CENTER FOR NANOSCALE SCIENCE AND TECHNOLOGY

University of Illinois at Urbana-Champaign

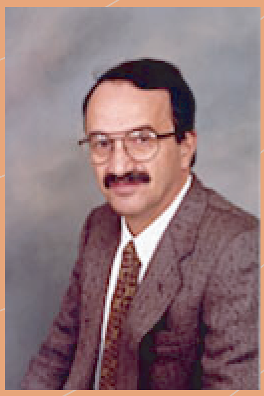
CENTER FOR NANOSCALE CHEMICAL-ELECTRICAL-MECHANICAL MANUFACTURING SYSTEMS

Nanotechnology: Feynman's "Room at the Bottom" and the Tyranny of Large Systems

Richard Feynman's famous essay "There is plenty of room at the bottom" has initiated much interest in nano-science research and many of Feynman's dreams have become reality as semiconductor devices approach atomistic length-scales. It has become clear, however, that any room gained at the "bottom" brings ever growing necessities for the large systems that are felt by design engineers as smothering tyranny. A well known example is the heat generation of VLSI systems. Any resolution of these problems is connected to enormous costs for the chip industry and is therefore only available for the conventional technology and not for new and risky ideas. The problems of scaling novel devices for conventional systems are therefore insurmountable at universities and smaller research institutions and it is natural to look for new and revolutionary systems in connection with new and revolutionary devices. In this lecture, I will discuss two proposals for new types of system design: (i) systems that work in analogy to the biological systems of nature and (ii) systems based on the principles of quantum mechanics e.g. the Quantum Computer.

The only working giant systems containing nano-devices are the actual objects of biology. It is well known that great advances in the understanding of these systems are being made, e.g. by DNA research. Ion channels, the transistors of nature, are less widely known, yet probably more important for the development of artificial systems that imitate biology. I will discuss these ion channels and possible artificial implementations using carbon nanotubes.

The realization of the quantum computer is still further off in the future. The basic element of quantum information is the Qubit. Practical implementations of Qubits are not yet available. I will therefore only discuss aspects of the physics of Qubits and quantum information and introduce an elementary system of Qubits that can solve special problems and may be realizable in the not too distant future by semiconductor devices. A critical view of difficulties in the theory of Qubit entanglement will also be given.



Karl Hess

Professor of Electrical & Computer Engineering
and Beckman Institute
University of Illinois at Urbana-Champaign

Karl Hess received his Ph.D. (Physics/Math) from the University of Vienna (Austria) in 1970. He is a Swanlund professor and Center for Advanced Study professor of Electrical and Computer Engineering at the University of Illinois and a full-time faculty member in the Beckman Institute; Computational Electronics Group. His fields of professional interest are semiconductor physics, computational electronics, quantum transport, and quantum information.

Some of Dr. Hess' honors include: Swanlund Endowed Chair, UIUC; Center for Advanced Study UIUC; Honorary Doctor of Sciences, ETH Zuerich 2003; Heinrich Welker Award 2001 UIUC; D. C. Drucker Tau Beta Pi Eminent Faculty Award, U of I (1995); IEEE David Sarnoff Field Award (1995); L. A. Friedrichs University Scholar (1993); IEEE-Electron Devices Society J. J. Ebers Award (1993); Beckman Associate, Center for Advanced Study, U of I (1982-1983); Fulbright Scholar (1973-1974); Fellow, IEEE; Fellow, AAAS; Fellow, APS; Fellow, American Academy of Arts and Sciences; National Academy of Engineering 2001; National Academy of Sciences 2003; Who's Who in America, and others.

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