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Atomic tweezers heave and haul

Crystals need to built ‘brick by brick’ for computers of the future, says **S.Ananthanarayanan**

Railway engineers used a novel method to lift massive girders while building the bridge over Thane creek. The girders were loaded on rafts and towed near the bridge piers. During high tide, the girders rose high enough to be jacked and positioned over the piers. When the tide ebbed, the girders were placed!

Nanoscience in computers

Computers really became possible with the development of transistors, which are electronic components the size of a thumbtack. But the real revolution came with the integrated circuit, which was a whole army of microscopic transistors built on a sliver of silicon. The method used is to ‘draw’ tiny circuit diagrams on crystals by optically reducing the size of normal circuit diagrams. The circuit elements, transistors, diodes (which are elements that control the passage of electric currents) then get deposited on the silicon crystal, along with conductors that connect the elements together.

Arrays of atoms.

Now, with the demand for increased power and speed of computing devices, this technique, too, is becoming ineffective. This is largely because the communication between elements is now too slow, or the crystals are not big enough to contain all the elements. Techniques have thus been developed to deposit individual atoms, or groups of atoms, on the face of a crystal, to cut both size as well as time for communications!

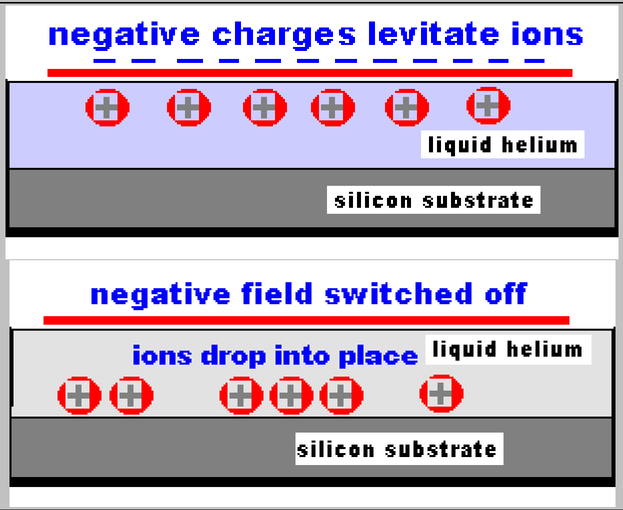
Don Eigler of IBM is celebrated for using the method to write the letters “IBM”, using xenon atoms on a nickel substrate.

Does not help mimic transistors

The difficulty with Eigler’s method is that it needs to ‘push’ the atoms around on the base, which does not work when the atoms to be placed have an affinity for the atoms in the base. In making useful electronic devices, there is a call to place phosphorus on silicon, for instance. As phosphorus tends to ‘bond’ with silicon, it just ‘sticks’ to the silicon base if it touches anywhere, and then cannot be moved to its correct place. The challenge was then to place the phosphorus at just the right place. Rather like the problem of lifting a heavy concrete girder and placing it just over the pier caps!

Floating the phosphorus ions

The method actually developed is uncannily similar to the trick of the railway engineers. The surface of the silicon is coated with a thin film of helium, at a temperature just above absolute zero. At this temperature, helium becomes a ‘superfluid’, or a fluid that flows without any resistance.



Phosphorus, in the form of charged ions, is then deposited on the liquid helium pool. Normally the ions would sink, but because they are charged, an electric field can keep them afloat. Again, as they are charged, they mutually repel and form into a regular, array-like pattern, known as a ‘Wigner crystal’. The array is manipulated as required, and when things are perfect, it is dropped into place by just evaporating the helium, the equivalent of ebb tide!