Institute for the Theory of Advance Materials in Information Technology

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Purpose of this Meeting

Serve as brief introduction to research activities in this area and to the goal of the institute.

People:

Professor Yousef Saad: Associate director, computer scientist
Professor Renata Wentzcovitch: co-Principal investigator, materials scientist

Dr. Dr. Scott Beckman, Materials Scientist
Dr. Costas Bekas, Computational Scientist
Dr. Murilo Tiago, Materials Scientist
Dr. Suzanne Shontz, Computational Scientist

My Background

1970: B.S. Physics, Kansas State University

1975: Ph.D. Physics, University of California, Berkeley

1976-78: Limited Term Member of the Technical Staff at Bell Laboratories

1978-80: Assistant Professor, Physics, University of Oregon

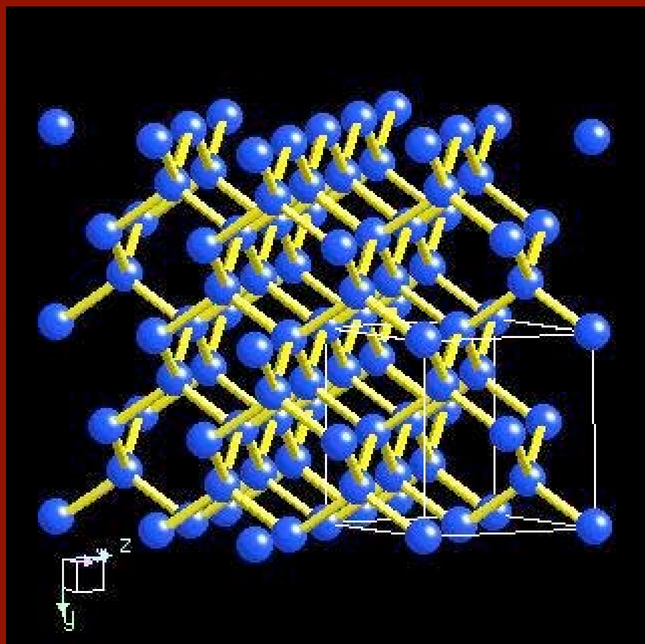
1980-87:   Research Associate, Group Head of Theoretical Chemistry and Physics, Corporate Research Science Labs, Exxon Research and Engineering

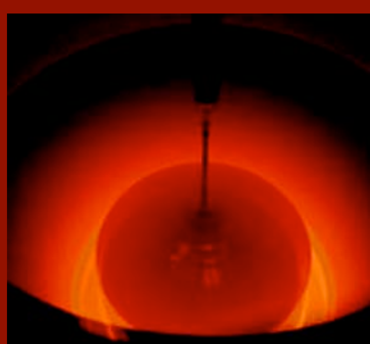
1987-2004: Institute of Technology Distinguished Professor, Chemical Engineering and Materials Science, University of Minnesota

2005- : ICES Chair of Computational Materials, Professor in Physics, Chemical Engineering, and Chemistry and Biochemistry, University of Texas

Research Interests: Computational materials science, the optical and dielectric properties of semiconductors, surfaces and interfaces in solids, point and extended defects in electronic materials, pressure induced amorphization and disordered systems, clusters and confined systems, diffusion properties and microstructure of liquids, molecular electronics and nanoscale phenomena.

Silicon





Silicon is one of the most abundant element in the earth's crust. Yet it is one of the most important technological material known.

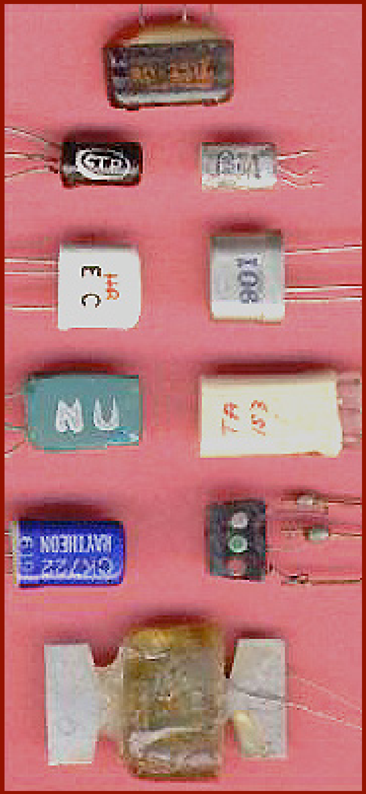
From beach sand to high performance computing.....

