# Semiconductors slow light

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'The speed of light' is a byword for the extremes of rapidity: nothing travels faster than light. But Chris Phillips of Imperial College in London and co-workers have found a new way to apply the brakes to light. As Phillips explains on Friday 21 April at the Institute of Physics Condensed Matter and Materials Physics conference, at the University of Exeter, he and his colleagues have shown that light passing through a sandwich of wafer-thin films of semiconductors can be slowed to less than 1/40th of its speed in empty space. And the researchers think that ultimately their semiconductor sandwiches could bring light to a complete standstill.

This kind of manipulation of the speed of light could be useful in schemes for processing information in the form of light pulses, rather than the electrical currents of conventional silicon-chip electronics. So-called optical information technology is already the standard means of transmitting information over large distances, by sending light down optical fibres; but if signals encoded in light particles (photons) can also be shunted around 'photonic circuits', equivalent to today's microelectronic circuits, that might make information technologies faster and more powerful.

Controlling the speed of light in such circuits could provide a way of synchronizing the signals, and even of storing information in 'frozen photons'. Devices that manipulate photons could also be used to create super-powerful quantum computers, which use the laws of quantum physics to perform calculations much more efficiently than today's supercomputers.

Making 'slow light' has been done before. It was first achieved in exotic materials: ultracold gases of metal atoms, cooled to within a whisper of absolute zero. Subsequently, researchers figured out how to use lasers to 'tune' the light-transmitting properties of solid, crystalline materials such as ruby so that a light beam passing through gets slowed down by its interactions with the atoms of the crystal.

Now Phillips and colleagues have found how to make 'designer' slow-light materials from the kind of semiconductors routinely used by microelectronic engineers. Light generally propagates through a material by bouncing between its atoms: each photon, a packet of oscillating electrical and magnetic fields, interacts with the electrons in the atoms in a way that is described by quantum theory. Exotic 'quantum optical' effects such as slow light can be created by using laser beams to alter the atoms' electronic states and thus to tamper with their interactions with photons, in effect making the photons dally longer with each interaction.

In a slab of semiconducting material such as silicon, the electronic states are too smeared out to permit this kind of fine-tuning. But in very narrow films of semiconductor, just a few nanometres thick, the electronic states are more sharply defined, and they can be adjusted by altering the film's thickness. Such thin slices are called quantum wells, and in effect they act like 'artificial atoms'.

Phillips and colleagues have shown that stacks of quantum wells made from the semiconductors indium gallium arsenide and aluminium indium arsenide have electronic states that can be tailored to manifest quantum-optical phenomena such as slow light. The layered films also display an unusual effect called 'gain without inversion', which enables a light signal to be amplified - the basic requirement for generating laser light - without first having to create the preponderance of high-energy electronic states required in conventional lasers.

Source: Institute of Physics