ScienceWise

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- **High marks at high cost?**
  Do syllabus pressures get in the way of good teaching?
- **Passionate about plants**
  New rural assistance scholarships aim to help students from the bush, fix the bush
- **Molecules with muscles**
  cyclodextrin molecular muscle offers smart material potential
- **Clearly Infrared**
  How the high infrared transparency of chalcogenide glass promises technological innovation
- **Flowers that tell lies**
  The extraordinary tricks used by orchids to lure pollinating insects

Volume 5 No. 4

ScienceWise

ANU College of Science Magazine

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Cover Image

NEWS

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The Editor's Corner

Seeking inspiration

Dr Tim Wetherell

It seems a very long time since I was at school, yet looking back, a lot of what happened in the grubby demountable buildings of that English government comprehensive had a profound effect on my life and my career.

In particular, I recall the physics teacher I had for years 7 and 8. He was an odd looking character we knew as Mr Childs but he was a great teacher. He knew his subject thoroughly and perhaps more importantly, he taught it in a dynamic and passionate way. Unfortunately from the schools perspective, he emigrated to Kenya in year 9. But by then, the seeds of what became my physics career had been planted. Five years later I was waving a less than tearful goodbye to the slums and derelict factories of my home town, as I too headed for sunnier climes.

I sometimes feel that the perception outside education is that to be a teacher you simply have to read a text book to the class. Nothing could be further from the truth. A good teacher inspires and motivates students. Takes complex and abstract scientific principles and brings them to life in a way the students can understand and relate to. Kindles a desire to learn that shapes a students career at a time in their lives when there are many distractions.

Students are the life blood of a university too. But any smart university recruiter knows that long before we see youngsters begin their science degrees, someone has had to inspire them to choose science subjects way back in their early teens. More often than not, that someone is a teacher. So supporting school teachers where ever possible makes good sense from a tertiary education perspective too.

One way we're able to do that at ANU is in the form of our professional development workshops for teachers run by the Centre for the Public Awareness of Science (CPAS). These workshops focus on explaining science in creative ways through the use of simple, familiar and easily obtained materials.

In a society that's becoming increasingly technology focussed, it's vitally important to get youngsters interested in science. Not all of them will go on to use it directly in their careers . But they will all participate in the decision making process that shape the world. And to do so effectively they must be well informed on science and technology issues.

I've no idea what became of Mr Childs in Africa, but I hope he's doing well. We need all the good science teachers we can get.

Perhaps not the most inspiring of settings, but good teaching can make a tremendous difference to students careers even when the resources and the setting are less than ideal.

High marks at high cost?

Do syllabus pressures get in the way of good teaching?

The chilling tale of the sinking of the Titanic, the physics of Olympic swimming, or a brief interlude to critique Pirates of the Caribbean are among devices teachers might use to lift a junior high school lesson on the physics of buoyancy.

However, many school teachers faced with heavy science syllabi, large class sizes, inadequate teaching and laboratory resources, and pressure to get exam scores up, are perhaps not getting as many opportunities as they would like to communicate classroom science in this way, says ANU postgraduate student Sean Perera from the Centre for Public Awareness of Science (CPAS). He fears that the upshot could be an exodus of students from science.

"Recent studies show that students in secondary school are losing interest in science. Fewer are opting to study science for the HSC and later at university."

The problem, expected to have big economic and social ramifications, has been blamed on the impression lower secondary school students get of science.

"The problem is not in primary school," says Perera, a microbiologist who did his undergraduate studies in India and his Masters degree in Sri Lanka. "Students are given the freedom to play around and experiment, but as soon as they start secondary school, they are not allowed to learn science that way. Science becomes textbook oriented and exam focused, and they don't like it anymore."

Many schools are forced to adopt the old-fashioned transmission method of instruction, he says. "To cover the extensive syllabus, the teacher has to stand in front of the class and just recite information."

A lesson on buoyancy would typically focus on an illustration of Archimedes' Principle with a force vector diagram, lifted from a textbook, explaining why a lump of wood might float rather than sink.

Although the transmission method is efficient in getting exam scores up, it makes it difficult for teachers to do what they do best; expose students to the excitement of scientific discovery – an experience that would motivate many to stay with science.

"The biggest problem is time limitation," says Perera. "Teachers are encouraged to reach for results, or outcomes. If schools are not producing enough students with high marks in science who go on to study science at university, it becomes difficult for principals to justify expenditure on science," he says.

