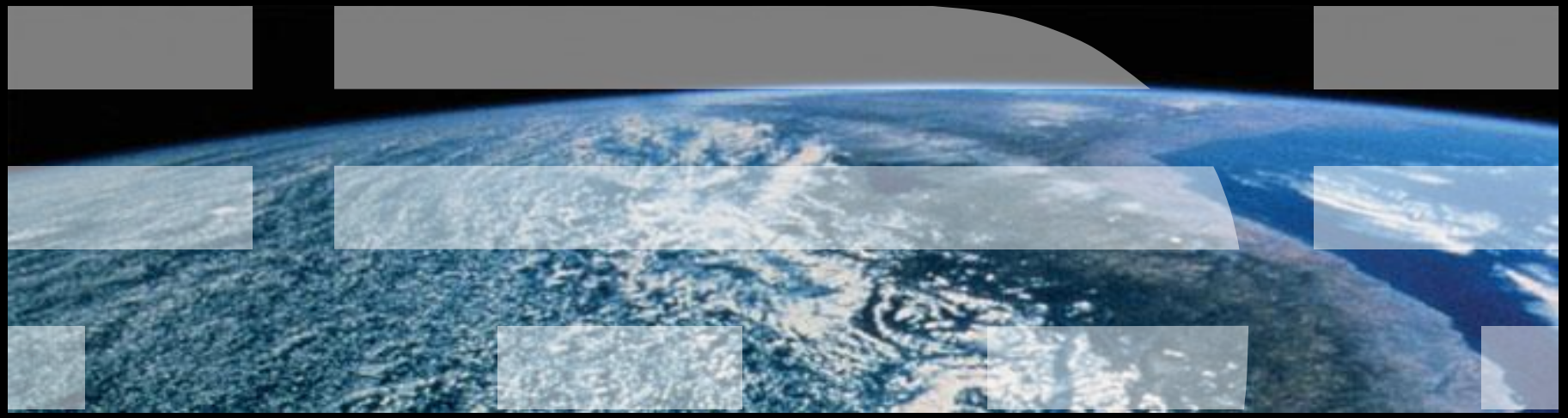


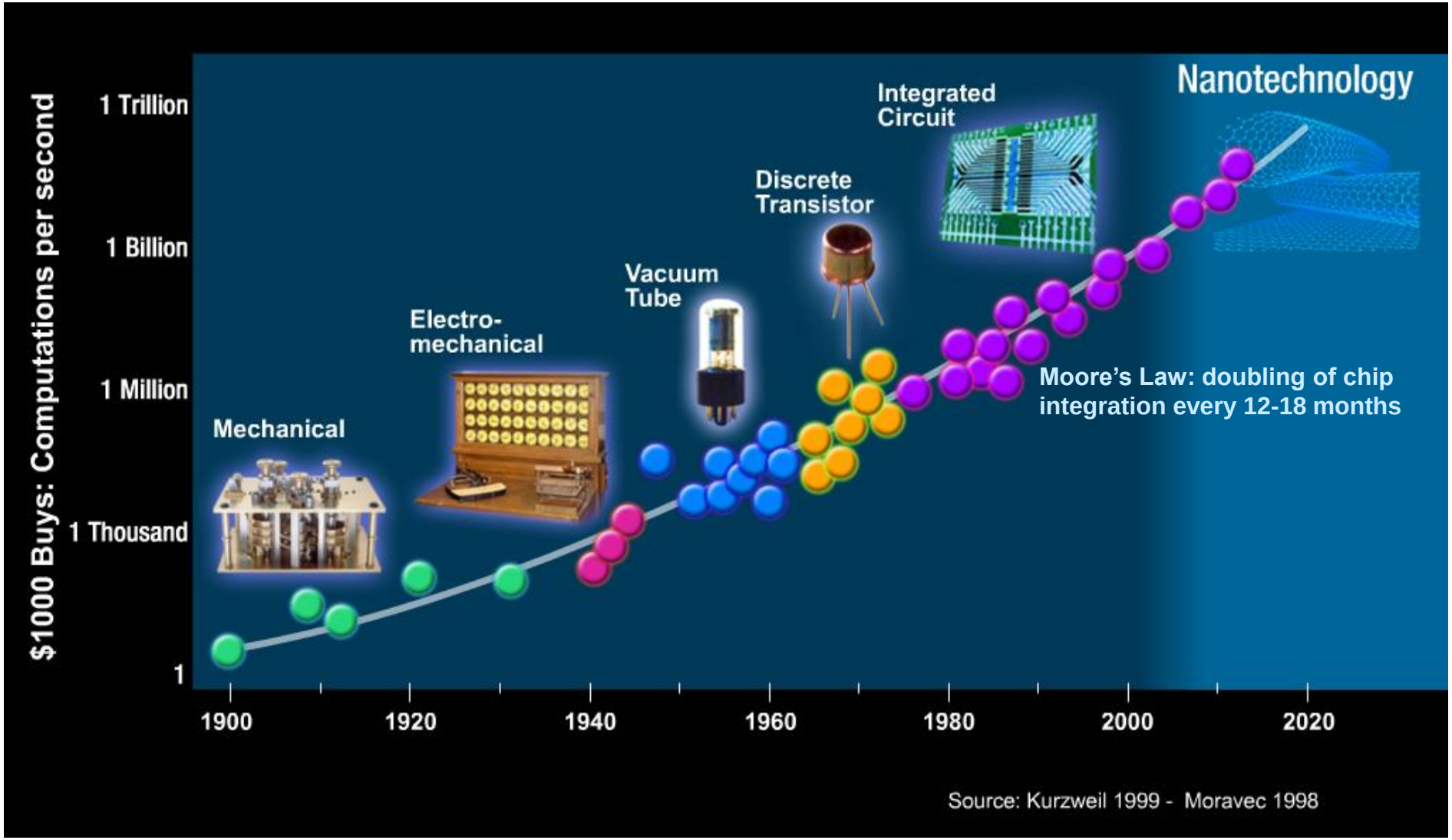
Collaboration as a Way forward for Semiconductor Technology – *Albany NanoTech*

Albany Innovation Conference

April 2013

Dr. Gary Patton
Vice President, IBM Semiconductor Research & Development Center
IEEE Fellow

Accelerating Advances in Technology



Milestones in Our Industry

1964 Solid Logic Technology

IBM System 360

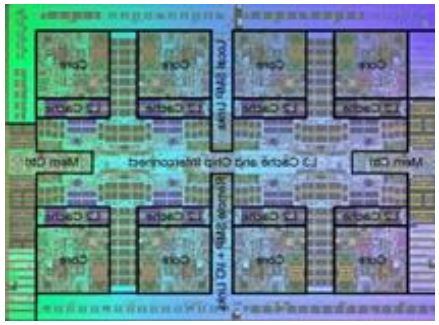
The machine that defined
the computer industry
and the modern IBM

Transistor

IBM System 360

SLT module c.1964
6 transistors,4 resistors

Power7 today (used in 'Watson')



