Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

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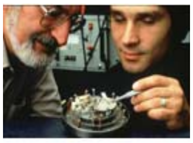
Factsheet

A History of Nanotechnology Milestones at IBM Research

IBM marks more than two decades of nanotechnology leadership. Two milestone IBM inventions—the Scanning Tunneling Microscope (STM) in 1981 and the Atomic Force Microscope (AFM) in 1986—provided researchers around the world with the specialized tools they needed to explore the nano-cosmos and manipulate materials at the atomic level for the first time.

Highlights spanning more than a quarter century of nanotechnology innovations from IBM Research Labs include:

1981
Scanning Tunneling Microscope (STM)



IBM scientists at the Zurich Research Laboratory invent the STM, giving ready access for the first time to the nanoscale world of individual atoms and molecules on electrically conducting substrates.

1986
Atomic Force Microscope (AFM)

The AFM, invented by IBM Fellow and Nobel Laureate Gerd K. Binnig, is quickly becoming the workhorse of nanoscience, providing general purpose imaging and manipulation in the nanometer realm.

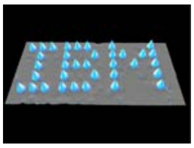
1986
Nobel Prize in Physics for the STM

IBM scientists Gerd K. Binnig and Heinrich Rohrer receive the Nobel Prize in Physics for the invention of the STM.

1988
Measuring Photon Emission at the Nanoscale

IBM scientists observe photon emission from local nanometer-size areas stimulated by a scanning tunneling microscope, allowing phenomena such as luminescence and fluorescence to be studied on the nanometer scale.

1989
Atom Manipulation

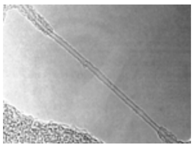


IBM Fellow Don Eigler is the first to controllably manipulate individual atoms on a surface, using the STM to spell out "I-B-M" by positioning 35 xenon atoms, and in the process, perhaps creating the world’s smallest corporate logo.

1991
Atomic Switch

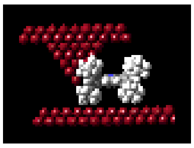
IBM scientists demonstrate an atomic switch, a significant milestone on the road to the eventual design of electronic devices of atomic dimensions.

1993
Discovery of Single-Wall Carbon Nanotubes



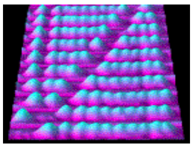
Scientists at IBM and NEC independently discover single-wall carbon nanotubes and the methods to produce those using metal catalysts.

1996
Atom Manipulation at Room Temperature



IBM Zurich scientists extend STM manipulation techniques to position individual molecules at room temperature for the first time.

1996
Nano-Abacus

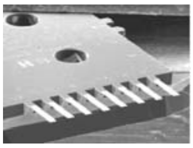


The world's smallest abacus is created out of 10 atoms by scientists at IBM’s Zurich Lab, another major milestone in engineering at the nanoscale.

1998
Molecular Wheel

IBM Zurich scientists and partners discover a molecular wheel, which shows promise for making nanoscale mechanical gears and motors.

2000
Nano-Nose



Scientists from the IBM Zurich Research Lab and University of Basel develop nanomechanical sensors using tiny silicon fingers to detect minute quantities of biochemical substances and to recognize specific patterns of DNA.

2001
Constructive Destruction

IBM's "constructive destruction" method overcomes major hurdle for building computer chips beyond silicon with a method to separate semiconducting and metallic nanotubes to form a working transistor on the nanoscale.

2001
Single-Molecule Computer Circuit

IBM scientists unveil the world's first single-molecule computer circuit, carbon nanotube transistors transformed into logic-performing integrated circuits, a major step toward molecular computers.

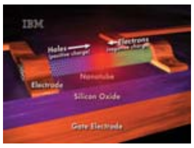
2002
Molecules Cascades

IBM researchers build world's smallest operating computing circuits using a molecule cascade, wherein molecules move in a manner analogous to falling dominos.

2003
3D Self Assembly of Nanoparticles

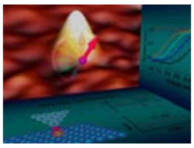
Scientists from IBM, Columbia University and the University of New Orleans demonstrate the first three-dimensional self assembly of magnetic and semiconducting nanoparticles, a modular assembly method that enables scientists to bring almost any materials together.

2003
Carbon Nanotube Light Emitter



IBM scientists demonstrate the world's smallest solid-state light emitter, suggesting that carbon nanotubes may be suitable for optoelectroinics.

2004
Spin-flip Spectroscopy

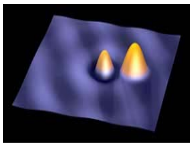


IBM scientists develop a new technique called “spin-flip spectroscopy” to study the properties of atomic-scale magnetic structures. They use this technique to measure a fundamental magnetic property of a single atom—the energy required to flip its magnetic orientation.

2004
Measuring Electron Spin

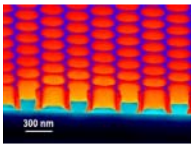
IBM scientists measure the tiny magnetic force from a single electron spin using an ultra sensitive magnetic resonance force microscope, showing the potential of vastly extending the sensitivity of magnetic resonance imaging.