Sean Perera

However, high marks could carry longer-term costs.

"There is a strong need for students to learn science in an inquiry based way," Perera says. "Many teachers like to teach through inquiry and exploration, but they don't have the luxury of time or the resources."

Perera is investigating ways to stem the tide. He is evaluating the impact of science communication training in professional development courses run by CPAS for science teachers. The workshops are held around Australia and overseas, including in Indonesia, Sri Lanka, Thailand and India. They focus on topics covered in the Years 7–10 curricula.

His results so far suggest that teachers buoyed by effective ways to communicate science are more adventurous in their teaching methods, coming up with their own creative ways, such as engaging examples and demonstrations, to get the science and the scientific method across.

"If they are structured well and have effective ways of communicating science, these workshops could empower teachers to teach science in more exciting ways," says Perera.

Teachers in Sri Lanka, for example, adapted a demonstration on the chemistry of fats and detergents by substituting coconut milk for cow's milk, he says. "The teachers became confident enough to play around with the science."

He wants to see schools reduce their reliance on textbooks and teaching guides, and give their students more practical experience. A good teacher is far more than a walking encyclopedia, he or she has the power to inspire youngsters to become all they can be.

For more information on CPAS teacher's workshops, see http://cpas.anu.edu.au/workshops

Passionate about plants

New rural assistance scholarships aim to help students from the bush, fix the bush

Australian agriculture and our native plant communities are currently facing a difficult period with drought, climate change and the propagation of pests all taking their toll. However Dr Adrienne Nicotra, a plant biologist from the School of Botany and Zoology, believes that with the application of the right science, we can make good much of the damage.

Dr Adrienne Nicotra

"We're fortunate to have many leading scientists from the fields of forestry, ecology, plant physiology and agriculture concentrated on the ANU campus, and also that we are in such close proximity to the CSIRO facilities at Black Mountain." She says. "But the key to success in any scientific program is people. Accordingly, we're very much on the lookout for promising students. Naturally we're keen to attract those with a high level of academic achievement, however over and above this, we want to attract young scientists who will be passionately motivated to develop scientific solutions to the current problems. We want to target students from rural areas in particular because we believe they will have direct experience of the current challenges facing plant sciences and strong desire to address them."

One of the current difficulties facing students from rural areas is the cost of interstate removal and travel to attend university. In an attempt to redress this problem, Dr Nicotra has initiated a program of sponsored rural assistance scholarships that help the brightest youngsters from the bush to come and study plant sciences at ANU. The first in what she hopes will be a series of these scholarships has been provided by the CSIRO Division of Plant Industry. Interested students are invited to see the website for further information . . .

http://cos.anu.edu.au/Plants

Molecules with muscles

Tim Wetherell

cyclodextrin molecular muscle offers smart material potential

Volume 5 No. 4

Karen Zhang came to ANU as an international student from China back in 2004 and is now completing her honours year in the PhB program – a unique degree structure that enables exceptional students to undertake research as part of their undergraduate studies. "As a PhB scholar, I love the opportunity to combine research with my studies. I find it really opens your mind and helps you get ahead" she says.

Karen is working in the Research School of Chemistry's Biochemical Reactions and Molecular Recognition group headed by Professor Chris Easton. Her area of interest is molecular muscles, a term given to a molecule that is able to change its physical dimensions when subjected to an appropriate stimulus. Earlier this year, Professor Easton's group achieved a world first by creating a cyclodextrin-based molecular muscle that can expand and contract when exposed to different wavelengths of light.

Cyclodextrins are complex toroidal molecules that can be created by the appropriate actions of enzymes on starch. One of their key features is that the exterior of the ring is hydrophilic, meaning they are highly soluble in water. The hollow interior is much less hydrophilic than the exterior, making cyclodextrins a good host for other smaller hydrophobic molecules that like to sit inside them.

The molecular muscles use two cyclodextrin rings. Through the centre of each ring passes a stilbene complex with a blocking group sealing the end to hold it in place. "You can imagine two molecular doughnuts each with a tail. Each ones tail passes through the hole of the other molecule forming a two ring complex" Karen explains. "Illumination with ultraviolet light at 350nm causes isomerisation of the stilbene resulting in a contraction of the system. The molecular complex can be re-expanded using light at 254nm."