Some History

In 1955, an early high-speed commercial computer weighed 3 tons, consumed 50 kilowatts of power, and cost $200,000. But it could perform 50 multiplications per second, a feat unmatchable by either a human or the latest adding machine. In 1977, a handheld calculator weighed under a pound, consumed less than half a watt of power, could perform 250 multiplications per second, and cost $300. (From the National Academy of Engineering website.)

Silicon: 1954

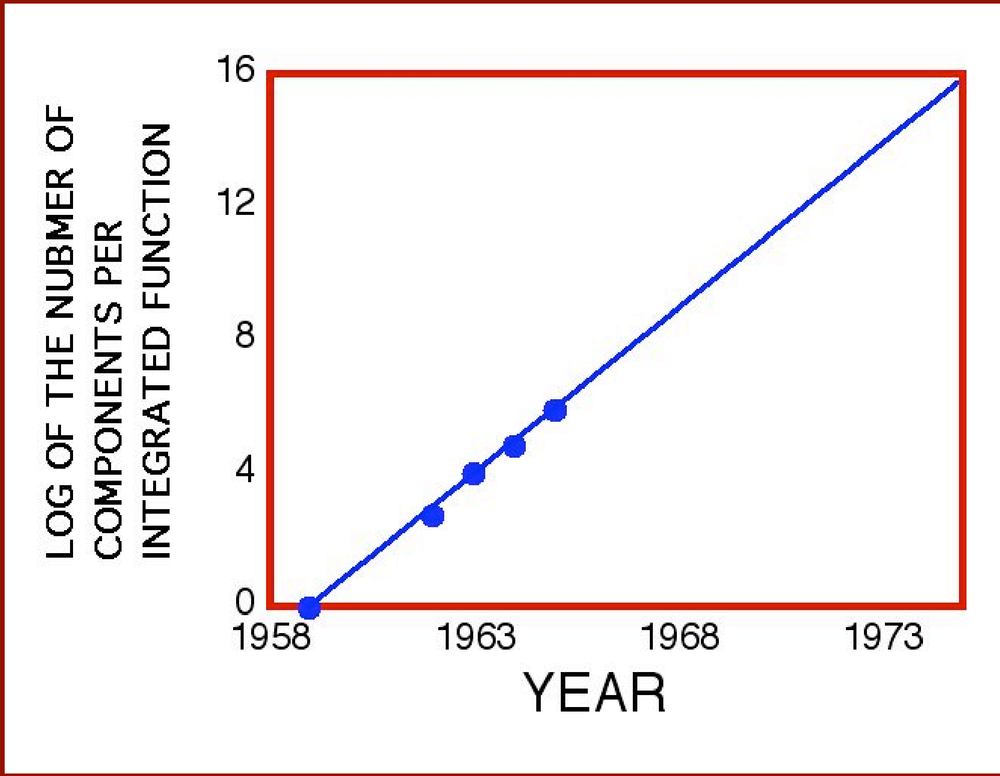
DALLAS (May 10, 1954) - A revolutionary new electronic product--long predicted and awaited--became a reality today with the announcement by Texas Instruments Incorporated of the start of commercial production on **silicon transistors**. By using silicon instead of germanium, the initial commercial silicon transistor immediately raises power outputs and doubles operating temperatures! The potential application of this entirely new transistor is so great that major electronics firms have been conducting silicon experiments for some time. -- Press Release Texas Instruments.



