GOLDEN SEEDS TO GROW NANOWIRE LASERS

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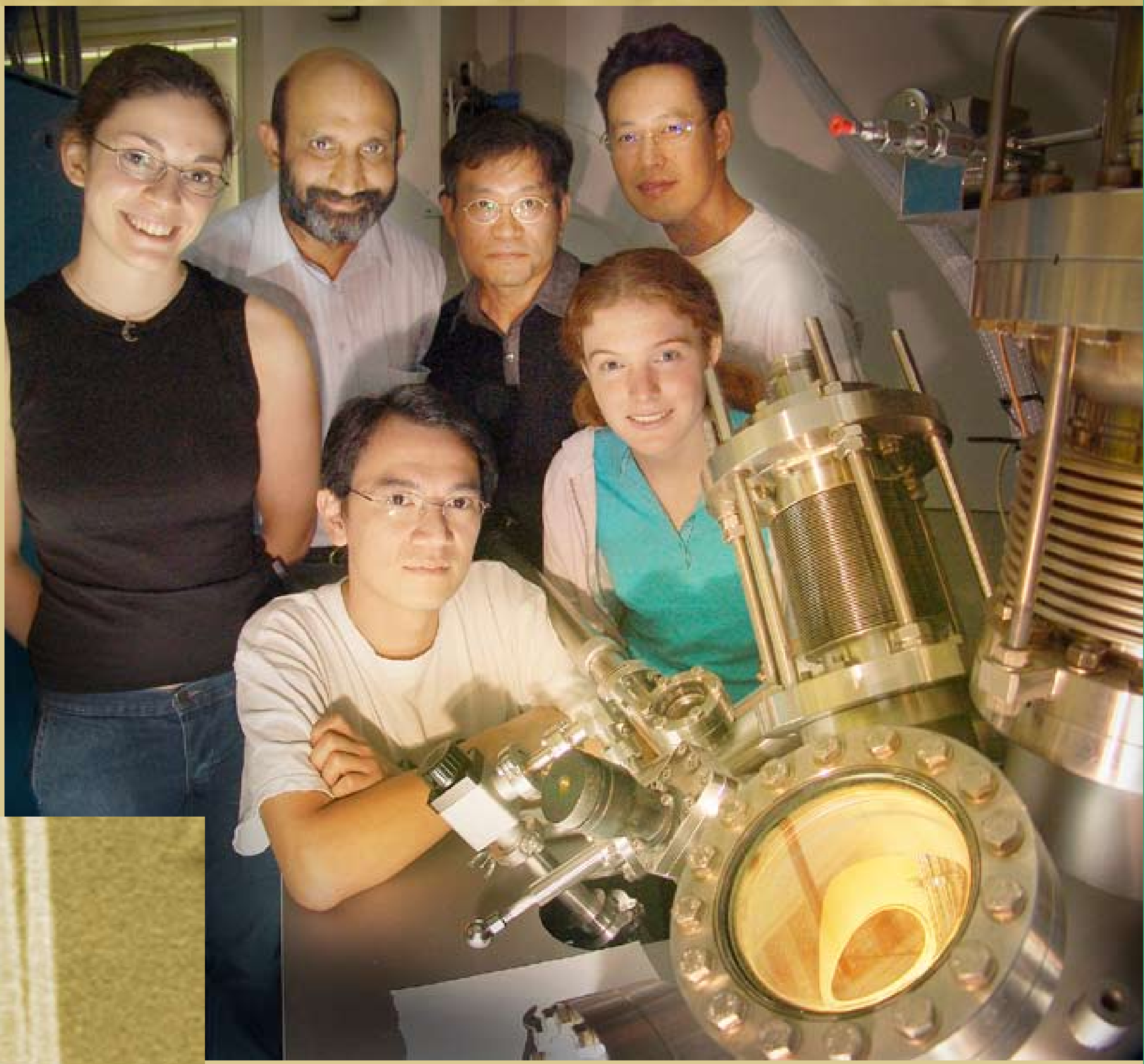
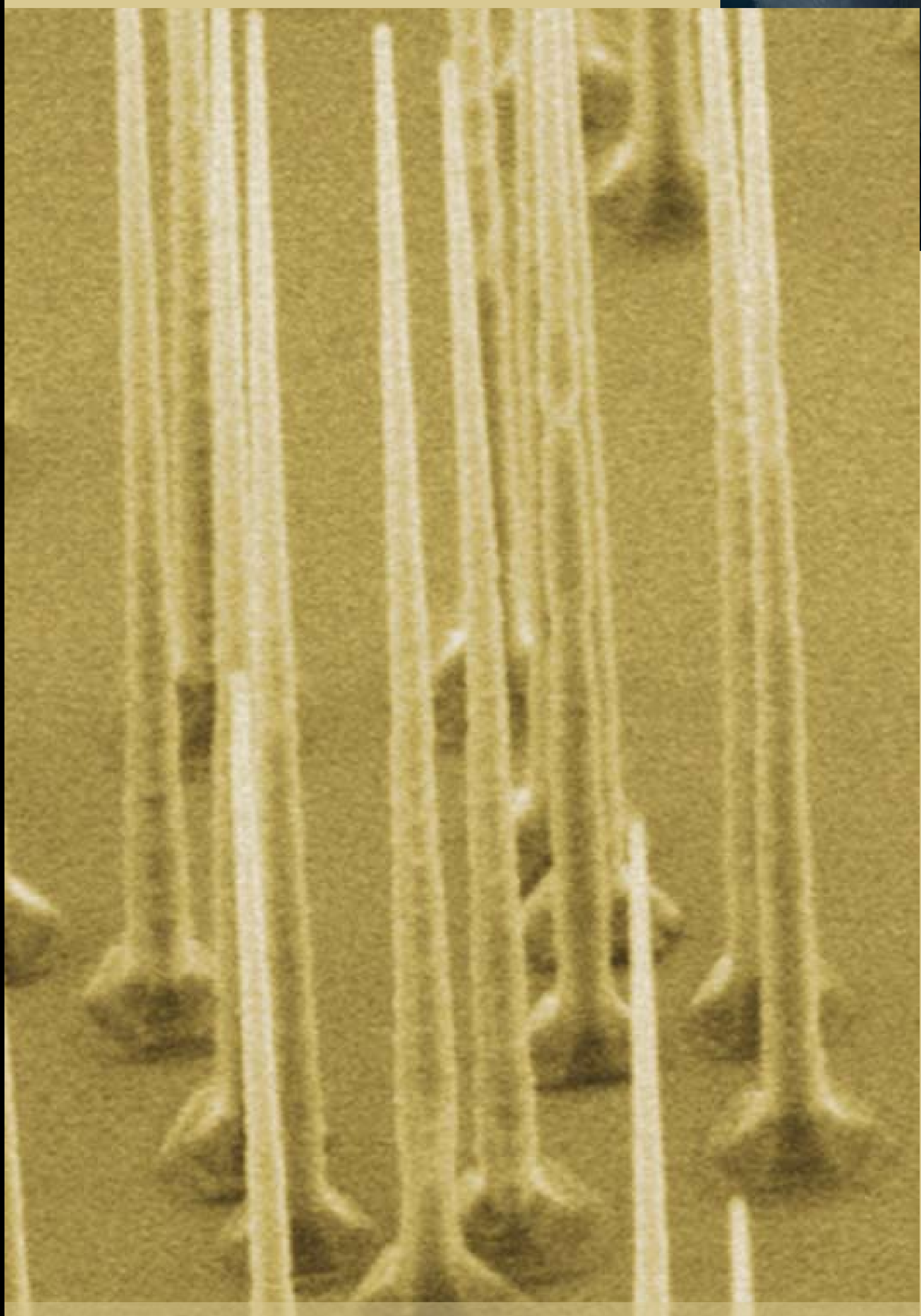
Gallium arsenide is a semiconductor with many applications in solid-state lasers and detectors. One way to make such devices is a technique known as Metal Organic Vapour Phase Epitaxy or MOCVD. A complex molecule is formed between an organic group and the metalic component atoms of the required semiconductor. When passed over a heated substrate wafer, the molecules dissociate, depositing their metallic cargo atoms on the surface where they combine with arsenic from arsine dissociation to form new layers of semiconductor crystal. By changing the composition of the gases, it is possible to grow layers with different properties creating the sandwich structures needed for devices. The wafers can then be cleaved into individual device chips. The problem is that some devices such as nanowire lasers, can't be grown in a large sheet then cut into individual chips. They have to grow straight up like tiny hairs rising from the wafer surface. To create such devices, scientists at ANU make use of an interesting property of gold/ gallium arsenide mixtures.