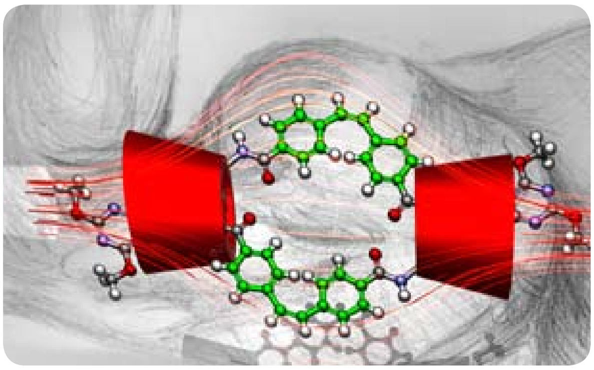


Illustration of the two interlocking cyclodextrin rings that make up the molecular muscle

Karen Zhang

Although the muscles can be cycled many times cis-stilbenes undergo competing reactions that have been suspected to cause the decomposition of the molecular muscle. Karen's honours project centres on trying to avoid this problem by substituting azobenzene as the photosensitive component.

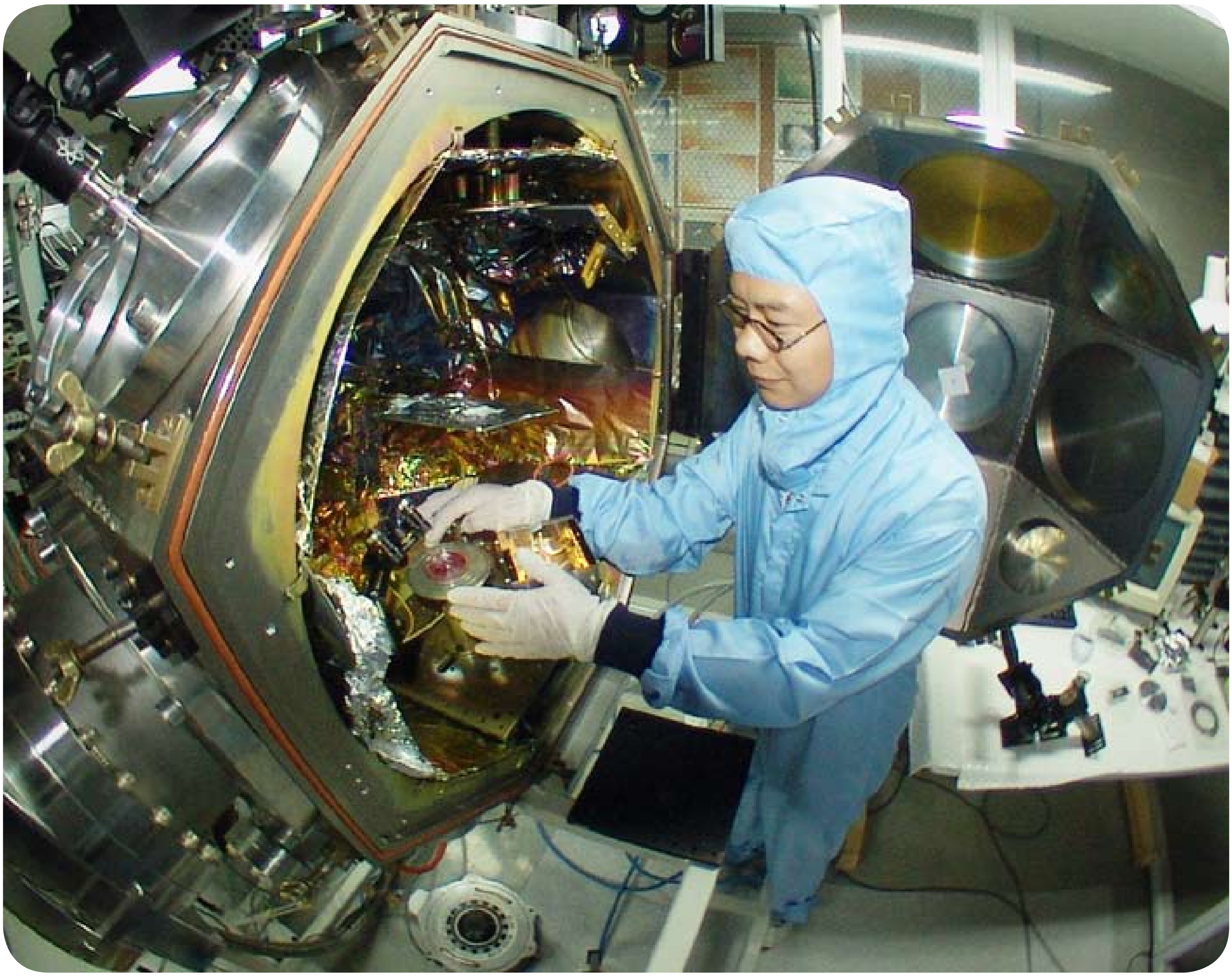
Part of the drive to develop artificial molecular muscles is the potential to use them in smart materials that can adapt to different environments. One example might be skin tight sports clothing that contracts around the wearer's body when in use then relaxes to ease getting in or out of the suit. Another might be pressure suits for pilots of high performance fighter aircraft, the suit contracting around the lower body to prevent blood draining from the brain in high G manoeuvres.

