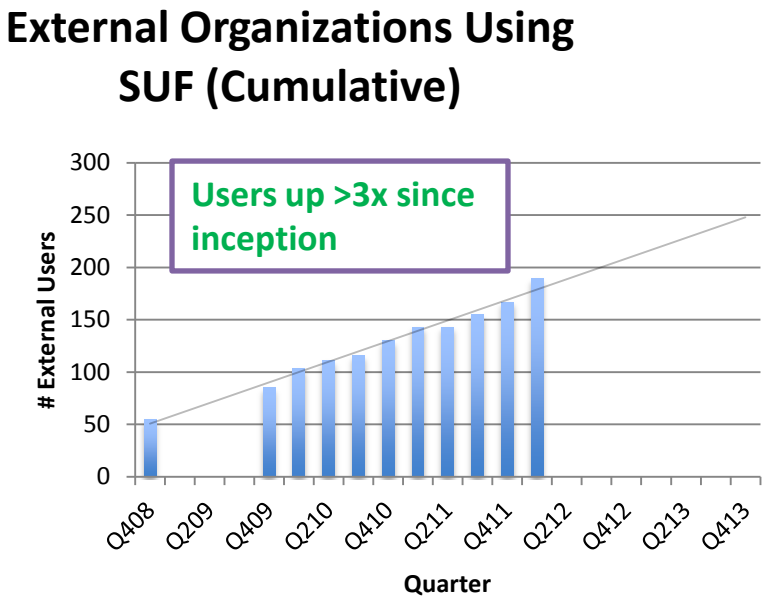
Research enterprise 3-4X larger than when we started

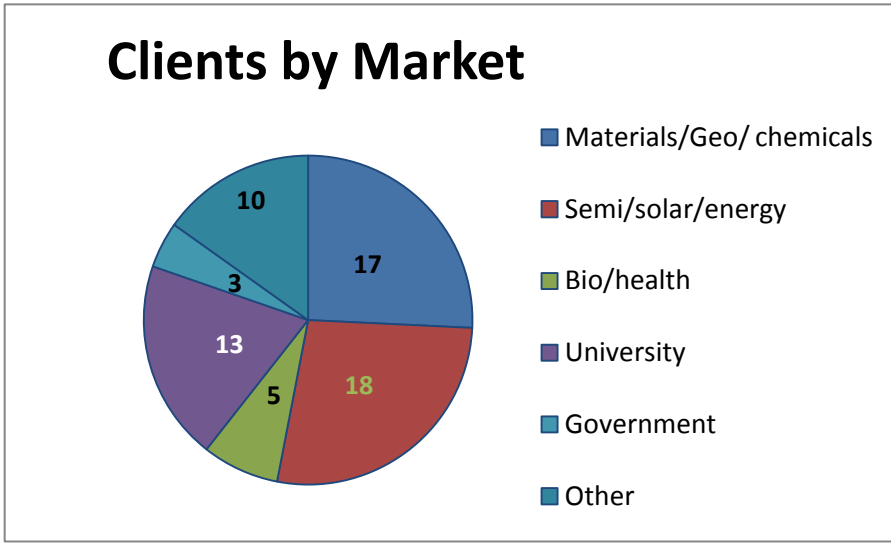


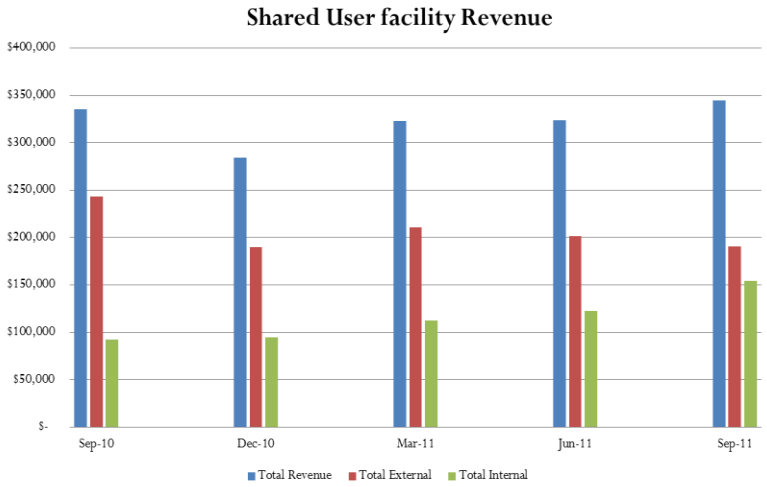
The "High Tech Extension" Concept

Nanoscience facilities and equipment can best benefit technology development when they are conveniently located and easy to use by businesses. Such access is especially important to the small and medium enterprises (SMEs) that are critical for early stage commercialization. State and regional economic development field staff can serve as "high tech extension" agents.