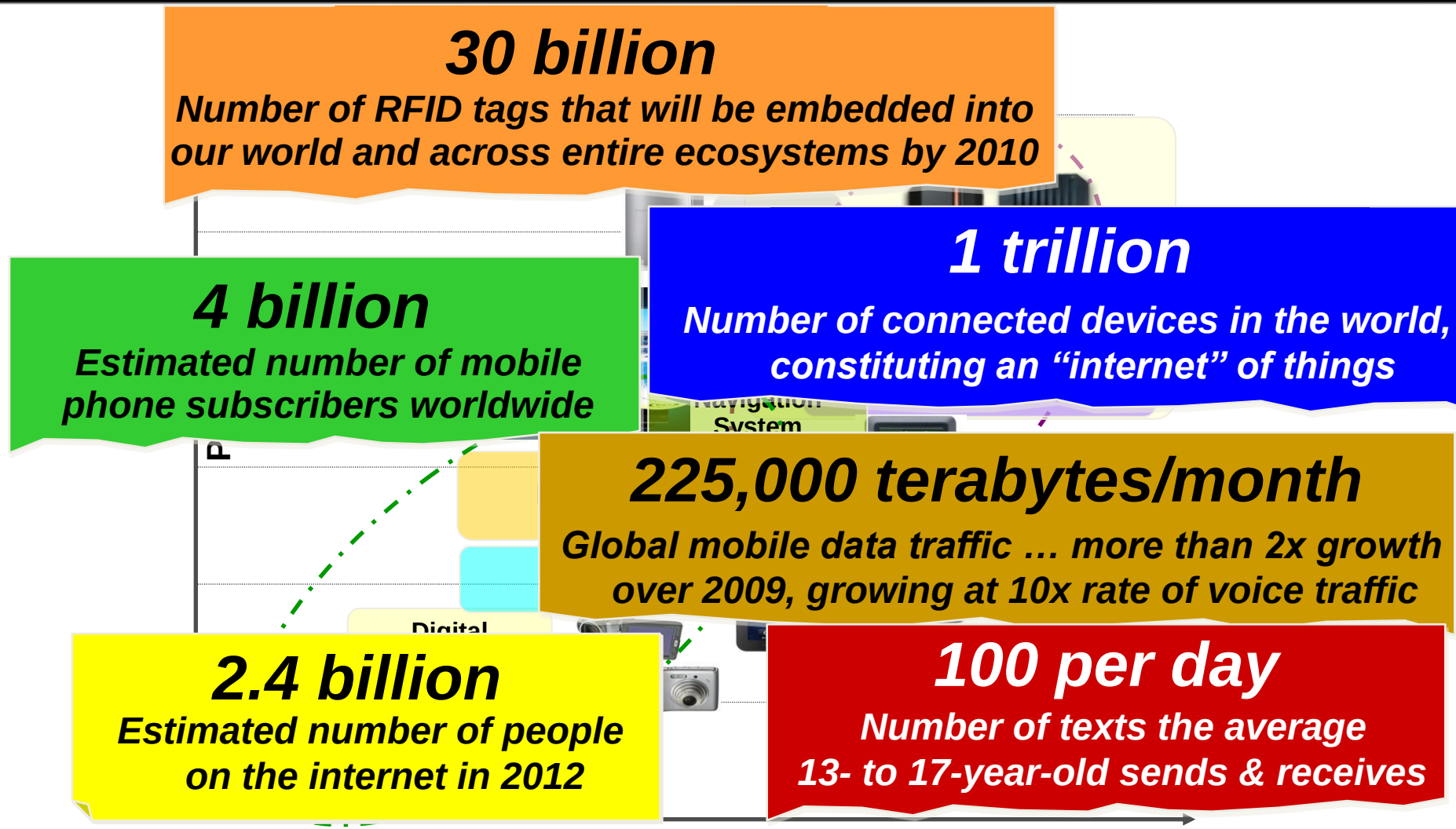
Watson System

- 360 Power7 chips
- 80KW / 80 Teraflops
- 1000Mflops/W

Chip

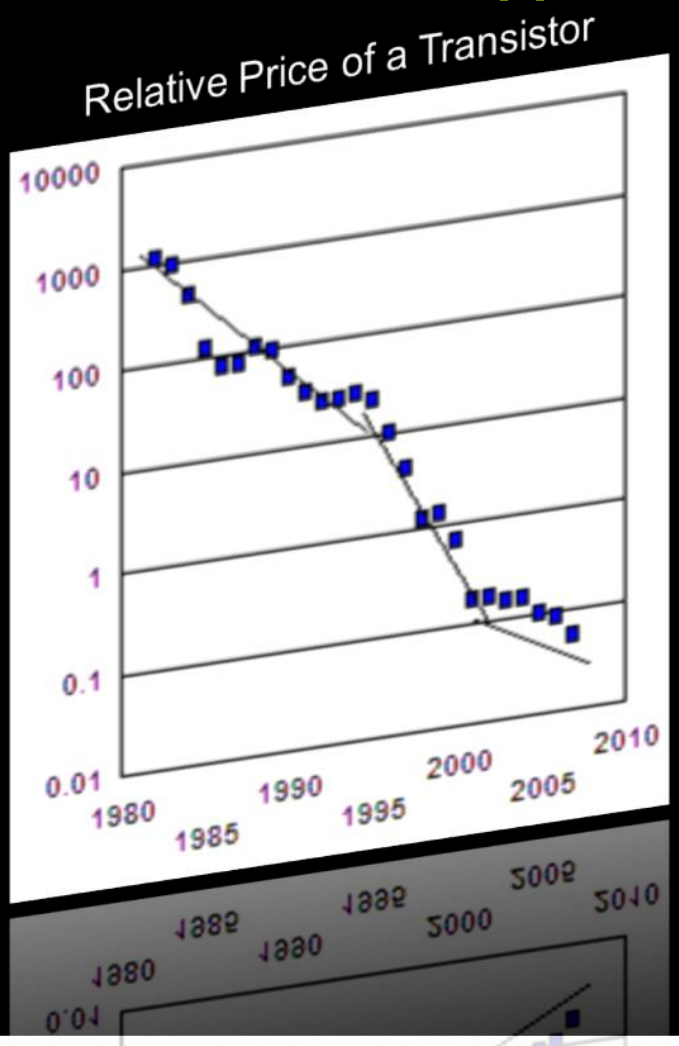
- 1.2 billion transistors/chip
- Embedded DRAM
- 190 watts max