When asked why she chose to study chemistry Karen says, "Chemistry deals with fundamental particles. OK, maybe not so fundamental as physics, but atoms. And atoms are the building blocks of everything. I'm constantly amazed by the new and creative ways we can assemble atoms into all sorts of cool molecules with interesting and useful properties."

Clearly infrared

David Salt

How the high infrared transparency of chalcogenide glass promises technological innovation



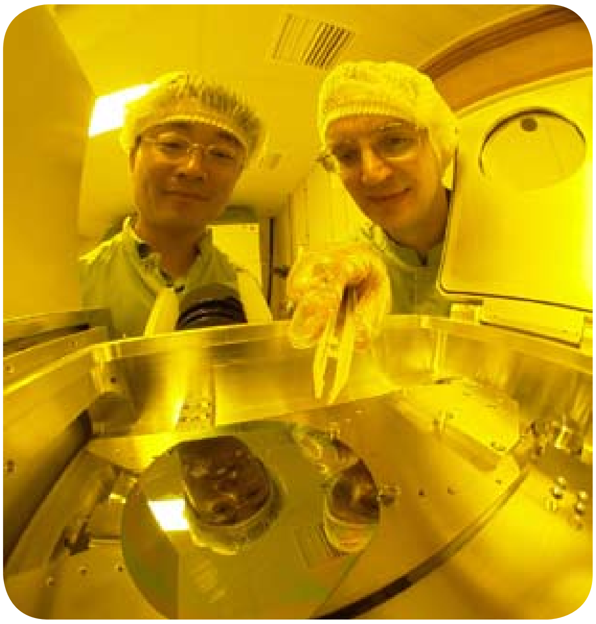
Dr Rong Ping Wang loading a target into the chamber for laser deposition

ANU researchers are setting new world records in processing a range of glass materials used to manipulate infrared light. Their results set the scene for a revolution in infrared technology that promises increased internet speed and much more besides.

Infrared light is that region of the electromagnetic spectrum that extends from the red end of visible light out to what we feel as radiant heat. It's a range of light wavelengths at the centre of many amazing applications that include remotely detecting explosives, chemicals and biological agents; dramatically speeding up internet communications; and even helping us detect earth-like planets in distant solar systems.

But working with infrared light has always been a challenge because, unlike other wavelengths in the visible spectrum, it doesn't transmit well through standard glass. However, there is a range of materials known as chalcogenide (pronounced chal – koj – enide) glasses that are excellent performers when it comes to the transmission of infrared light. If we could build tunable infrared sources and optical chips out of chalcogenide glass it would open up a new world of infrared usage. The reason it hasn't happened yet is because chalcogenide glass is devilishly difficult to work with.

"Chalcogenide glasses are basically alloys that contain one of the chalcogon elements on the periodic table," says Dr Steve Madden from the Laser Physics Centre. "These include sulphur, selenium or tellurium, and they're typically alloyed with elements like germanium, arsenic, gallium, antimony and silicon. These glasses are already used in thermal infrared night vision systems but up till now it's been a major challenge to take them the next step and use them in thin films as part of optical chips and waveguides.



Dr Duk Choi and Dr Steve Madden working with a plasma etcher

"The problems are two fold – producing a film of chalcogenide material with minimal defects and of the desired composition, and then processing it without introducing imperfections that will destroy its ability to transmit and manipulate infrared light."

And researchers at the Laser Physics Centre have made significant advances in both areas. First, in order to create superior quality chalcogenide films they employ an ultrafast pulsed laser to ablate chalcogenide glass targets. Atoms dislodged from the target are then deposited as a thin film.