ONAMI High Tech Extension







1Q2012

189 external clients - cumulative

76 external users - 49 Oregon

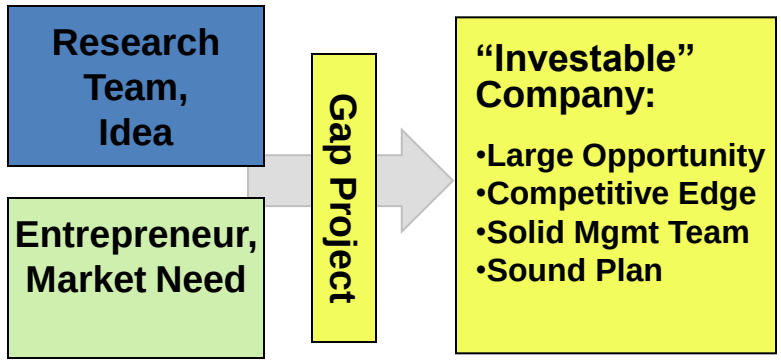
9 new clients reported

First-time user grants:

Vitriflex, AISThesis, Oral Biotech, Trimble, Inspired Light, Triquint, Microchip

The ONAMI Commercialization Gap Fund Concept

Technology Stage	Company Stage	Funding Source
Research Result	(NA)	NNI Grants
Proven Prototype	***Formation***	***Gap Grants (state + federal)***
Products, Sales	Development	Early Stage Investors
Product Line Expansion	Growth	Various (private)



Federal/state partnerships in "gap" (aka "valley of death") funding for new ventures commercializing NNI technology could accelerate commercialization by 2-4 years and also ensure proper focus on economic returns and job creation.

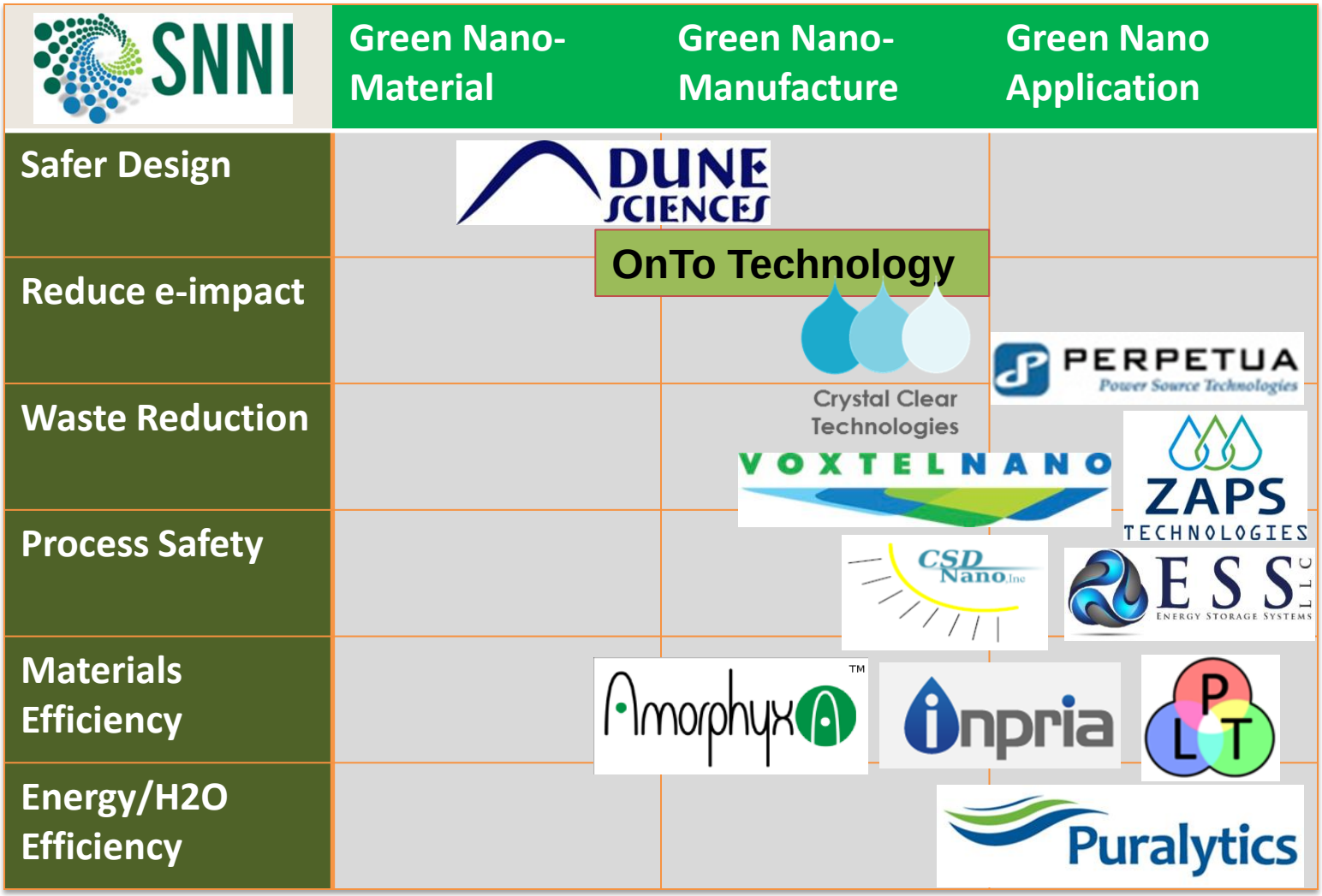
The ONAMI Gap Fund Portfolio, February 2012