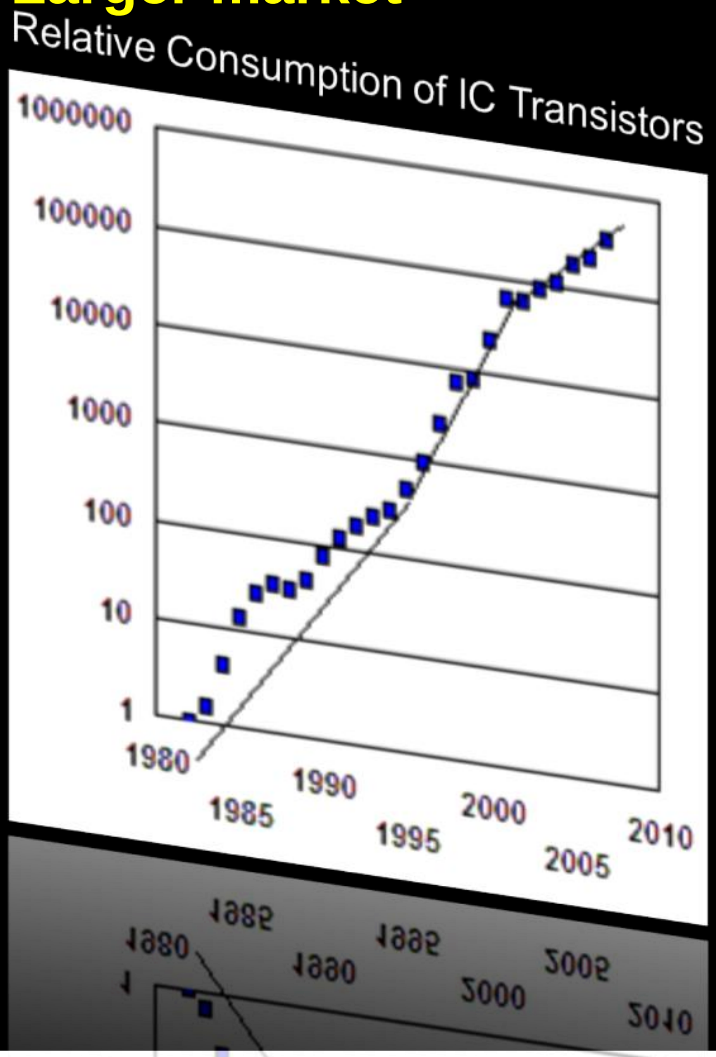
Chip Technology is Changing the World



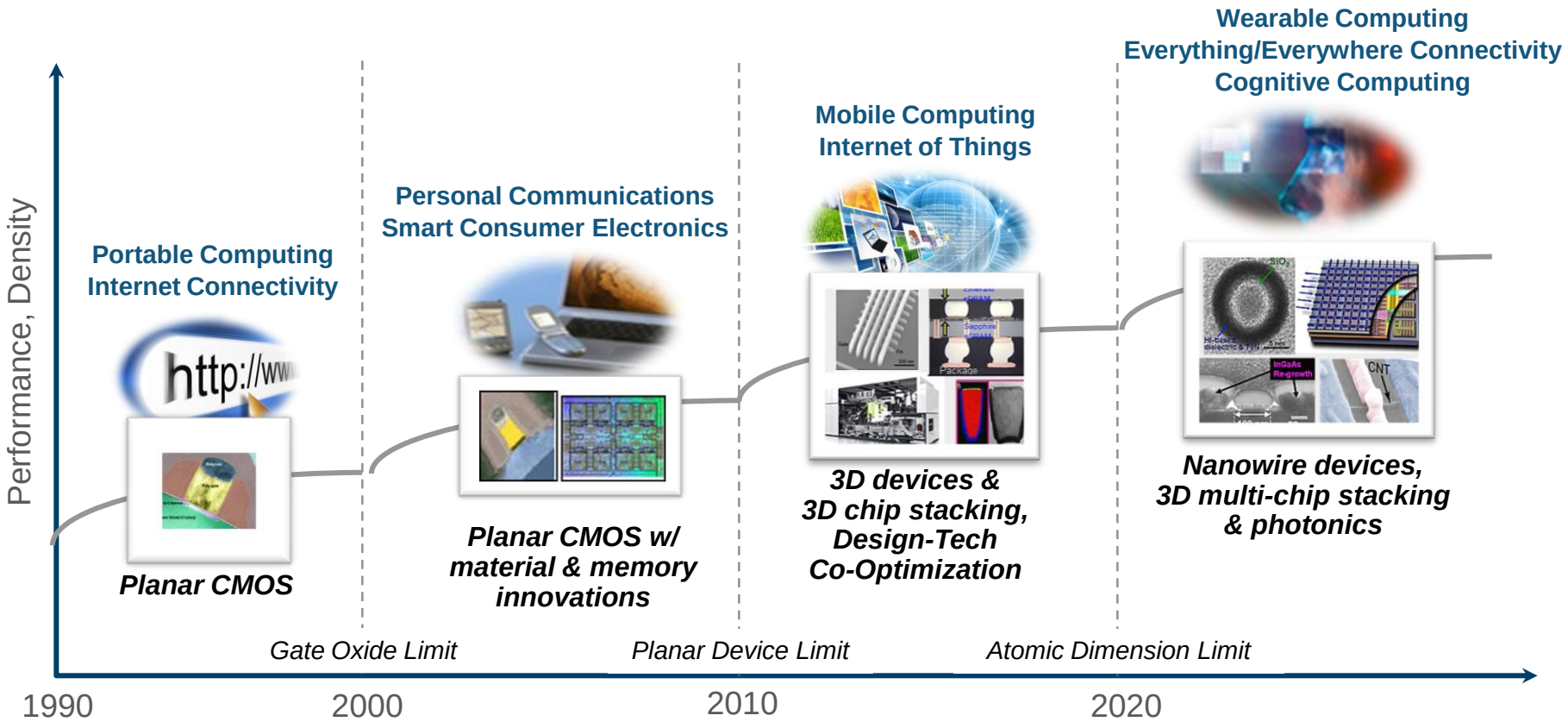
Driving Force: Economics

Smaller features → Better performance & cost/function → More applications → Larger market