"The material being deposited is quite literally ripped apart at the atomic level by a laser pulse about a millionth of a millionth of a second short with a peak power around a million Watts squeezed into a tiny fraction of a square millimetre," explains Dr Andrei Rode, the scientist who developed the unique ultrafast pulsed laser deposition system along with co-inventors Barry Luther-Davies and Eugene Gamaly at the Laser Physics Centre.

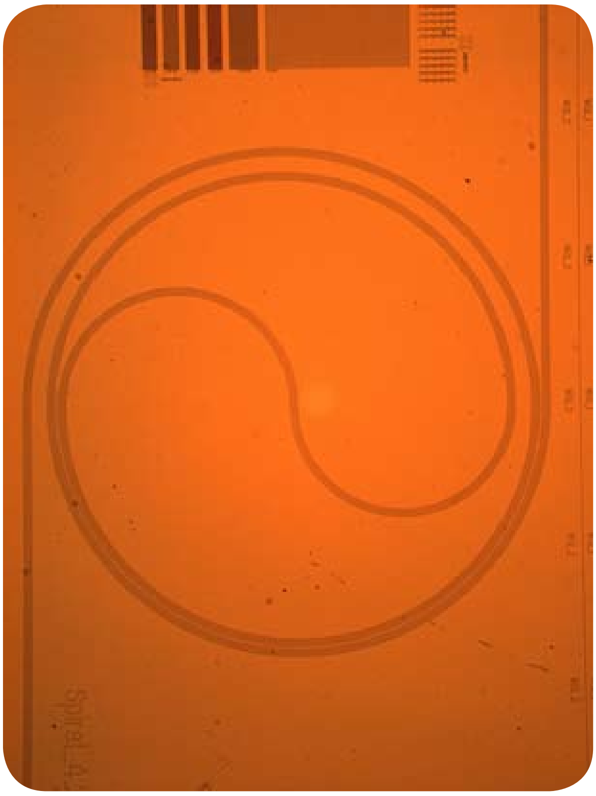
"Laser is the only clean tool where all the energy is harnessed in depositing the material you want without any contamination from the surrounding environment," says Dr Rode. "Our system is ideal for the growth of high-quality films of the desired composition without defects, which usually spoil the quality of light transmission along the films."

The second area of challenge is then taking these films and processing them into waveguides in ways that don't damage the glass. The team has crafted new techniques for chalcogenides which enable high resolution patterning and etching of the material without damaging it or introducing loss to the final device.