2004
Atomic Storage



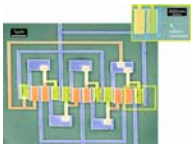
Scientists at IBM’s Zurich Research Labb manipulate and control the charge state of individual atoms. This ability to add or remove an electron charge to or from an individual atom can help expand the scope of atom-scale research. Switching between different charge states of an individual atom could enable unprecedented control in the study of chemical reactivity, optical properties, or magnetic moment.

2005
Slowing the Speed of Light



Using nanoelectronic fabrication technologies, IBM researchers create a tiny device that slows the speed of light, representing a big advance toward the eventual use of light in place of electricity in the connection of electronic components, potentially leading to vast improvements in the performance of computers and other electronic systems.

2006
Complete Carbon Nanotube Integrated Circuit

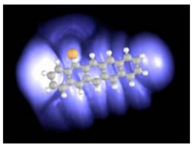


IBM researchers build the first complete electronic integrated circuit around a single “carbon nanotube” molecule, a new material that shows promise for providing enhanced performance over today’s standard silicon semiconductors. Importantly, the beakthrough builds on standard semiconductor processes, using a single molecule as the base for all components in the circuit.

2006
Controlling Atomic Magnetism

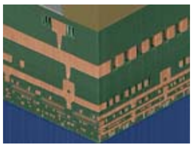
IBM scientists develop a powerful new technique for exploring and controlling atomic magnetism, an important tool in the quest not only to understand the operation of future computer circuit and data-storage elements as they shrink toward atomic dimensions, but also to lay the foundation for new materials and computing devices that leverage atom-scale magnetic phenomena.

2006
Controlling Metal-Molecule Contacts



IBM Zurich researchers explored the quantum mechanical effects of attaching gold atoms to a molecule. The work demonstrated that it is not only possible to control the atomic-scale geometry of a metal-molecule contact, but also its coupling strength and the phase of the orbital wave function at the contact point.

2007
"Airgap" Technology



IBM demonstrates the first-ever manufacturing application of "self assembly" used to create a vacuum—the ultimate insulator—around nanowires for next-generation microprocessors for its "airgap" chip technique.

2007
Magnetic Resonance Imaging (MRI) on the Nanoscale

IBM researchers develop MRI techniques to visualize nanoscale objects. This technique brings MRI capability to the nanoscale level for the first time and represents a major milestone in the quest to build a microscope that could "see" atomic structures in three dimensions.

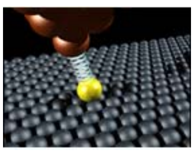
2006
Single Molecule Switch and Memory Element

IBM Zurich researchers demonstrate how a single molecule can be switched between two distinct conductive states, which allows it to store data. The researchers found that certain types of molecules reveal intrinsic molecular functionalities that are comparable to devices used in today's semiconductor technology, a promising result in exploring molecular building blocks for future memory and logic devices.

2007
Impact Ionization Field Effect Nanowire Transistor

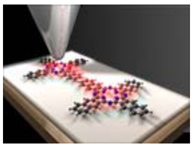
IBM Zurich researchers demonstrate the first impact ionization field effect transistor in a nanowire architecture. Such nanowire transistors use much less voltage for switching. Semiconducting nanowires are a promising technology for extending the CMOS roadmap.

2007
Measuring Atomic Anisotropy



IBM scientists measure the magnetic anisotropy of a single atom. This property determines an atom’s ability to store information. The breakthrough is a major step in understanding the ability for single atoms to maintain a specific magnetic direction, making them suitable for future data storage applications.

2007
Molecular Logic Switch

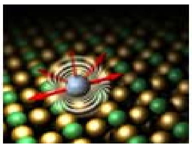


IBM researchers unveil the first single-molecule switch that can operate flawlessly without disrupting the molecule's outer frame. In addition, the researchers also demonstrate that atoms inside one molecule can be used to switch atoms in an adjacent molecule. This represents a rudimentary logic element and paves the way toward building computing elements at the molecular scale that are vastly smaller, faster and use less energy than today's computer chips and memory devices.

2007
Nanoprinting

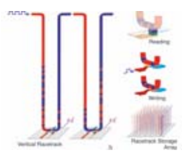
IBM Zurich researchers in collaboration with scientists from the ETH Zurich demonstrate a new, efficient and precise technique to print at the nanoscale, using particles only 60nm in size. The method could advance the development of nanoscale biosensors, of lenses that can bend light inside future optical chips, and the fabrication of nanowires that might be the basis of tomorrow’s computer chips.

2008
Measuring the Force to Move an Atom



IBM scientists, in collaboration with the University of Regensburg in Germany, are the first ever to measure the force it takes to move individual atoms on a surface. This fundamental measurement provides important information for designing future atomic-scale devices: computer chips, miniaturized storage devices, and more.

2008
"Racetrack" Memory



IBM scientists achieve a breakthrough in a nanoscale memory technology dubbed "racetrack" memory. An electric current is used to slide—or "race"—tiny magnetic patterns around the nanowire "track," where the device can read and write data in less than a nano-second. This could lead to electronic devices capable of storing far more data than is possible today, with lightning-fast boot times, far lower cost and unprecedented stability and durability.

More information

Dr. Karin Vey
Communications Manager
IBM Zurich Research Laboratory
Phone +41 (0)78 890 88 44
vey@zurich.ibm.com