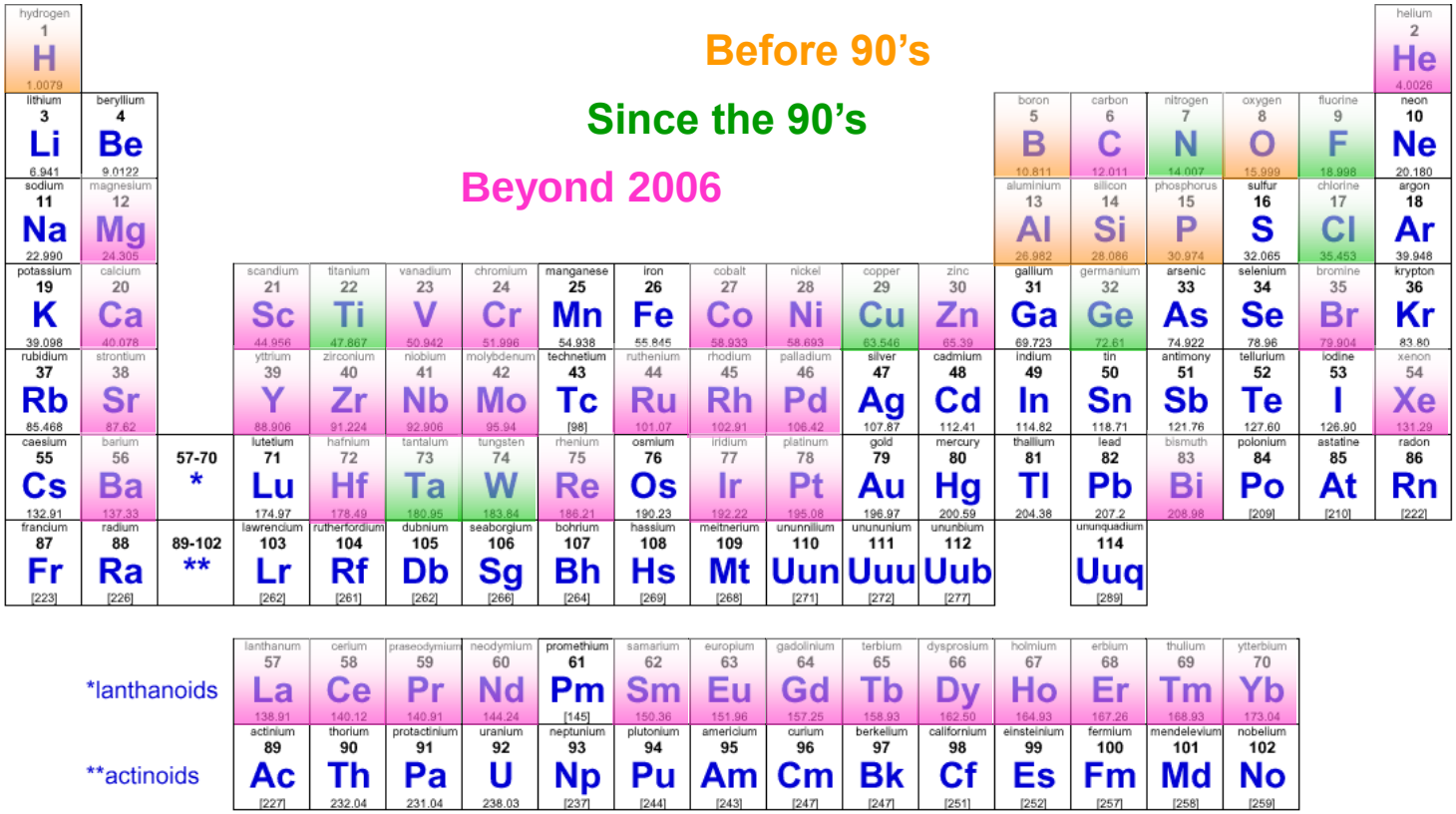


Silicon Technology Innovation for Ubiquitous Computing

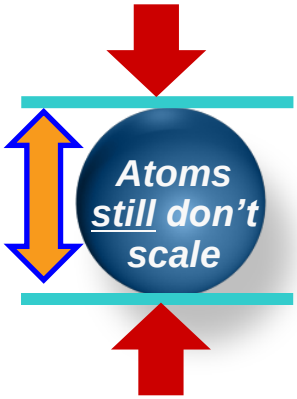


Scaling Thru Materials Innovations

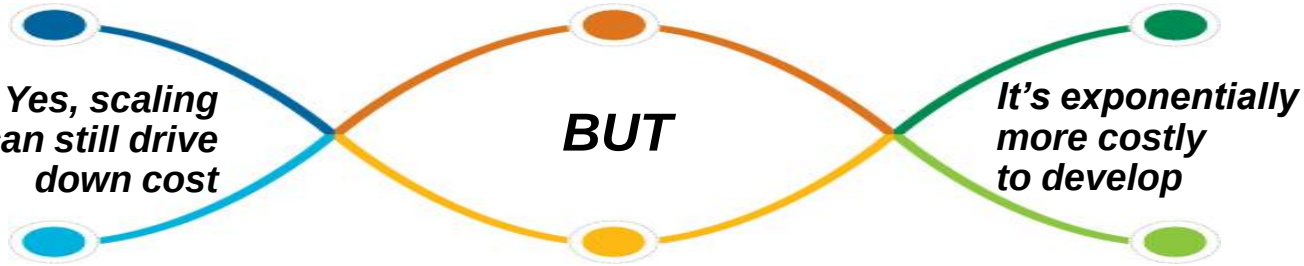
- **Elements Employed in Silicon Technology**



Changing Innovation Requirements



Traditional scaling is reaching its limits…but the economics of Moore's Law are still holding…



Continued advances mean changing the way we think about innovation

Innovation

Technical Innovation

- Material & Process innovation must be able to counter the limits of traditional scaling
- Long-term R&D focus/investment needed to drive this innovation and sustain roadmap
- Design technology must be able to support & leverage materials and process innovation (Design-Technology Co-Optimization)

Business Model Innovation

- Collaborative R&D replaces independent R&D
- Collaboration needs to include all functions (semiconductor manufacturers, equipment vendors, & material suppliers)
- Shared investments / learning fosters breakthroughs beyond what would be possible for a single company / function

9

Innovation Technology Pipeline – From Research to Market

Fundamental Research

New materials, processes, & devices

- Si Nanowires
- Low Dimensional Carbon Electronics
- Phase Change Memory (PCM)
- Silicon Nanophotonics

IBM Yorktown, Almaden, & Zurich

Advanced Semiconductor R&D

Innovation & Collaboration in process & packaging technology

- Process Element & Device Exploration
- Adv. Packaging Center / 3Di
- Equipment Dev. Center (EDC)
- Sematech
- G450C Consortia

Albany NanoTech

Technology Development

Multi-Company Collaborations

- Process Technology Development
- Packaging Technology Development

IBM East Fishkill
IBM Bromont
GF Malta

Manufacturing

Process synchronized fabricators (GDSII compatible)

- High Performance Server, ASICs, & Games Products
- Foundry Technology Offerings

IBM East Fishkill
IBM Bromont
GF Malta

Innovation Fueled by Long-Term R&D Investment



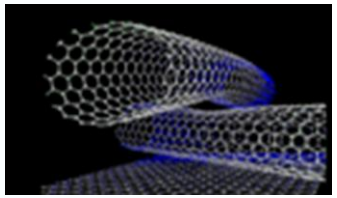
LAB	IBM Yorktown	IBM Almaden	IBM Zurich
RESEARCH	Devices, Materials, Nanoscience & Technology	Materials, Nanoscience & Technology	Nanoscience & Technology
PROJECTS	Deep Research in Solid State Devices, Si Nanowire, Carbon Nanotubes / Graphene, III-V Devices, New materials, Si Nanophotonics, Adv. 3D IC, New memory technologies.	New Solid State materials, Advanced Lithography Photoresist, Direct Self Assembly, Atomic scale microscopy, Nanobiology, Cognitive Computing,	Spintronics / Magnetism, Nanowires, Packaging for Thermal Management, MEMS / NEM, Computational Material Science, Photonics, III-V Materials, Molecular Electronics, Nanobiology
FACILITY	Microelectronics Research Line, E-Beam, Blue Gene, Advanced Diagnostic & Test Instrumentation, Nuclear Accelerator, WATSON	Research Labs, E-Beam, Clean Room, Dry & Wet Labs, Materials Scale Up Facility, Blue Gene, STM, AFM, TEM, NRA	Binnig and Rohrer Nanotechnology Center, "Noise-Free" Labs, Probe Microscopy, Nanostencil Patterning

- IBM inventors received a record 6,478 U.S. patents in 2012
- 20th consecutive year topping the list of the world's most inventive companies

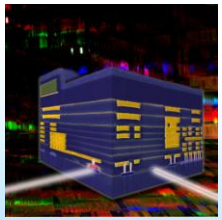
Future Technology Innovations in the News

IBM Claims Carbon Nanotube IC Breakthrough

*Claiming a first, IBM said its researchers placed **more than 10,000 working nanotube transistors on a single device** using standard semiconductor processes…*



EE Times Oct 2012



IBM Develops Nanophotonics Chip For Faster Communications

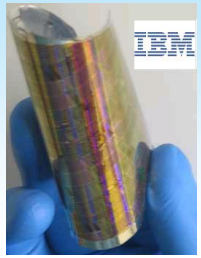
*… **silicon nanophotonics**…chips use pulses of light to communicate… . The key innovation isn't just the technology… It's the fact that its commercial and scalable.…*

Forbes, Dec 2012

IBM paves way for wearable electronics, folding displays

*… a new, low-cost technique for **manufacturing silicon-based electronics on a flexible plastic substrate**…research suggests that flexible, affordable electronics **can be made with conventional processes at room temperature**.*