Nanowire lasers rise like skyscrapers from the substrate wafer. The base of these structures is only a couple of hundred atoms across.

At the right temperature and pressure, gold and gallium arsenide form a eutectic - an alloy of the two materials with a lower melting point than either of its components. If a wafer of gallium arsenide is covered with microscopic gold spots and heated to just the right temperature, a tiny pool of liquid eutectic forms below each spot. When the MOCVD reactor is tuned to this eutectic point the temperature is too low for efficient deposition onto solid Gallium Arsenide so the metal organic and arsine molecules deposit their semiconductor cargo on the wet eutectic below each gold seed rather than the wafer surface. This causes the material below the seed to grow and crystallise into miniature towers of perfect semiconductor pushing the gold seed and its eutectic base upwards as they do so.

Conventional fabrication techniques such as the masking and lithography used in computer chip manufacture, simply can't make gold spots small enough to seed good nanowires. So the ANU group use nanometer sized gold balls suspended in solution. Due to their inherent electrical charge, the tiny gold particles stick electrostatically to the surface of the specially prepared wafer in a similar way to toner on photocopy paper.

With the conditions set just right, these tiny seeds can grow perfect straight nanowires 50 times as long as their 200 atom thickness. The wires are then coated with another semiconductor, aluminium gallium arsenide, which has a lower refractive index. This creates a tiny optical fibre only a few tens of atoms across. At one end of these fibres is the original gold seed, which not only makes a good laser cavity mirror but also a perfect electrical contact.

Due to their tiny size, such nanoscale fibre lasers can be modulated at vastly higher speeds than conventional telecommunications lasers offering the potential to speed up the networks. They also have very low threshold lasing currents reducing power consumption and unwanted heating effects.

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