Quantum Science could Provide Faster Chips

Researchers at the University of Wales, Bangor and the Jet Propulsion Laboratory in Pasadena have invented a new way of etching micro-chips which, in theory, can produce much smaller circuits than current 'classical' methods. In the 25 September issue of Physical Review Letters, they show that in quantum theory so-called 'entangled' light-particles, or photons, can give a much higher resolution than 'normal' light focussed through a lens. The authors call this 'quantum lithography'.

Traditionally, the circuits on micro-chips are produced by etching with light. Between the chip and the light source, a mask prevents light from illuminating certain areas. The exposed areas are then removed with chemicals, resulting in a circuit. However, it has been known since the nineteenth century that the size of the smallest features you can see with light is about half a wavelength of the light used. As a consequence, we can only create circuits as small as that.

Quantum mechanics changes the story. It dictates that every particle has corresponding wave properties, and the more energetic the particle, the shorter its wavelength. Quantum lithography effectively shortens the wavelength by making the photons work as a collective.

'The trick is to keep all the photons together, so that they behave like a single particle, a sort of 'multi-photon,'' says Pieter Kok, a Dutch PhD student studying at the University's School of Informatics. 'When the photons behave like a single, more energetic particle, its wavelength seems shorter. On top of that, quantum lithography requires the multi-photon to interfere with itself.' This type of interference is a basic feature of quantum mechanics. The interference pattern consists of light and dark lines, half a wavelength apart. If you can make this wavelength smaller, you increase the resolution.

'This method could have far reaching implications for the micro-chip industry,' says Dr. Sam Braunstein, Reader at the University of Wales, Bangor. 'There are technical difficulties to be overcome, but this work has encouraged other scientist to address these problems.'

'This work offers such great opportunities. Currently, the smallest details on micro-chips are roughly 180-220 nm wide, the width of about 2000 atoms, or 400 times thinner than a human hair. With quantum lithography we could write details smaller than 25 nm, at which point the classical laws of physics break down and quantum effects come in. We might even go further and exploit these quantum effects. This would create a whole new type of computers,' he added.

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