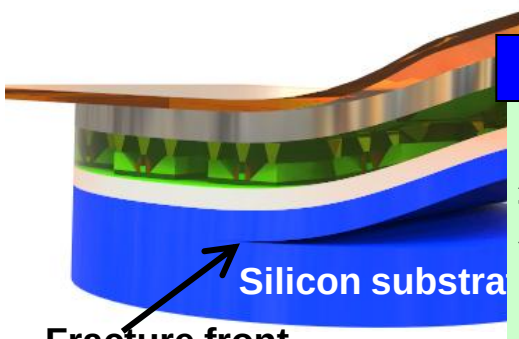
EE Times Dec 2012

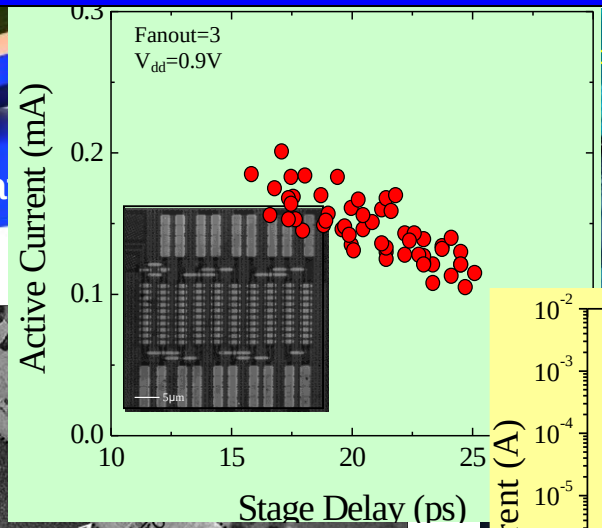


Everywhere Computing

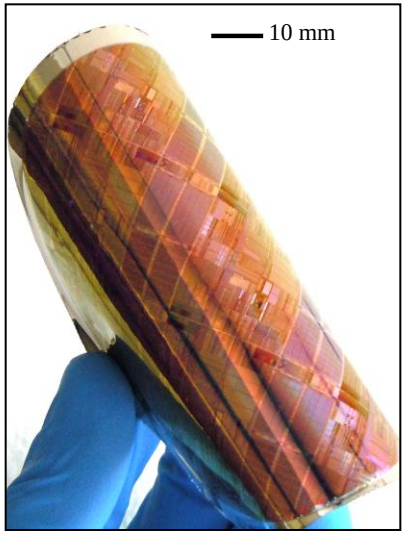
Mighty electronic chips in your clothes to monitor your vitals?
d fits in your back pocket?

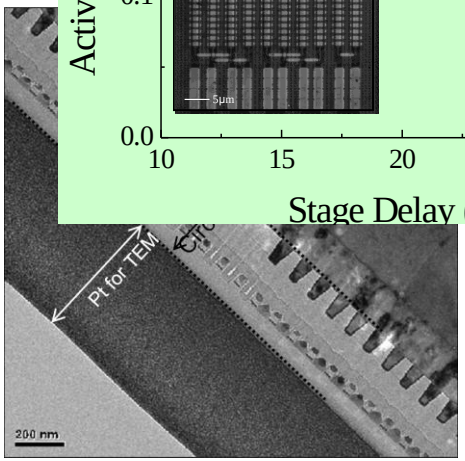
Fastest flexible ROs to date!

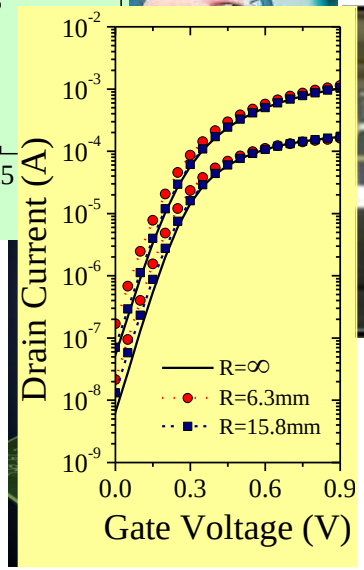


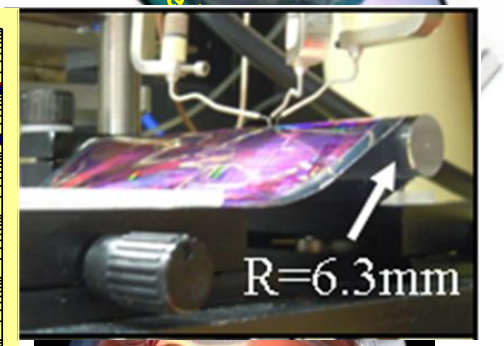


Roll it thinner than a dime!









Much thinner than a sheet of paper!

Innovation Fueled by Increased R&D Investment

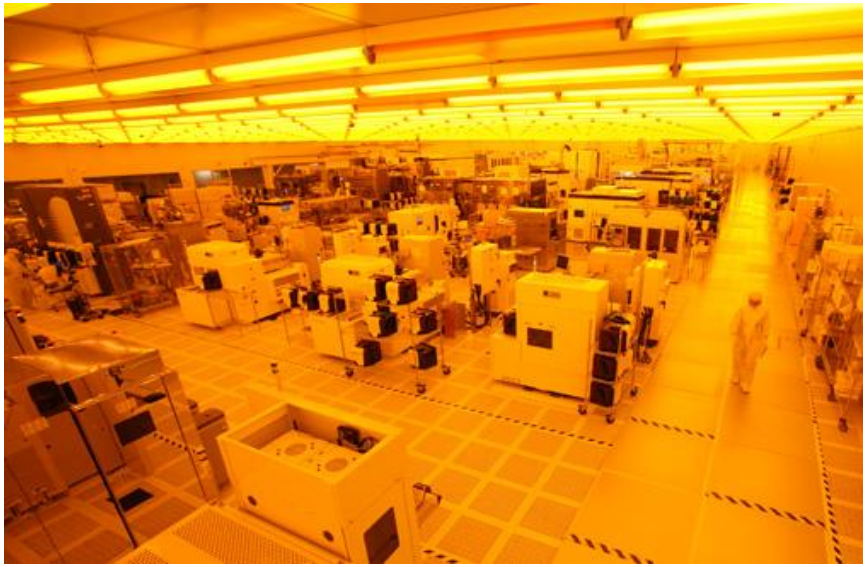
Albany NanoTech Research Facility

State of the art pilot line and a one of a kind partnership:

- New York State
- IBM
- SUNY Albany / CNSE
- Leading edge semiconductor partners
- Equipment & Material Suppliers
- SEMATECH HQ

Site population has more than doubled over last 3 years

Albany NanoTech Research Facility Capability



A unique and one of a kind partnership between New York State, IBM, SUNY and leading edge semiconductor partners from around the globe on a *state of the art manufacturing/pilot line.*

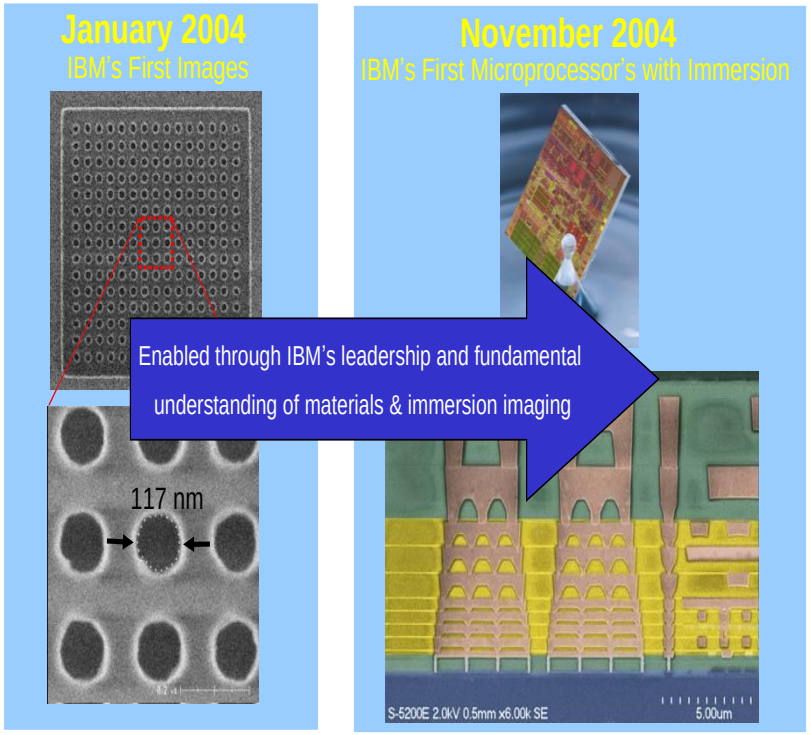
Developing a world class high technology work force for New York, IBM and the world.