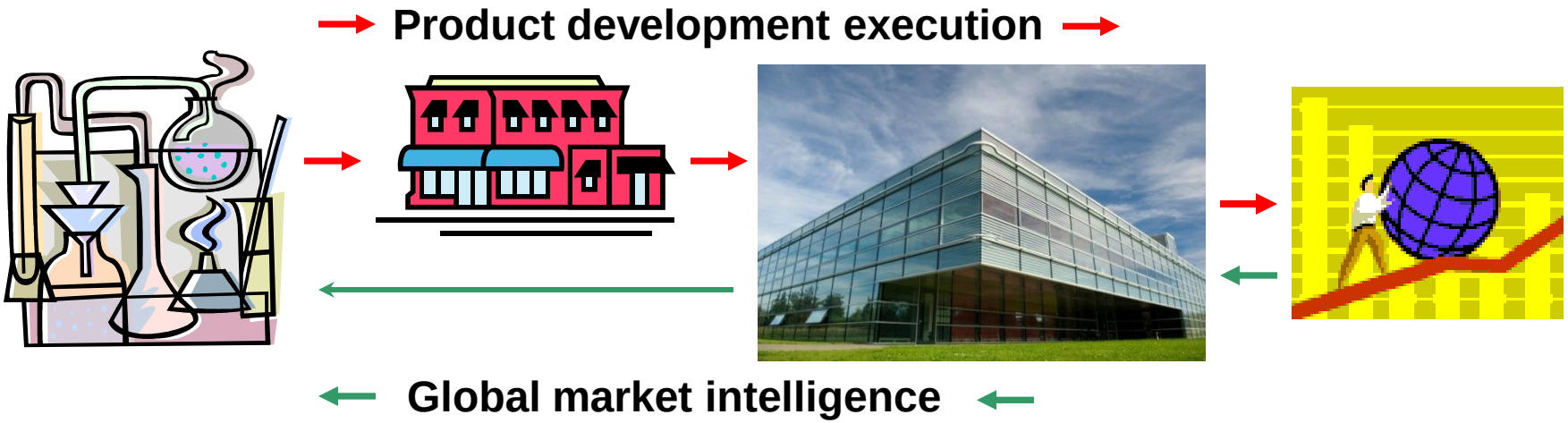
http://www.onami.us/Commercialization/currentProjects.php