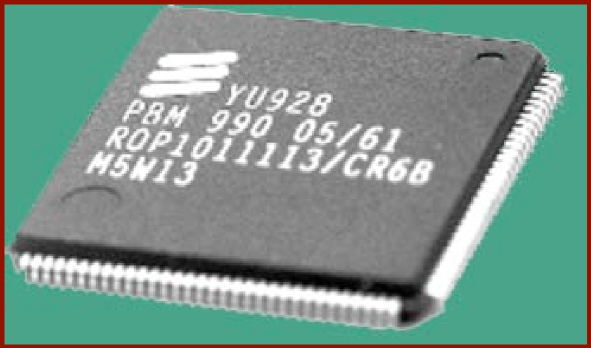
From the Transistor Museum.

Moore's Law

- "Gordon Moore made his famous observation in 1965, just four years after the first planar integrated circuit was discovered. The press called it "Moore's Law" and the name has stuck. In his original paper, Moore predicted that the number of transistors per integrated circuit would double every 18 months." --Intel website

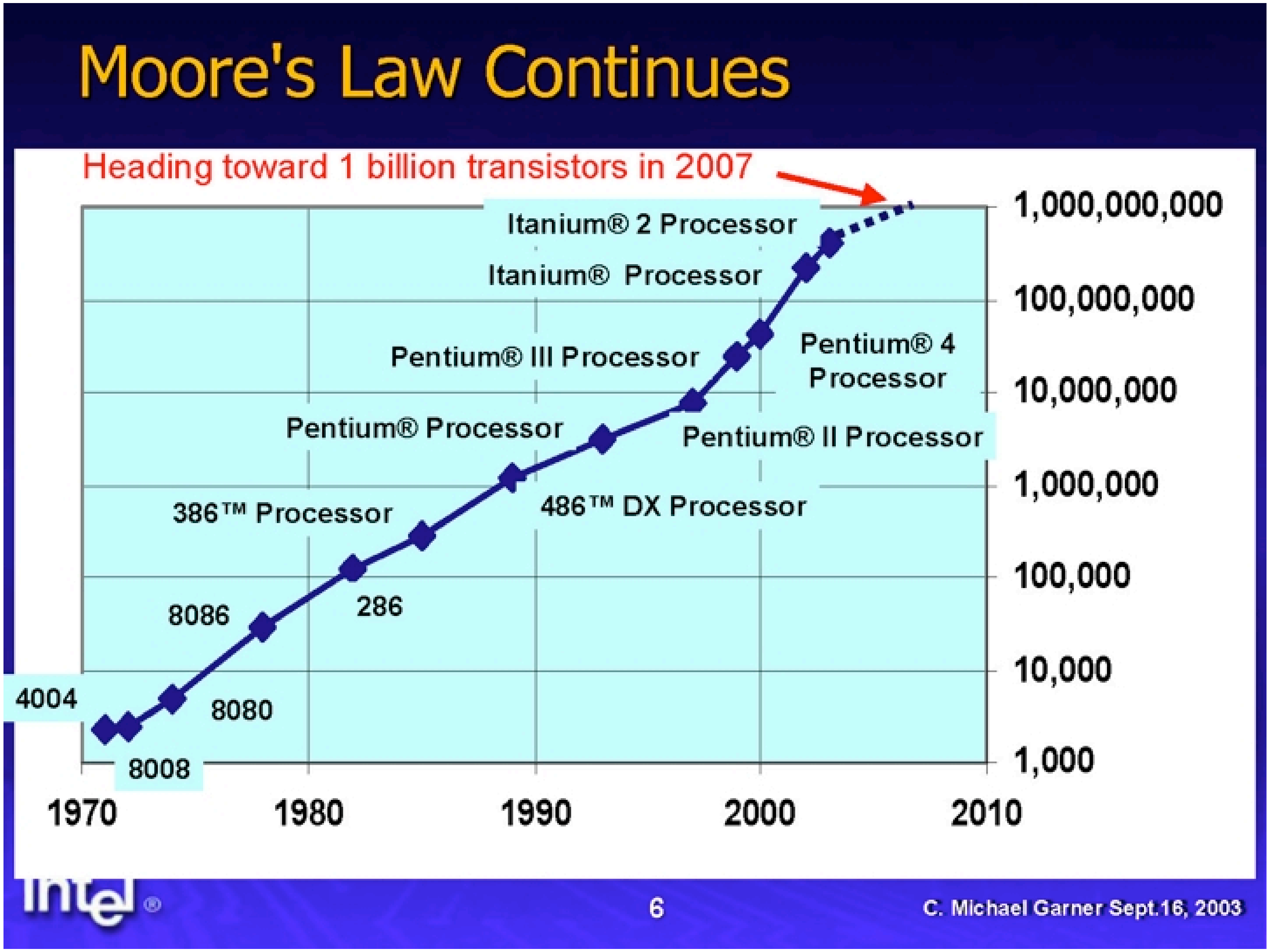


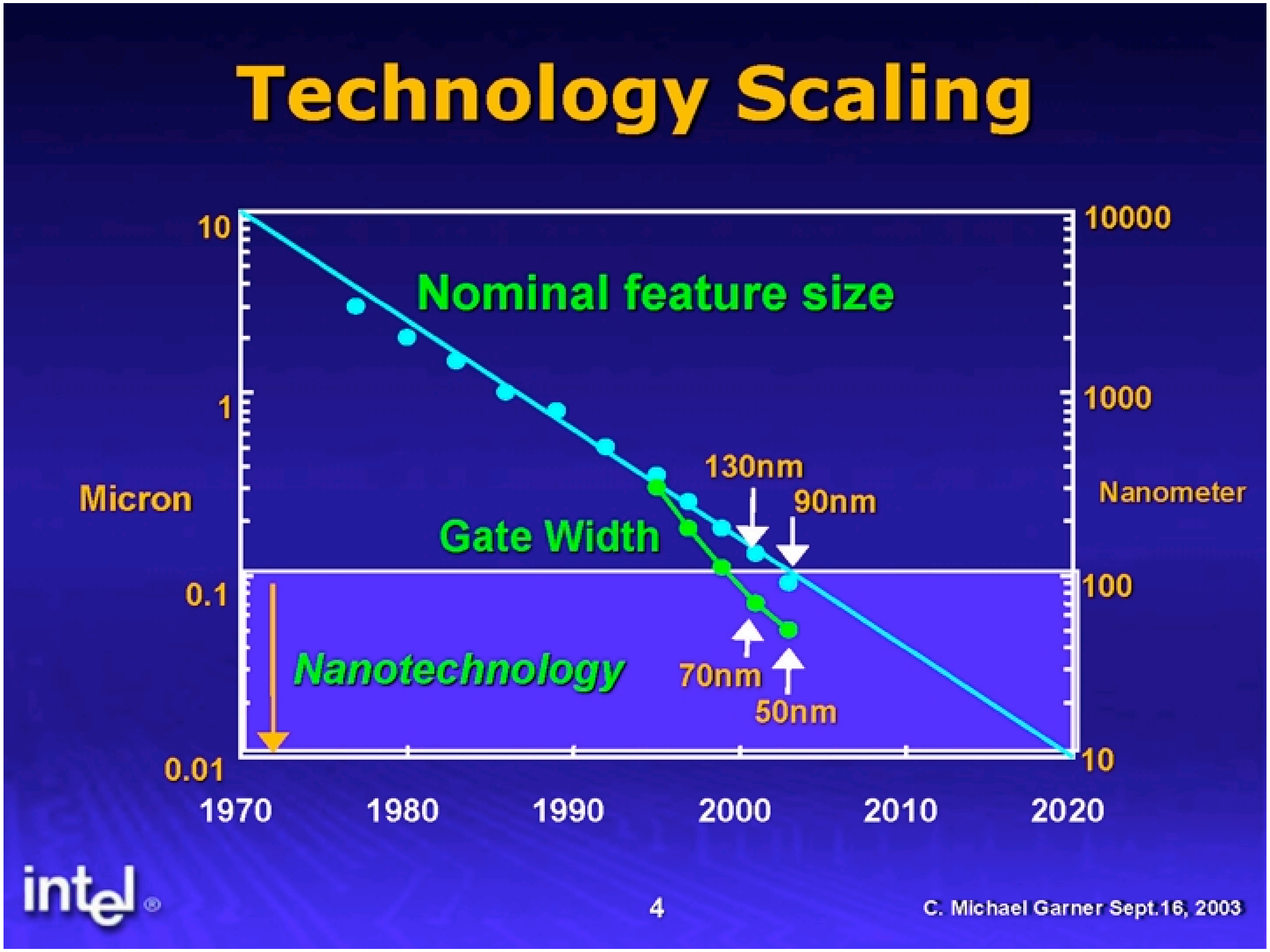
More recent developments in silicon



SANTA CLARA, Calif., June 11, 2001 - Intel Corporation researchers have demonstrated that there are no fundamental barriers to extending Moore's Law for another decade by building the world's fastest silicon transistors. These transistors -- featuring structures just 20 nm in size -- will allow Intel to build microprocessors containing a billion transistors, running at speeds approaching 20 GHz and operating at less than one volt in approximately 2007.   -Intel Press Release

Heading toward the nanoscale.....





Intel is now a "nanotechnology company."

Gordon Moore: Some More Quotes

What we end up doing is really selling real estate. We’ve sold area on the silicon wafer for about a billion dollars an acre....

E.O. Wilson, the famous Harvard biologist who is an expert on ants, estimates that there are [about]10^{16} ants on earth. ...this year we're making one transistor for every ant....

Number of Transistors Made in One Year

- Nova PBS program says more transistors are made each year than the number of raindrops that fall in California.
- Number made: 10^9/wafer x 100,000 wafers x 250 days = 10^{16} transistors
- Area of California= 200 x 400 x $(5,280)^2$ x $(12)^2$ sq. in. = 10^{14} sq. in.
- Rain drops per sq. in. 10 in x 1 sq.in /(0.01 cu. in./ drop)=1,000 drops per sq.in
- Total number of drops per year= 10^{17} drops!

Role of Semiconductor in Advanced Technology

- Semiconductors have been widely recognized as a key enabler for the new economy described earlier. In a recent study on the economic impact of America's manufacturing industries, entitled "Turbocharging the U.S. Economy," the semiconductor industry was identified as the largest, contributing over 20 percent more to the U.S. GDP than the next largest sector (automobiles).