No corollary exists in the industry for collaboration between academia, State government, and industry

Albany NanoTech Early Achievements

➢ *First demonstration of immersion lithography*

1st example - IBM Litho Research…leadership solutions at Albany Nanotech



➢ *World's Smallest SRAM Flycell*

EE Times europe
Global news for the creators of technology
Production News

IBM claims 22-nm SRAM success

By Peter Clarke
(08/18/08, 10:27:00 AM EDT)

LONDON — IBM and its joint development partners Advanced Micro Devices Inc., Freescale, STMicroelectronics, Toshiba and the College of Nanoscale Science and Engineering, have claimed they have developed the first working SRAM cell implemented in a 22-nm manufacturing process. The cell was built at CNSE's 300-mm research facility in Albany, New York.

X bit laboratories
News

IBM and AMD Outpace Intel in Developing New Production Technologies

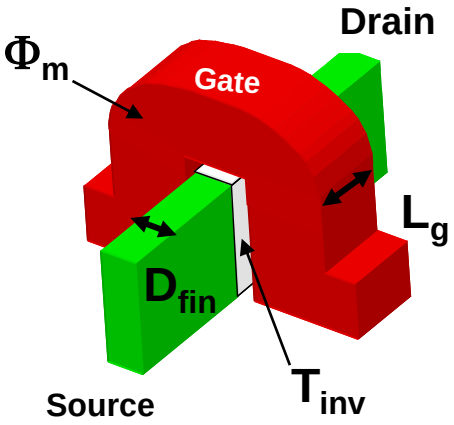
[08/18/2008 05:09 PM] by Ilya Gavrichenkov

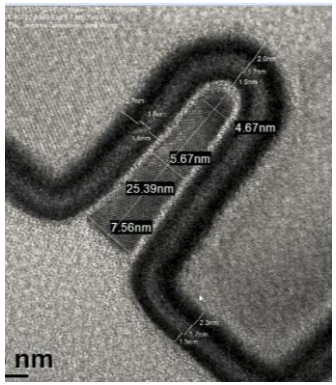
IBM and its joint development partners - AMD, Freescale, STMicroelectronics, Toshiba and the College of Nanoscale Science and Engineering (CNSE) - today announced the first working static random access memory (SRAM) for the 22 nanometer (nm) technology node, the world's first reported working cell built at its 300mm research facility in Albany, NY.