Thrust Area and Project Host Campus	**MECS** (microtech-based energy and chemical systems)	**Green Nano** (materials and processes)	**Solid State** (batteries, printed electronics, green electronic materials)	**Nanoscale Metrology**	**Nano Bio-Tech**
OSU	Home Dialysis Plus ABP Mtek Energy Trillium Fiberfuels Apex Drive Labs NWUAV Mtek desal Applied Exergy	Inpria Nanobits CNXL Voxtel Nano CSD Nano Microflow CVO *Amorphyx*	Peregrine/Promat OnTo Technology Energy Storage Solutions Inspired Light	ZAPS Technologies	Northwest Medical Isotopes
PSU/OHSU	*Energy Storage Systems*	Puralytics	Pacific Light Technologies	Flash Sensor	DesignMedix PDX Pharma
UO		Crystal Clear Technologies Dune Sciences	Perpetua Power	NemaMetrics	Floragenex *Quintessence* *Cascade Pro.*

$103M leverage to date, more pending

A Green Nano Startup Portfolio





Organizational roles/needs in technology commercialization:

Research Institutions: scientific discovery, fundamental invention, talent development, shared user facilities. **Need:** public and philanthropic funding, enabling regulatory/legal environment

Startup companies: pioneering technology and market development of small - but disruptive – first opportunities. **Need:** equity/royalty licenses, large company customers/partners, high-risk (early stage) capital, minimal regulatory/legal burdens

Large companies: Manufacturing scale-up and global business development. **Need:** large & profitable “mainstream” markets, low-risk technology options

The Oklahoma Nanotechnology Initiative

Jim D. Mason, CCE, CEcD, EDFP
Executive Director
Oklahoma Nanotechnology Initiative
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405-664-0273
www.oknano.com

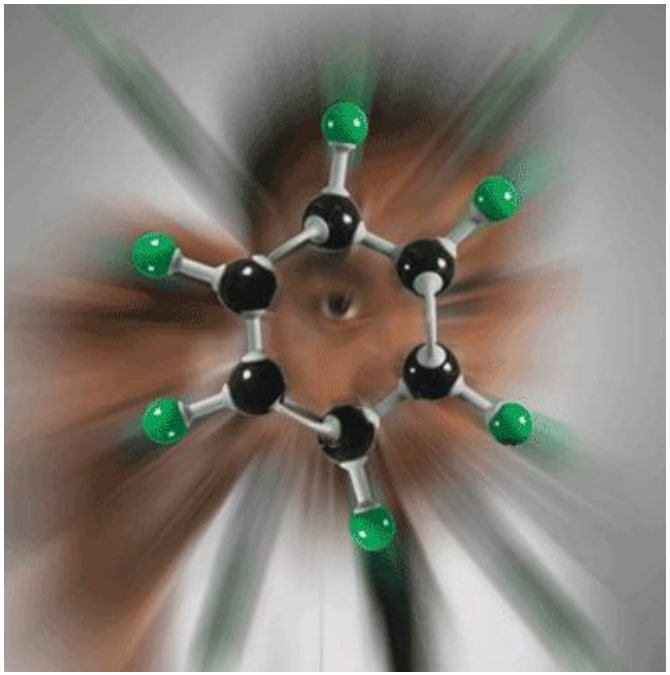
OCAST

Technology Initiatives, LLC

ONI timeline

- 2000-EPSCOR Grant provided nano equipment, researchers, fellowships
- 2003 – Oklahoman Nano Initiative created
- 2004- ONI funded by state legislature $125 k for each of two years
- 2005 – Hired Exec. Director
- 2006 – Gov. signed Oklahoma Nanotechnology Sharing Incentive Act providing $2 M per year for ONI & ONAP

ONI VISION



- **“Oklahoma companies are world leaders in creating new and improved products through applications of Nanotechnology.”**

- Since 2006 we have Oklahoma has seen an increase from **six** companies involved in nanotechnology to 70 Oklahoma companies today!

- In 2010 ONAP-funded projects raised $10 for every $1 of state funding.
- In 2011, ONAP-funded projects raised $18 for every $1 of state funding.
- More than 250 new jobs have been created by ONAP funded companies.
- Each of our 29 funded ONAP projects has resulted in a new or improved commercial product going to market!

Oklahoma Nano Companies