CAPEable collaboration

University/industry collaboration is enabling leading edge research in Cambridge. By **David Boothroyd**.

If there is one area of science where industry and academia should come together, it is surely electronic engineering. The potential commercial applications of electronic developments are so huge that you might believe innovative work in academia would be feeding continually into the commercial world.

Yet it doesn't always happen, for various reasons: different attitudes and values, even lack of confidence and trust, can sometimes make leading electronic companies and top flight research departments uncomfortable bedfellows.

But not so in Cambridge, where a special industry/university organisation has been running successfully for the last five years: the Centre for Advanced Photonics and Electronics, or CAPE. During that period, CAPE has brought together Cambridge University's Engineering Department's Electrical Engineering Division with several industrial partners, including ALPS Electric, Dow Corning and Marconi (subsequently incorporated in Ericsson). Carl Zeiss SMT is also associated with CAPE, whose director is Professor Bill Milne, head of the Electrical Engineering division.

CAPE provides a new form of joint university-industry research that is leading edge and commercially relevant," says Dr Daping Chu, chair of the CAPE Steering Committee and head of the Photonics and Sensors Group. Dr Chu was previously an executive researcher for Epson's Cambridge Research Laboratory, where he worked on several cutting edge technology projects including ferroelectric thin films and non volatile memories, and inorganic and organic thin film transistors.

"CAPE was formed as a way in which the university could address global issues involving open innovation, in partnership with companies of international importance in the supply chain in the photonics and electronics industries."

The basic aim was not to do contract research of any form, but rather to focus on innovating and developing materials, processes, components and systems with the potential to have a major impact on the photonics and electronics markets.

Part of the University's Department of Engineering, CAPE resides within the Electrical Engineering Division and its funding supports about a quarter of the division's research portfolio, some £7.5million over the five years that CAPE has been running. CAPE has important links with other organisations, notably the Cambridge Integrated Knowledge Centre (CIKC), funded by the Engineering and Physical Sciences Research Council. CAPE made an important contribution to the attraction of the CIKC funding to Cambridge University.

CIKC helps to commercialise research topics arising from CAPE and other projects by supporting fabrication of prototypes, frequently involving SMEs.

CAPE prides itself on its approach to academic-industrial collaboration, which, says Dr Chu, is notably different to what happens in the US.

"A typical US model of universities and industry working together would be MIT or Stanford, where they receive funds from companies but, typically, do not give their industrial partners any say in what happens. With our Technology Focus Groups (TFGs), the University and industry are both true participants. The University's researchers will advise the companies on the best way to approach and conduct a particular research project, but it is always very much a matter of agreement between us all."

Importantly, CAPE partners can veto the appointment of a new partner – a direct commercial competitor could make true collaboration impossible.

The results of CAPE's work are controlled via Strategic Partnership Agreements, according to which ownership of intellectual property is retained within the university, with industrial partners benefiting from preferential licensing. The aim is to provide the fastest route from research to commercialisation.

Dr Chu believes CAPE's success has validated one of its basic purposes. "Originally, CAPE was set up as something of a pilot study, to see how best to get the University and industry to work together. Now, after five years, we know it has worked well."

The benefits of CAPE have definitely been two way – and as someone who has been employed in both industry and academia, Dr Chu is well qualified to judge.

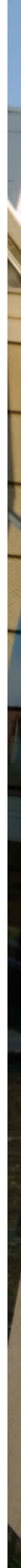
"The industrial partners have had expert technical input from the cream of Cambridge University's engineering group and have benefited from combining with each other, thanks to the use of non disclosure agreements. CAPE has definitely fostered interaction between them; in some cases, even to our surprise. University researchers have gained too. People at universities are often technically excellent, but sometimes are not too aware of what is going on in the commercial world. CAPE has helped a lot in that respect."

Today, CAPE has four TFGs, devoted to communications, materials and processing, displays, and energy and the environment. Among topics researched by the TFGs, two key projects are currently well underway towards practical implementation: Video Holographic Projection Display Systems (ViHPS), and multistable reflective colour displays for electronic posters.

The concept of holographic video projectors arose over a number of years from work done by the Photonics and Sensors Research Group led by Professor Bill Crossland, the original CAPE chairman and now Emeritus Professor of Photonics. Since 2004, the ViHPS project has been running with CAPE partner ALPS Electric, which is developing the technology at its UK site in Milton Keynes. Working systems have already been demonstrated.

The sort of holographic video projectors being developed project conventional video images from a small pixellated hologram displayed on a

Photos: Charlie Milligan



From left to right: Dr Neil Collings, member of the Holographic Projector Team; Professor Bill Milne, director of CAPE and head of the Electrical Engineering Division; Dr. Daping Chu, head of the Photonics and Sensors Group and chair of CAPE; and Anna Jeziorska-Chapman, member of the Holographic Projector Team microdisplay, rather than from a small pixellated version of the same image. The hologram is computer generated, calculated in real time from a video datastream.

'Holographic methods have also been used for 3d displays', CAPE says, 'but this is a very different subject. 3d holographic displays are large and expensive systems whose main application is likely to be in industrial computer aided design. Our holographic video projectors are for projecting conventional video data streams and are intended for the mass display market'.