Albany NanoTech Recent Achievements

➢ 3D FinFET Innovation

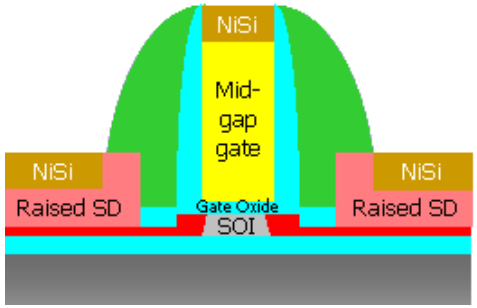
– 14nm & 10nm Products

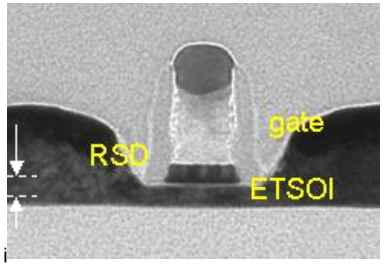




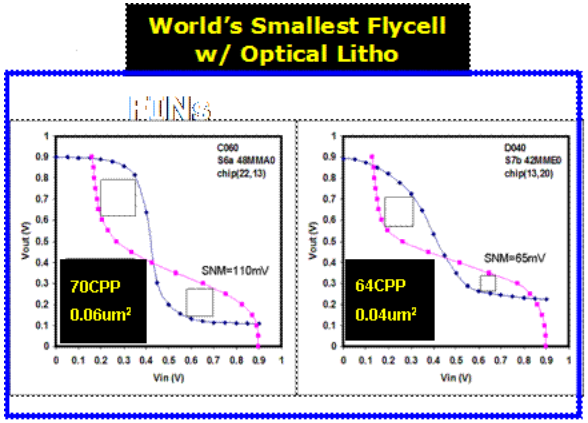
➢ FD-SOI Innovation

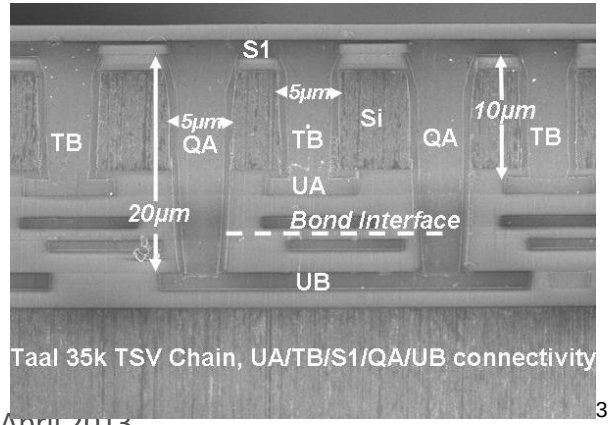
– IBM Partner 28nm Product





➢ 3Di innovations

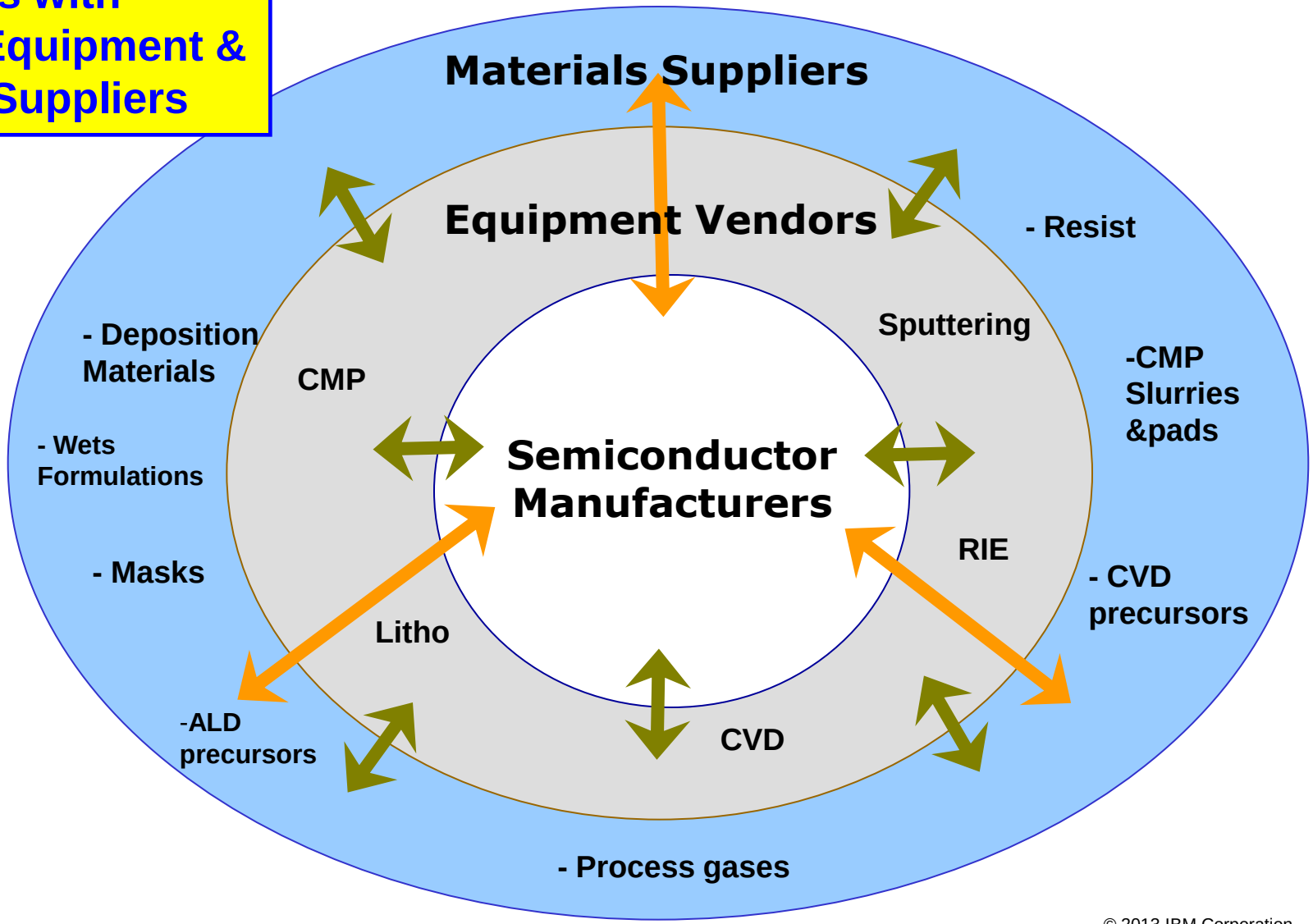




NFX: Site of EUV Center of Excellence at Albany

Expanding Universe of Collaboration

24 Projects with
14 Major Equipment & Materials Suppliers



Innovation Fueled by Collaboration: *Albany Example*

ASML

TOKYO ELECTRON

APPLIED MATERIALS

Cabot Microelectronics

Canon CANON ANELVA CORPORATION

HITACHI Semiconductor

Shin-Etsu

Soitec

JSR Micro JSR MATERIALS INNOVATION

ALBANY NanoTech

SEMATECH
Accelerating the next technology revolution.

Lam RESEARCH

STMicroelectronics

COLLEGE OF NANOSCALE SCIENCE & ENGINEERING UNIVERSITY AT ALBANY

IBM Partners

GLOBALFOUNDRIES

RENESAS

SAMSUNG

IBM

varian semiconductor equipment

KLA-Tencor

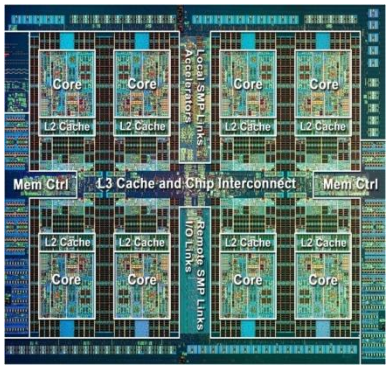
NOVELLUS

Equipment Development Center (EDC)

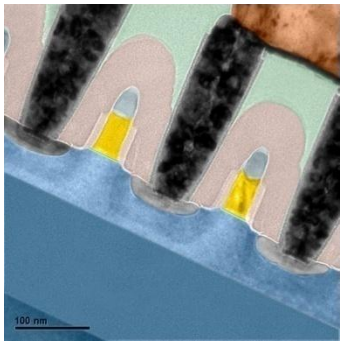
Design-Technology Co-Optimization:
From Atoms and Molecules to Supercomputers

End-to-End Materials and Technology Innovation and Enablement for Semiconductor Chips and Computing Systems

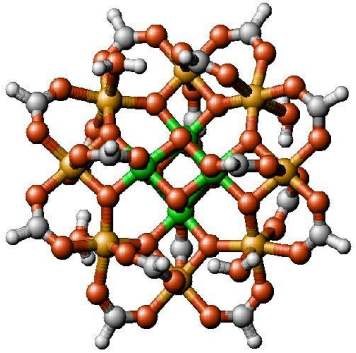
Servers and Supercomputers



Electronic Design and Processor Enablement



NanoDevice technology



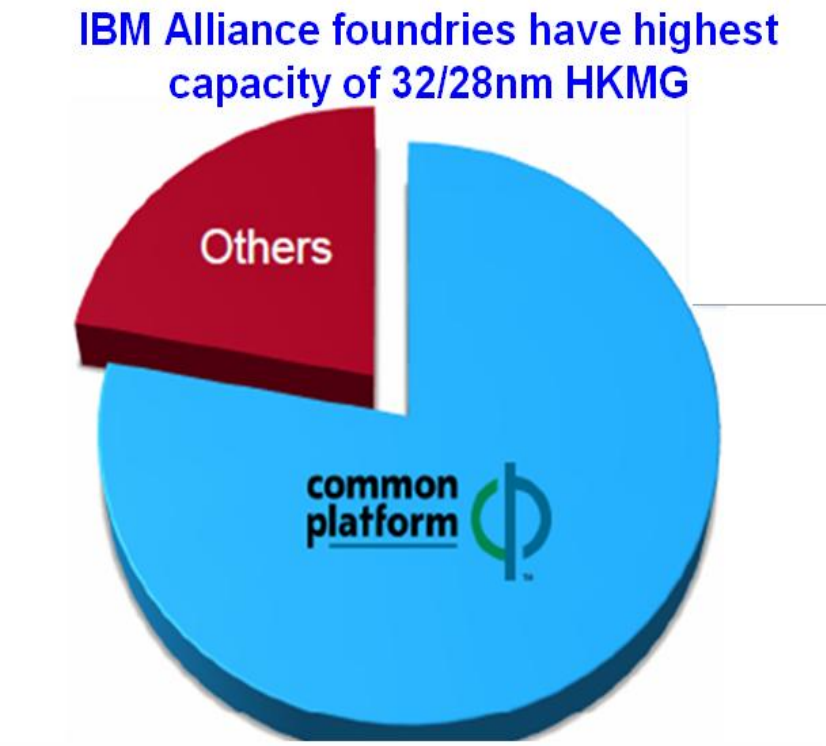
Atoms and Molecules : Materials Innovation

Power 7+ Process Chip

- **567mm2 32nm SOI eDRAM technology**
- **Eight processor cores**
- **80MB on chip eDRAM shared L3**
- **Equivalent function of 5.4B transistors due to eDRAM efficiency**

Design-Technology Co-Optimization:
Quad Core Processor inside a phone

IBM Alliance 32nm LP
High-k Metal Gate First Process
Twice the logic density of 45nm processes while maintaining low power:
Ideal for mobile applications

