

# The Application of Nano-scale Technology on Future IT Industry



**Professor R. Stanley Williams**  
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**Date:** 17 February 2006, Friday  
**Time:** 1 – 2 pm  
**Venue:** Engineering Auditorium (Blk EA)  
Faculty of Engineering

There is currently a tremendous business incentive to invent new electronic devices and circuits that will have dimensions of the order of nanometers. In addition, new fabrication techniques will be required that can inexpensively produce and connect these devices in vast quantities. The challenges are equivalent to those faced by the inventors of both the transistor and the integrated circuit, who replaced the existing vacuum-tube and wiring technologies with solid-state switches and lithographic fabrication, respectively. In order to satisfy both requirements simultaneously, we have assembled a trans-disciplinary team of chemists, physicists, engineers, computer scientists and mathematicians at HP Labs.

Two complementary research areas relevant to future nanocomputing systems are currently under investigation: (1) nano-scale switching devices and circuits for both electrons and photons, and (2) the development of new and inexpensive fabrication techniques. Our approach for the construction of electro-photonic circuits involves the explicit incorporation of defect tolerance, which is the capability to operate perfectly even in the presence of manufacturing mistakes in the circuit, into the design of the system. This prerequisite arises from the realization that it is prohibitively expensive to fabricate a perfect network of billions of nanoscale components. However, by introducing the appropriate amount of redundancy and utilizing concepts from coding theory, arbitrary complexity can be programmed into a highly regular structure and at the same time any defects can be avoided.

Our research group has recently demonstrated the ability to fabricate electronic devices with sub-viral length scales (e.g. ~15 nm) and to build nanoscale devices with the capability to perform signal restoration and inversion (required for universal computing) without the need for transistors or any semiconductor at all. This has led us to discover an entirely new logic family based on the Boolean "Implication" operation that is specifically suited to the properties of nanoscale switches and crossbars. We have built and demonstrated memory and logic circuits based on these new ideas that exceed the density of today's semiconductor circuits by one to two orders of magnitude.

I will describe how fundamental research in a corporate research laboratory can be a strategic asset for the company, and how it is possible to mix curiosity-driven discovery with invention by the proper choice of research area.

## About The Speaker

R. Stanley Williams is an HP Senior Fellow at Hewlett-Packard Laboratories and founding Director (since 1995) of the HP Quantum Science Research (QSR) group. There are five HP Senior Fellows out of a total technical staff of ~40,000 at Hewlett-Packard. The QSR was established to prepare HP for the major challenges and opportunities ahead in electronic, photonic and mechanical device technology as features continue to shrink to the nanometer size scale, where quantum mechanics becomes important. He received a B.A. degree in Chemical Physics in 1974 from Rice University and his Ph.D. in Physical Chemistry from U. C. Berkeley in 1978. He was a Member of Technical Staff at AT&T Bell Labs from 1978-80 and a faculty member (Assistant, Associate and Full Professor) of the Chemistry Department at UCLA from 1980 – 1995. His primary scientific research during the past thirty years has been in the areas of solid-state chemistry and physics, and their applications to technology. This has evolved into the areas of nanostructures and chemically-assembled materials, with an emphasis on the thermodynamics of size and shape. Most recently, he has examined the fundamental limits of information and computing, which has led to his current research in molecular electronics. He has received awards for business, scientific and academic achievement, including the 2004 Joel Birnbaum Prize (the highest internal HP award for research), the 2000 Julius Springer Award for Applied Physics, the 2000 Feynman Prize in Nanotechnology, the Dreyfus Teacher-Scholar Award and the Sloan Foundation Fellowship. He was named to the inaugural Scientific American 50 Top Technology leaders in 2002 and then again in 2005 (the first to be so named twice), and the molecular electronics program he leads was named the Technology of the Year for 2002 by Industry Week magazine. In 2005, the US patent collection that he has assembled at HP was named the world's top nanotechnology intellectual property portfolio by Small Times magazine, and the Wall Street Journal named the crossbar latch as one of the 30 major technology breakthroughs of the year. He was a co-organizer and co-editor of the workshop and book "Vision for Nanotechnology in the 21st Century", respectively, that led to the establishment of the U. S. National Nanotechnology Initiative in 2000. He has been awarded forty-five US patents with more than fifty pending, he has published over 270 papers in reviewed scientific journals, and he has written several general articles for technical, business and general interest publications (including an article in the Nov. 2005 issue of Scientific American). One of his patents was named as one of five that will "transform business and technology" by MIT's Technology Review in 2000. He has presented hundreds of invited plenary, keynote and named lectures at international scientific, technical and business events, including the 2003 Joseph Franklin Lecture at Rice University, the 2004 Debye Lectures at Cornell University, the 2004 Herman Bloch Lecture (and medal) at the University of Chicago, and the 2005 Carreker Engineering Lecture at Georgia Tech.

**All Are Welcome**

**Hosted by Nanoscience and Nanotechnology Initiative**