The Economist

Microlasers

Precipitate action

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MOST improvements in modern electronics are driven by the ability to shrink the size of components to truly diminutive proportions. The success of modern photonics—in which computer circuits use light rather than electrons to shuttle information around—may depend on a similar ability to miniaturise. For many key components of photonic circuits, such as small, efficient lasers, miniaturisation is already possible, but it involves expensive equipment and a lot of skilled labour. A paper in this week's *Applied Physics Letters* could be the first step to doing away with all that. Hui Cao, a physicist at Northwestern University in Illinois, has found a way to make lasers a thousandth of a millimetre across in a beaker of chemicals.

Large, table-top lasers come in many varieties, but all have the same basic ingredients. A cavity filled with a light-amplifying (or "gain") medium is surrounded by mirrors that prevent light from leaking out of the cavity. When the gain medium is pumped with energy, some of the electrons in its atoms get kicked into higher energy levels. As these electrons fall back into their original orbitals, they give off light, which bounces back and forth between the mirrors. Because this light is unable to escape, it stimulates the emission of even more light from the gain medium, until a single frequency begins to dominate. That frequency is strong enough to leak out of the cavity through one of the mirrors that has deliberately been made more weakly reflecting than the rest.

Lasers less than a thousandth of a millimetre across, or microlasers, function in basically the same way as their table-top counterparts, with carefully grown crystals (often made of a semiconducting material, such as gallium arsenide) acting both as the gain medium and as the mirrors. That is why these microlasers are so difficult and expensive to make. It takes fancy techniques such as photolithography or electron-beam lithography, which employ controlled beams of light or electrons, to carve out cavities that are just the right size and scatter virtually no light.

Dr Cao's lasers are cheap and easy to make because they are based on an entirely different principle. Instead of trying to minimise the light-scattering in a cavity, they exploit it. The idea behind these so-called random lasers is simple. If light is scattered so strongly that it goes almost everywhere, some is bound to bounce back into the cavity and get trapped there.

This phenomenon is called Anderson localisation. It was first discovered decades ago with electrons in solids. Since Anderson localisation depended on the wave nature of electrons, physicists quickly realised that it could work with light, too.

To get Anderson localisation to operate in a random laser has not been easy, mainly because it is hard to find a substance that both acts as a high-gain medium and scatters light very strongly. Prior to Dr Cao's work, a few other groups did indeed get powders and suspensions containing small particles to emit light, but that light—known as amplified spontaneous emission or ASE—did not have true laser-type qualities. The differences between ASE and laser emission are subtle (laser light is created by stimulating electrons to emit light rather than having them emit it spontaneously), but they matter for practical applications. Laser emission is far more efficient, and thus more likely to be useful in integrated circuits.

Dr Cao's group first solved the problem of using Anderson localisation to create a true laser last year, but the resulting devices were a millimetre across. That is too large for them to be considered true microlasers. Now, the team has shrunk the product to the requisite thousandth of a millimetre across, which will easily fit on a chip.

The biggest appeal of these new microlasers, however, lies in the simplicity with which they can be synthesised. They consist of clusters of zinc-oxide crystals, which are easily precipitated from a solution of zinc acetate in diethylene glycol (better known as antifreeze) at the right temperature. The clusters form the cavity that traps the light, and the zinc oxide itself acts as the gain medium.

Currently, Dr Cao's microlasers need to be pumped optically—that is, with a large, table-top laser—to do their job. This makes them difficult to use in integrated circuits. So she is now working out how to pump them electrically, using a tiny source of electrons that would also fit on a chip. The electron source of choice is another new piece of microtechnology, the carbon nanotube. Such tubes, which are cylindrical versions of "buckyballs", or soccer-ball-shaped carbon molecules, would be ideal sources of focused, energetic beams of electrons, as they are tiny and can be mass produced. Certainly, Dr Cao has found in carbon and antifreeze splendidly cheap materials for her microlasers—so long as they work.

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