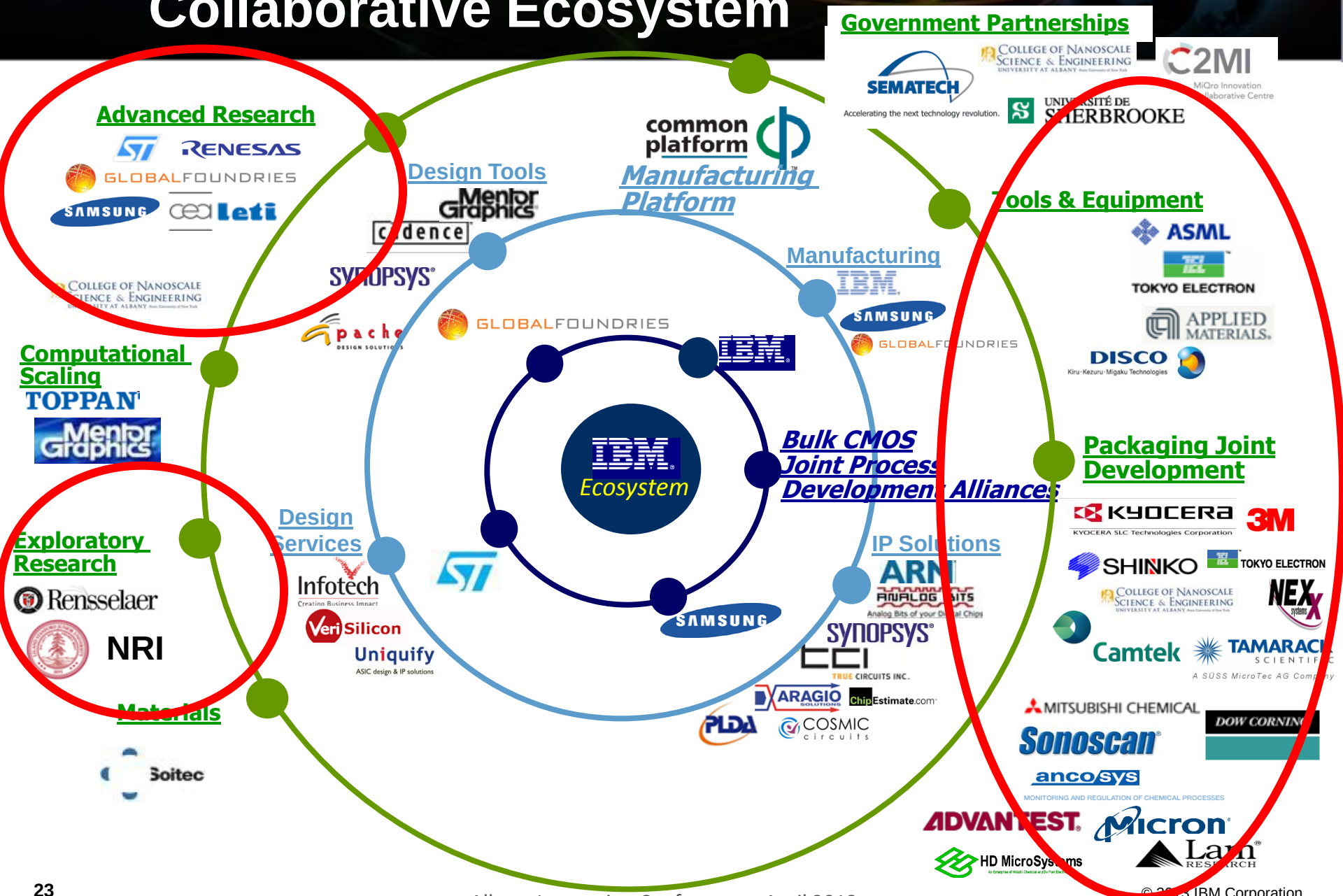


[4Q12, World Wide 32/28nm Foundry Capacity]

Courtesy: Samsung, CPTF, Feb. 2013

Source: http://www.samsung.com/global/business/semiconductor/minisite/Exynos/products4quad.html

Innovation is Fueled by Growing Collaborative Ecosystem



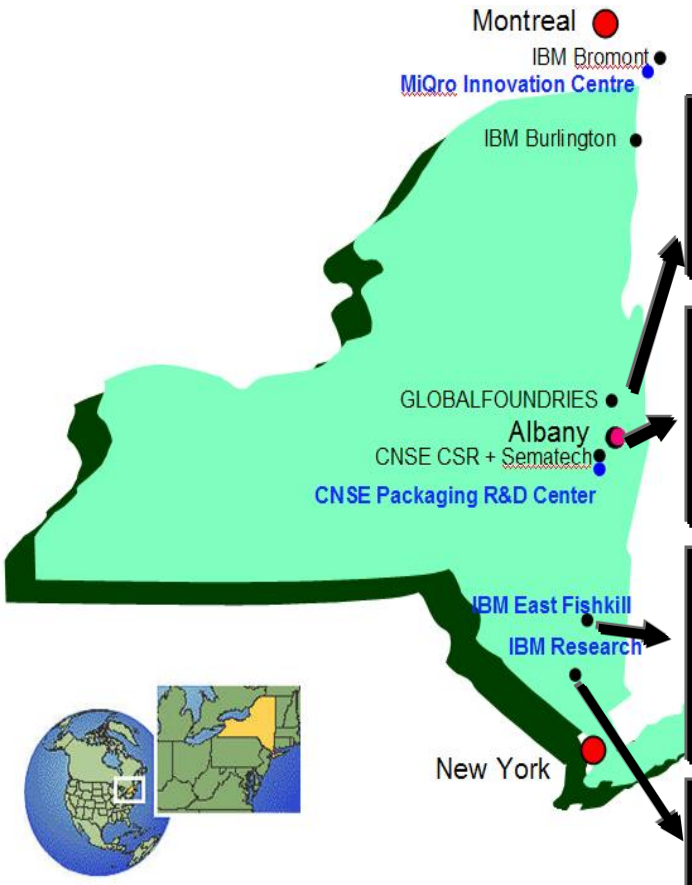
IBM @ Albany NanoTech Summary

- **IBM's Research capability at Albany is unparalleled in the Industry**
  - Fast TAT for integrated end-to-end processing
  - Flexibility for Materials & Process Research
  - Collaborative Model working very well and currently focused on 14 nm and beyond roadmap

- **The Albany Site continues to expand significantly in scope & size**
  - 200mm → 300mm state of the art silicon facility
  - New Advanced Packaging Center
  - New EUV Center of Excellence
  - Increase in presence and investment by tooling suppliers
    - Equipment Development Center
  - G450 Consortia commenced

- **IBM @ Albany NanoTech is *Extremely Well Positioned* to Push the Limits of Conventional Scaling and Evaluate New Device Ideas**

New York State
High Tech Semiconductor Corridor



GlobalFoundries Malta Fab 8
- Next Generation semiconductor plant to have 300,000 sq ft manufacturing capacity

Albany NanoTech
- World class 300mm Research facility formed through Industry-Government collaboration
- 300mm silicon facility, Advanced Packaging Center, and EUV Center of Excellence

IBM East Fishkill
- 300mm Semiconductor Development and Manufacturing
- Evolutionary and revolutionary Packaging Technology

IBM Yorkown Research Center
- Fundamental research exploring new materials/process/paradigms
- Multiple additional research labs worldwide

Summary

- **Technology advances increasingly require innovation and "disruptive" approaches to enable cost effective solutions**
- **Technology, resources and financial challenges are dictating a collaborative business model to drive advances**
- **IBM has been a pioneer in setting up collaborative ecosystems to drive technology solutions**
- **Collaborative Albany, NY Model Demonstrated Outcomes:**
  - **Technology Innovations**
  - **Employment Growth**
  - **"High-Tech manufacturing, R&D Corridor" in North-east USA**
- **Semiconductor fabs are THE critical "center pieces" for such broad Electronic Systems Design and Manufacturing ecosystems**