

FEATURES

The light at the end of the tunnel

Australian researchers are in a worldwide race to develop the first miniature photonic chip - a device that will use light in the same way that current chips use electrons.

While enormous machines gauge out seven metre wide tunnels from the hard rock beneath Martin Ams' feet as part of the Epping to Chatswood Rail Line, the Macquarie University PhD student focuses on making tunnels just five microns wide - one twentieth the width of a human hair - within a one centimetre piece of glass.

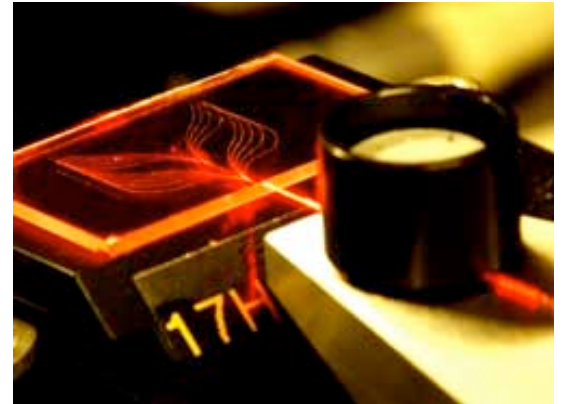
Ams' project is a vital part of the research being undertaken by the Centre for Ultrahigh-bandwidth Devices for Optical Systems (CUDOS), a collaborative venture combining the expertise of researchers at the CSIRO and five Australian universities - Macquarie, Sydney, ANU, Swinburne and UTS.

The collective goal of the CUDOS team, which began operating at the beginning of 2003 under the Australian Research Council's Centres of Excellence scheme, is to produce a miniaturised photonic chip, only millimetres in size, upon which the next generation of optical systems will be built.

In the past few decades, optics have revolutionised the way we communicate. Optic fibre cable - long, thin, flexible and transparent rods of glass along which lasers shoot pulses of information at about 300,000 kilometres per second - have enabled cable TV, the Internet and mobile phone networks to link people around the globe almost instantly.

But while optical fibre has much more bandwidth - the amount of information that a fibre can carry - than the copper wire traditionally used in telecommunications, network speeds are still restrained by the signal processing devices at the ends of the cables which receive and channel the data.

"One of the big limitations with current telecommunication circuits is the switching at the end of your optic fibre networks, where you have to convert to electrical signal, read the intended address of the message and then send it off back down the line," says Macquarie CUDOS Node Director, Dr Michael Withford. "That bogs the whole process right down, and if you look for example at the demands on the Internet at the moment, there are more and more calls for bandwidth and greater data speeds. The speed of conventional microelectronic technology is ultimately limited and we've started looking at photonic analogues."

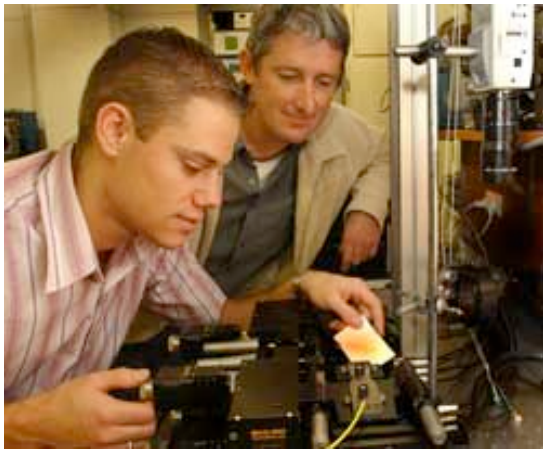


The laser beam illuminates optical pathways within a tiny glass block.

Photonics is the branch of optics that concerns the generation, transmission, detection and analysis of light as a means to convey, collect and process information. The CUDOS goal of creating a completely photonic computer chip is the 'holy grail' of photonics - chips that will perform the same basic function as current electronic chips, without the need to convert the information from the digital form used by both computers and optic fibre cable into the electronic, and then back again into digital.

Ams' PhD project deals with fabricating the microscopic pathways within the chip itself, along which the light will be guided. Using an infra-red femtosecond laser, which creates very short, high intensity pulses, he has been altering the internal structure of high purity glasses.

"At the laser's focal point the glass becomes very hot, it melts, and after a while it will cool and densify at this little point and you'll have an actual microstructure point deep inside the glass," Ams explains. "If you move the focal point around inside the glass, you can actually create a pathway, or densified structure.



Macquarie University laser researchers Martin Ams (left) and Dr Michael Whitford (right).

"If I then put light down the main pathway of this structure I've formed, I can totally internally reflect and therefore guide light along the pathways inside the glass. We can make the pathways as long as we want and do any sort of pattern we like."

Other CUDOS researchers are currently working on the microscopic switches, circuits, amplifiers and other features - also completely photonic - for the photonic computer chip, making it faster, cheaper and more compact and robust than current silicon wafer chips with copper wiring. Fellow Macquarie and CUDOS PhD student Andrew Lee, for example, is working on photonic crystals which reflect certain wavelengths of light, while allowing others to pass

through.

For 'next generation' technology that will have so many applications in telecommunications, computing, and mobile devices, just to name a few obvious fields, there are of course huge potential rewards, and consequently, international competitors. However, Withford believes that Macquarie's Centre for Lasers and Applications' (CLA) 10 years of experience in using lasers to burn microscopic holes in everything from catheters to Olympic torches, will give Ams a crucial edge.

"[CLA Foundation Director] Professor Jim Piper and I were writing a grant for the laser that Martin is using on this project years ago," Withford says. "We had conceived all these ideas back then and had a little bit of an insight into where the world was going as far as telecommunications and photonics.

"But the field has evolved rapidly and by the time our application was accepted and we got the laser on deck 18 months later, reports of research breakthroughs were already coming out. We've since caught up, and hopefully with our expertise developing novel optoelectronic devices we'll start to forge ahead and surpass them."

Indeed, Ams has already caught up to Japanese and Italian researchers in successfully producing simple light devices such as 'X' couplers - two straight pathways that cross to form an 'X', splitting light in two directions at the junction.

"We can vary the angle of the junction, which will vary the amount of light going through each output," Ams says. "There are plenty of other devices we can develop, this is just a simple one we've been able to show works. I have a vision of creating spiral structures in the glass, but at the moment I'm just trying to make light go around a bend. Once I've done that and I know the parameters I need, the possibilities are endless."

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