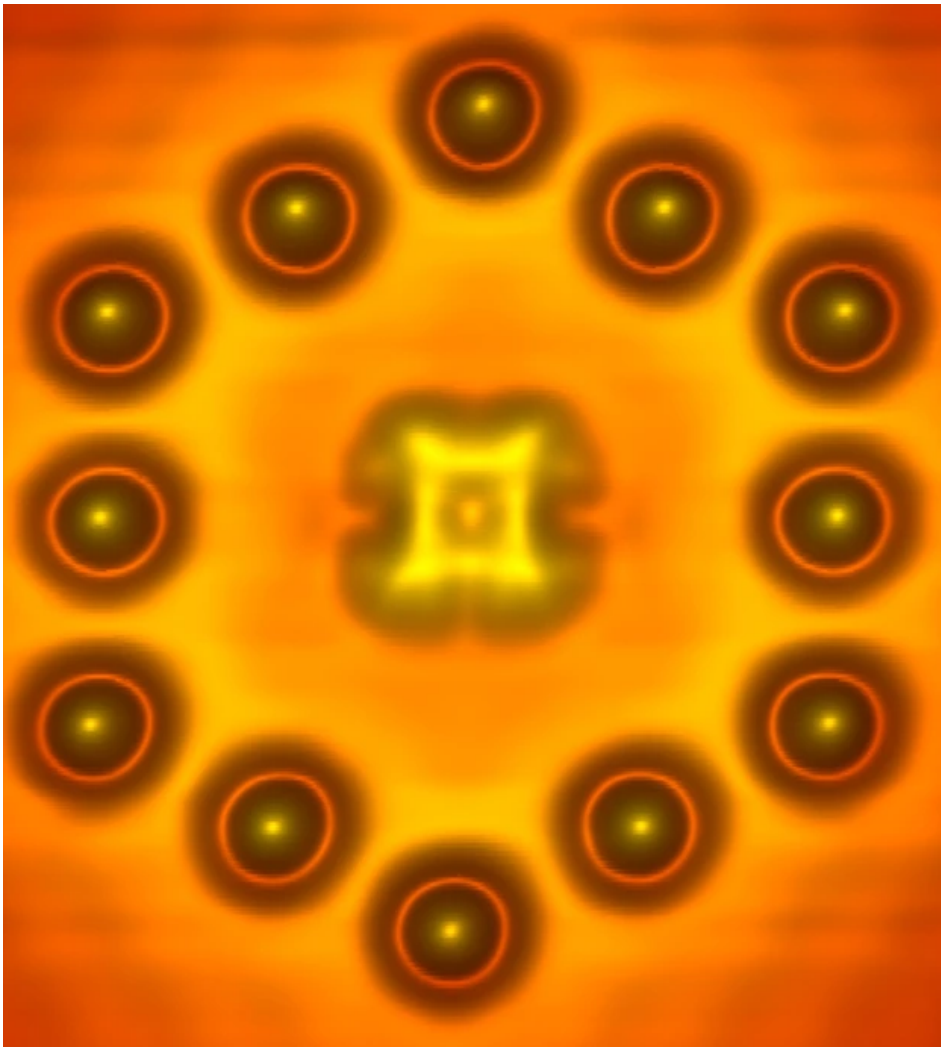
At the limit of Moore's law: scientists develop molecule-sized transistors

Researchers find transistors can be produced consisting of atoms 600,000 times thinner than a human hair – paving way for atom-scale chips

Samuel Gibbs, July 21, 2015,
http://www.theguardian.com/technology/2015/jul/21/limit-law-scientists-molecule-sized-transistors-atoms-chips

Scientists have created a transistor made up of a single molecule. Surrounded by just 12 atoms, it is likely to be the smallest possible size for a transistor – and the hard limit for Moore’s law.

The transistor is made of a single molecule of phthalocyanine surrounded by ring of 12 positively charged indium atoms placed on an indium arsenide crystal, asrevealed in the scientific journal Nature



Phthalocyanine molecule in centre of transistor is surrounded by 12 positively charged indium atoms. Photograph: US Naval Research Laboratory

Physics.

Each indium atom is 167 picometres in diameter, which makes them 0.167nm wide or 42 times smaller than the very smallest circuits currently possible, asrecently revealed by IBM.

For comparison a strand of human hair, at 100,000nm thick, is about 600,000 times wider than the atoms surrounding the new transistor. A red blood cell is a 36,000 times bigger, at 6,000nm in diameter. Even a strand of DNA is 15 times bigger at 2.5nm wide.

The transistor represents a big step forward toward quantum computing, and was made possible using a scanning tunnelling electron microscope to place atoms in exact positions and control the electron flow through the gate.

Typically scientists working to this atomic scale have struggled to reliably control the flow of electrons, which are difficult to contain and can jump outside of the transistor, rendering it useless.

The international team of researchers from Paul-Drude-Institut für Festkörperelektronik and the Freie Universität Berlin, Germany, the NTT Basic Research Laboratories, Japan, and the US Naval Research Laboratory also discovered unexpected behaviour from the transistor. The orientation of the molecule of phthalocyanine – an organic molecule typically used in dyes – at the heart of the transistor is affected by charge.

Its orientation could be changed by altering its charge, leading to more than a simple on-off switch-like state as seen in traditional transistors.

The work proves that precise control of atoms to create a transistor smaller than any other quantum system available is possible and opens the door to further research into harnessing these tiny transistors for computers and systems with orders of magnitude more processing power than today’s machines.

Chip manufacturers have struggled to maintain Moore’s law, which dictates that processing power will double every 18 to 24 months, primarily through the doubling of the number of transistors they can fit on a chip. The more transistors that can fit on a chip, the more powerful it can be.

Chips used in computers are currently made at the 14nm scale, but going smaller has proven difficult, with 7nm the latest breakthrough. While single-molecule transistors are nowhere near being ready to put into a chip, this new research will help bring about quantum computing, widely considered to be the next stage in the evolution of computers.