Such projectors have several potential benefits. They can project conventional video images much more efficiently, greatly reducing power consumption and size, making microprojectors possible. Costs are also potentially cut. They are inherently more fault tolerant than conventional projectors because pixel failures in the hologram have little effect on the projected image. They are also flexible, in that many image features – size, aspect ratio, number of pixels and information content – can be modified using the software that generates the holograms. Images can be projected onto virtually any surface shape without distortion, so there is no need for a flat surface as with conventional image projection. Even the performance parameters of the projector can be modified in software.

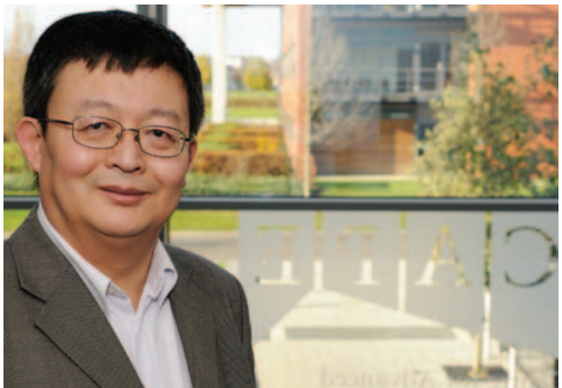
Conventional projection displays take a brightly illuminated, small image of a scene from a micro display and enlarge it by projecting it. However, the micro display image absorbs most of the light illuminating it, often around 90%. In CAPE's holographic projector, the image is projected from a 'phase only hologram' of the scene, which ideally absorbs none of the incident light. It does however modulate the phase of the incident light, so light can be diffracted or deflected by phase only gratings on the microdisplay.

Thus a black region can be created on the playback screen by deflecting the light away from it to a bright region of the image. The phase only hologram of a scene is calculated so that when it is illuminated by a laser, the scene is reproduced some distance from the hologram by means of diffraction. This distance can be altered using a lens.

Several areas of electronic technology are making such projectors feasible. These include small semiconductor laser light sources of adequate power and low cost and microdisplays that can modulate the phase of the incident light. To do this, CAPE is using liquid crystal over silicon (LCoS), a technology that is also challenging to take over part of the conventional projector market. CAPE staff have played a substantial role in developing LCoS – the first known published devices were made by a group led by Prof Crossland in around 1980.

The ViHPS project has already shown results. In May 2006, a monochrome projector was demonstrated in Tokyo at the ALPS Show. About the size of a credit card, the device showed real time images from a video camera as guests approached it. This was followed by a miniature full colour projector demonstrated at the same event in September 2008.

Currently, ALPS is working with another company to produce a head up projector system, with potential uses for aircraft and automotive displays, which could be announced early next year.



The benefits of CAPE have definitely been two way – and as someone who has been employed in both industry and academia, Dr Chu is well qualified to judge.

CAPE's second major project, involving Dow Corning and start up company Advex, is based on the use of smectic A liquid crystals and coloured dyes to create reflective colour and electronic print displays including 'e-posters'. A research project is underway at the CIKC, with Advex as partner, to develop processes for producing plastic colour displays for e-posters.

The basic smectic A liquid crystal electro optic technology originated in the 1980s in Prof Crossland's research group (then at ITT) and several companies have since attempted to commercialise it in different ways.

More recently, Prof Crossland's group measured exceptional reflective viewing characteristics for dyed smectic A devices and discovered exceptional life time properties with particular siloxane based materials when suitably doped. They therefore proposed their use in e-poster displays.

Today's display industry may be large – worth more than $100billion per year – but it still cannot deliver either the size or reflective viewing characteristics of printed media. Reflective colour displays that could do this are a Holy Grail for the display industry.

"But, today, no e-print displays can challenge good quality print and few can challenge poor quality print," Prof Crossland says. "But dyed smectic A displays are a start."

For example, monochrome smectic A devices can approach the viewing characteristics of newsprint – a white state reflectance better than 55% and reflective contrast better than 7:1. At least for very large displays, CAPE believes full colour is feasible.

This is a true electronic ink technology: one electrical pulse colours the liquid crystal ink and a second pulse clears it. Pictures remain for many years with no need for electrical power and large arrays of pixels can be addressed without the use of any pixel circuitry – no active matrix is required. This lowers costs and enables very large arrays of pixels to be addressed.

The original smectic A displays did not involve a dye and were based on the scattering of light. Briefly passing a low frequency electric current through the liquid crystal produces a stable scattering state, a process called dynamic scattering. A high frequency electric pulse causes this scattering state to clear. Scattering and clear states are semi-permanent. Some problems that still need to be addressed include the photo stability of dyes in bright sunshine, and more affordable ways of achieving the three layer stack structure needed for full colour devices.

With CAPE's first five year phase coming to an end, a new three year phase is being planned, due to start in April 2010. New companies will almost certainly join, and if one of those being mentioned as a possible partner – a major international telecoms company – is anything to go by, CAPE's reputation and research should be enhanced still further.