Total Number of Papers Published on Silicon by Decade

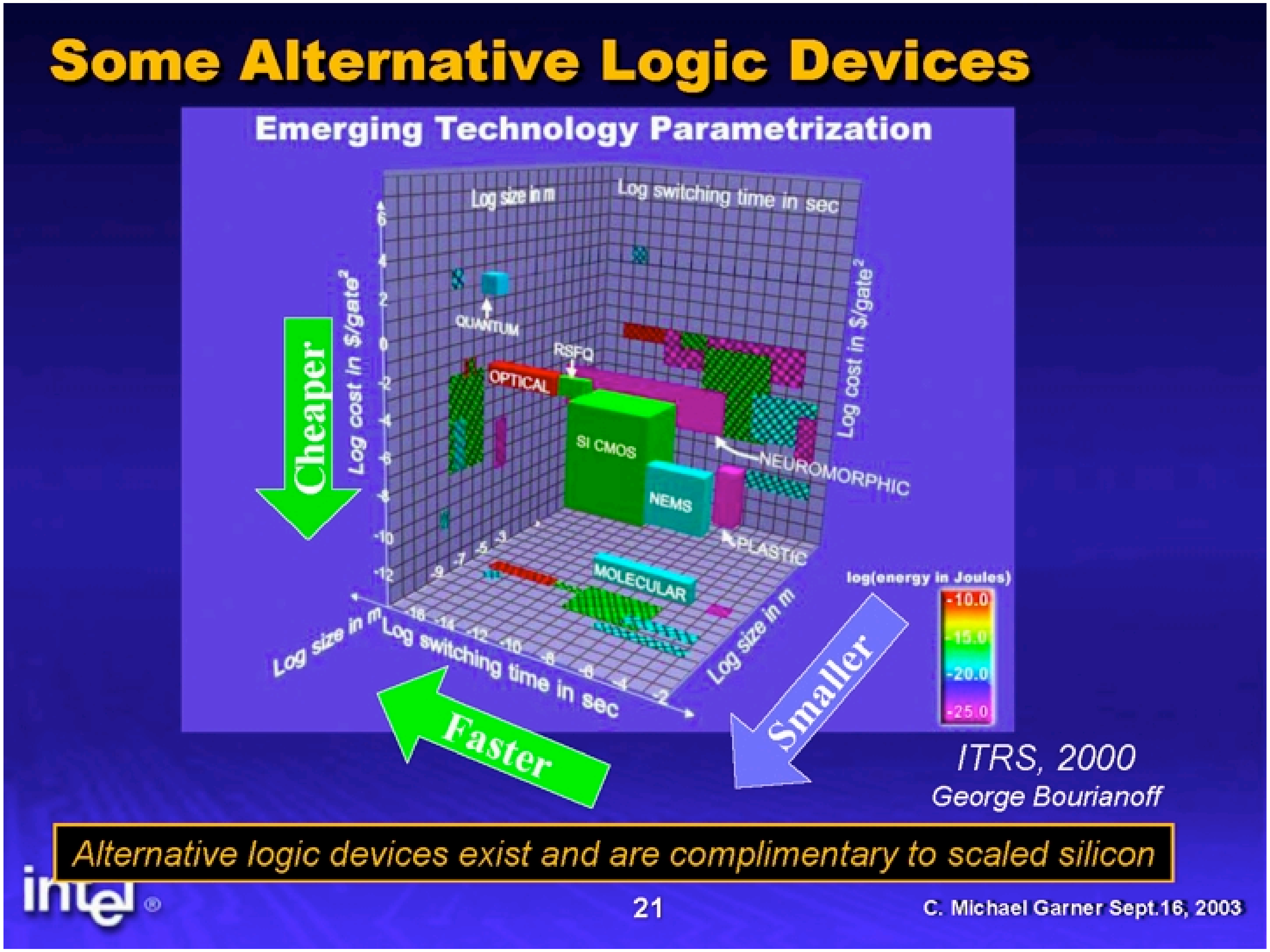
Number of papers (INSPEC):

1970-1979	30,505
1980-1989	84,202
1990-1999	135,652*

* That’s one paper every 90 minutes!

Jim’s Observation: Each decade the number of papers on silicon increases by 50,000

Examples of Materials of Interest to Intel....



NSF is interested in supporting this activity!

Institute for the Theory of Advanced Materials in Information Technology

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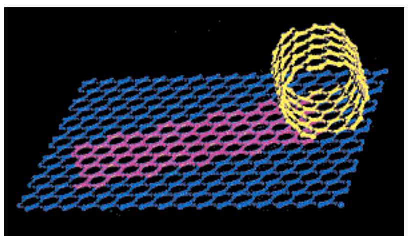

Silicon based technology dominates the ongoing miniaturization of electronic components. For the past thirty years, Moore's law has characterized progress. However, Moore's law cannot hold indefinitely. There are serious scientific and technological issues that must be resolved as device features shrink to nanoscale dimensions where quantum mechanical effects become important. For example, design rules for transport based on simple Ohmic behavior and field-effect transistor digital function will become suspect as a consequence of quantum effects. The Institute for the Theory of Advanced Materials in Information Technology is dedicated to promoting research on understanding and predicting these effects in electronic materials. New materials other than silicon will be explored theoretically and computationally for the construction of electronic devices at small dimensions. The Institute aims to promote innovations in new materials and to advance research related to information technology. Representative research areas within the institute will include the study of organic and plastic semiconductors, low-k dielectrics, dilute magnetic semiconductors and spintronic devices, carbon nanotubes, and nanowires. Research activities will also include examining multiscale phenomena and developing high performance algorithms targeted at simulating and modeling the properties of advanced materials.