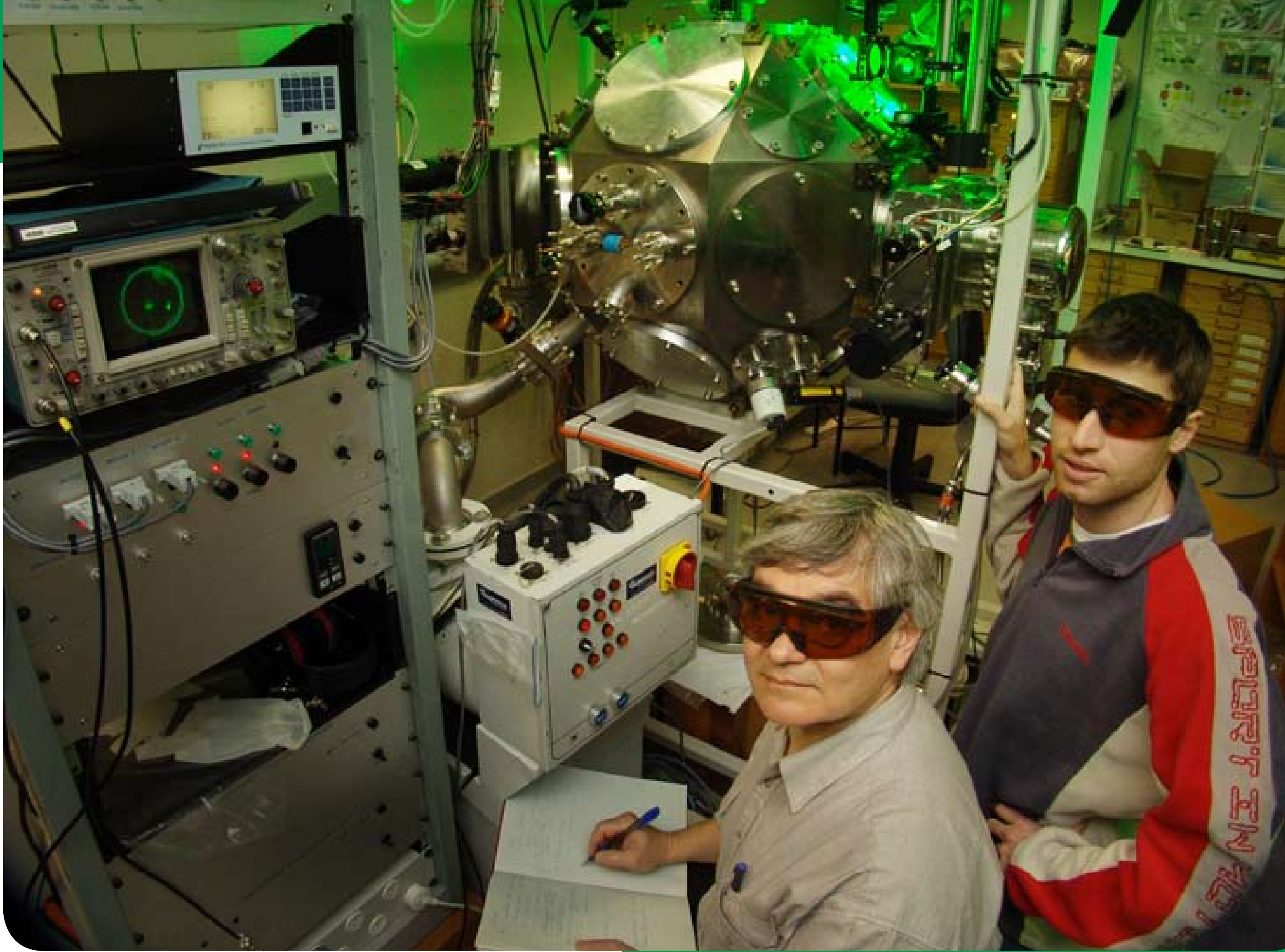
"Chalcogenide glasses are very sensitive to the chemicals traditionally used to define patterns in photoresist onto chips," Dr Madden, leader of the Planar Integration team at the Laser Physics Centre. "We've developed special etch recipes that enable us to get very smooth etch surfaces, far better than anyone else has ever demonstrated, and we've tailored the photolithography process to prevent the developer from attacking the chalcogenide. So, by combining those two steps we've been able to do very high quality handling and etching of the chalcogenide. And our methods use standard industry equipment so our techniques can be scaled up for industry.

"The advances we've made in producing higher quality films and more effective processing have produced results four to ten times better than anyone else worldwide."

The work is being undertaken within the ARC funded Centre for Ultrahigh Bandwidth Devices for Optical Systems (CUDOS). Their results are a huge leap towards making commercial infrared optical chips. The ANU group has successfully made optical wires up to 22 cm long that are essentially loss free.



The researchers have produced a chalcogenide waveguide measuring 22cm long, a world record.

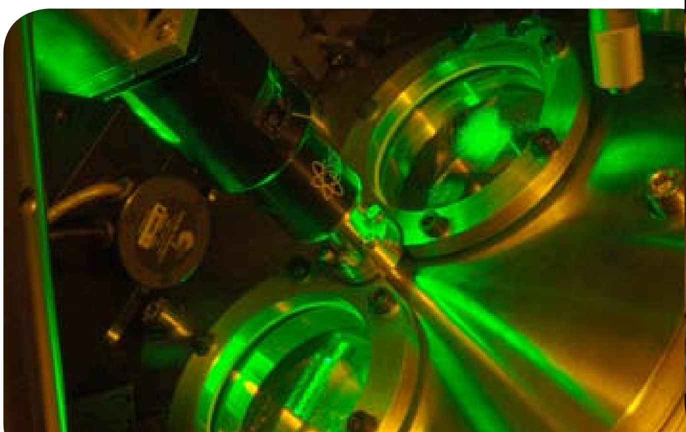


Dr Andrei Rode (left) and Nathan Madsen at work in the Laser Physics Centre.

Below: Dr Douglas Bulla tests a photonic chip

"The work we've been doing with CUDOS has been to trying to make long waveguides measured in the tens of centimetres," says Dr Madden. "Up until now the longest chalcogenide waveguides have been 6 cm long. We've now made them up to 22 cm and we're aiming for 50 cm. With wavelengths this long it's possible for non-linear processes to take place with the power of light coming out of an optic fibre. This makes these things perfect for optical chips."

In conjunction with other colleagues within the CUDOS Centre, the researchers are investigating the potential of the devices for 'All Optical' processing of ultra-high speed data traffic for telecommunications networks. As there are no electronics involved in this type of processing, it is expected that such devices may be able to process data at rates hundred times faster than electronic systems. In collaboration with the Danish Technical University all optical multiplexing at 640 Gb/s has already been demonstrated using an ANU device, illustrating the promise of this revolutionary technology.



Flowers that tell lies

Tim Wetherell

The extraordinary tricks used by orchids to lure pollinating insects

Orchids are far more common that many people might think. In fact they account for about one in ten of all flowering plant species. Some of the most famous ones grow epiphytically on rainforest trees but there are many others that simply grow on the forest floor amongst the other terrestrial plants.

Like many flowering plants, most orchids rely on insects to carry pollen from one plant to another. However, whilst most flowering plants offer a food reward to their pollinators, almost a third of orchid species resort to deception. In many cases this is a simple lie; the flowers look and smell like they would bear nectar but contain none at all. However, in other orchids, this deception can take quite bizarre forms such as sexual deception. To achieve this, the orchid produces strange flowers with dark globular growths on one petal that may bear a superficial resemblance to a female insect. However, in the insect world, good looks alone are not enough, the female's pheromone scent being the most important attractant for males. Accordingly, to complete the deception, the orchid flower produces molecules that mimic these pheromones. The scent, and to a lesser extent the flower's appearance, entice the male insects to land on it. When it does so, the orchid's unusually large pollen mass becomes attached to its body. Some orchids even go so far as to temporarily trap the male insect by closing their petals once it lands. To escape the insect has to squeeze past the sticky pollen bundle.

Of course given the diversity and abundance of sexually deceptive orchids, there has to be a mechanism by which they can ensure that the pollen from a particular orchid finds its way to another plant of the same species. Generally, this is achieved by each species of orchid targeting a single species of local insect, which in turn has its own specific pheromone.

Professor Rod Peakall from the ANU School of Botany and Zoology is one of the world's leading authorities on orchid pollination. Together with his research group, he's currently conducting a study of Australian terrestrial orchids that use sexual deception to lure pollinating insects.

"When we began our study of some 30 orchid species growing in the southern half of Australia, we imagined that we might find 30 different combinations of pheromone used to attract the pollinating insects." He says. "In fact so far it has turned out to be just four communication channels." This raises the question, how do orchids ensure that they don't attract the pollinator insects of different orchid species which could lead to hybridisation?

Professor Rod Peakall

The key to avoiding such hybridisation turns out to be locality. If two species live in geographically distant habitats, there is no danger of inter-pollination so they can both use the same pheromone mimic to attract the same insect species at the same time. "It's a bit like FM radio. Many different stations can transmit on the same frequency providing they are in widely separated parts of the country." Dr Peakall explains. "And of course conversely, if the two orchids share the same location, then they have to use a different pheromone mimic.

Apart from shedding light on the behaviour of orchids, this work has wider implications for evolutionary biology and especially for our understanding of speciation; the process by which populations of living things diverge into separate species that are no longer able to effectively interbreed. One of the most important mechanisms driving speciation is geographical isolation. Some members of a population become separated by large distances perhaps as the result of environmental changes or simply by chance. Each sub population then further evolves to suit its new habitat and eventually, the two groups become so genetically distant they form separate species.

However there is another more contentious speciation mechanism called sympatric speciation in which some new species form without this geographical separation. Dr Peakall believes that some of the orchid data point strongly to this possibility. In this case, it's the highly specific relationship orchids have with their insect pollinators that could drive the speciation. A small mutation can subtly change the orchid's pheromone mimicking molecule, for example it may become an isomer of the original (same chemical composition but different structure). Insect response to pheromones is highly specific, and such a change in the flower may change the pollination insect species it attracts. From that point on the two orchid populations would become effectively isolated from each other even though they still inhabit the same physical place. If this turns out to be the case, it will be one of the very few cases of sympatric speciation that has been directly observed.

Say it with flowers - it doesn't have to be true! Some species of orchid use elaborate and devious sexual deceptions to lure insect pollinators.

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