Centre for Advanced Photonics and Electronics (CAPE)
Contents

Preface 2
About CAPE 4
CAPE Model of Academic-Industrial Partnership 8
CAPE Organisation 10
Steering Committee Members 13
CAPE Partners 14
BIACD 15
CRRC 16
Huawei 17
Jaguar Land Rover 19
University of Cambridge 20
Views from the University 24
CAPE Activities 26
Project PIs and Researchers 27
Acorn Fund 28
CAPE Lectures 35
Views from PIs and Researchers 36
CAPE in the News 42
Views from Partners 48
Get Involved 50
Advantages of working with CAPE 51
Contact Details 53
Preface

The Centre for Advanced Photonics and Electronics (CAPE) is a unique partnership between the University of Cambridge and a small group of international photonics and electronics companies whose market orientation places them in a non-competitive supply-chain or value-chain relationship with respect to each other.

The mix of partner interests has shifted over the years, but the current CAPE Partners (BiACD, CRRC Zhuzhou Institute, Huawei Technologies and Jaguar Land Rover) continue to represent business interest on a global scale.

CAPE operates under the CAPE Partnership Agreement (CPA), as endorsed by all industrial CAPE Partners for the purpose of jointly commissioned research and development.

CAPE’s objective is threefold:

Technology advancements through landscaping and project work,

Business opportunities between CAPE Partners,

Outreach activities to a wider community.

Thus far, the CAPE research portfolio amounts to £14.1 million, with several new projects on the horizon. The research outcome is mostly important early-stage IP. CAPE Partners have taken some projects forward to the stage of mass production and framework technology transfer, such as holographic head-up displays and Smectic-A liquid-crystal technology.

CAPE creates business opportunities and future vision. CAPE Partners’ engagement provides a unique opportunity to interact and to broaden each other’s views. This enables all of us to make a greater impact on society and further enhance the business value of our enterprises.

CAPE’s approach is to invent and develop through multidisciplinary research in strategic areas of interest to both the UK (as specified by EPSRC) and beyond. We cover all levels from materials, processes, components, and systems to customer expectation. We aim to define future strategy and market implementation; to set the industry agendas for the convergence of technology platforms; and to be involved in policy-making and regulatory work and contribute to societal needs.

There are opportunities to expand CAPE projects by leveraging the industrial funds invested through CAPE via external bodies such as the UK government.

Membership of CAPE can also provide networking benefits from existing links between the University of Cambridge and other academic centres, in both the UK and elsewhere. Consultative inputs from other universities have already assisted some of CAPE project research programmes.

CAPE delivers “Technology from Science.” We do this by accessing world-leading expertise in every branch of engineering and science at the University of Cambridge and by collaborative work with the support of cutting-edge R&D facilities within the Electrical Engineering Division.

Professor Daping Chu
Director of CAPE
About CAPE

CAPE was established on 1 October 2004, as a way in which the University of Cambridge could address global issues involving open innovation, in partnership with companies of international importance. Founded upon the University’s world-leading facilities and expertise in electronics and photonics, CAPE is housed within the University’s Electrical Engineering Division although its activities involve many academic researchers beyond Cambridge University Engineering Department.

Operating under the original CAPE Strategic Partnership Agreement (CPA), it formed a new model of joint university-industry research that was leading edge, vertically integrated and commercially relevant. Through joint governance and joint sponsored research, the CAPE Partnership has developed a research portfolio at the cutting edge of contemporary technology. Strategic placement of the CAPE Partners in the supply chain creates relationships without conflict of interest.

CAPE started its second phase on 1 April 2011 with a new CAPE Partnership Agreement, endorsed by ALPS Electric Co. Limited, Disney Research, Dow Corning Corporation and Jaguar Land Rover. Beijing Aerospace Times Optical-Electronic Co. Technology Ltd. (ATOE) joined the CAPE Partnership on 1 October 2013, following internal re-organisation, this partner was renamed the Beijing Institute of Aerospace Control Devices trading as BIACD. CRRC Zhuzhou Institute joined CAPE in October 2015 and Huawei Technologies Ltd became a CAPE Partner in April 2017. As well as the CAPE Partners, Carl Zeiss Microscopy Ltd was a CAPE Associate in the field of electronic imaging.

The CAPE research portfolio during the first CAPE phase amounted to £7.5 million, with a further £14.1 million invested during the second phase. CAPE was also instrumental in the University being able to attract further funding of over £14 million from other sponsors and industry partners, which together with the initial £12 million support from the University for building infrastructure gives an overall investment of £47.6 million.

CAPE and our CPA are constantly evolving to adapt to internal and external environmental needs, with the aim of enhancing academic research and creating benefit for business. There are currently four CAPE Partners each with global business interests: BIACD, CRRC Zhuzhou Institute, Huawei Technologies and Jaguar Land Rover.
Highlights

- **42** CAPE projects
- **21.6** CAPE research funding (£M)
- **26** additional leveraged funding (£M)
- **47.6** Total investment (£M)
- **51** CAPE Acorn Fund winners
- **40** across 40 Acorn projects
- **8** Postdoctoral Blue Sky Award
- **30** CAPE Postgraduate Award (CAPA)
- **13** CAPE Undergraduate IIB Award (CAUPA)
- **15** CAPE lectures
- **167** publications
- **11** Principal Investigators (PIs) involved
- **10** current and past partners
- **47** Researchers
- **67** patents
CAPE Model of Academic-Industrial Partnership

The CAPE model for industrial/academic collaboration is specialised and unique, differing in many ways from existing arrangements between industry and other universities, e.g., programmes available in the USA at MIT, Stanford and UC Berkley. CAPE resembles a joint development agreement more closely than any university research club does.

CAPE is a partnership between the University and a small group of international photonics and electronics companies whose market orientation places them in a non-competitive supply-chain or value-chain relationship with respect to each other. CAPE relies on the CAPE Partners being able to accommodate each other’s business interests to allow this collaboration.

The executive body in CAPE is the Steering Committee, which commissions all CAPE research. Members are from both academic and industrial partners, with equal voting rights between the academic and industrial interests, i.e., sharing the governance of all CAPE research within the University with the industrial partners.

All financial contributions to CAPE are spent on jointly commissioned research that is directly for the benefit of the CAPE Partners, apart from a small percentage that is set aside for CAPE operations. Each CAPE Partner will invest a minimum contribution per year in CAPE (some of which may be in-kind). Apart from the small percentage set aside for CAPE operations, all this resource will be available for jointly-commissioned research over which CAPE Partner has direct control through their representation on the CAPE Steering Committee.

CAPE offers wide access to engineers, scientists and postgraduate students within the Electrical Engineering Division, the Engineering Department and other areas of the University and in the other CAPE Partners.

CAPE seeks to engage with business development processes in CAPE Partners. Exchange of scientists and engineers between the industrial and academic partners, including the possibility of the placement of an embedded researcher within the Electrical Engineering Division, is a rule rather than an exception.

The key features of CAPE are:

1. CAPE is a partnership between the University and a small group of international photonics and electronics companies whose market orientation places them in a non-competitive supply-chain or value-chain relationship with respect to each other. CAPE relies on the CAPE Partners being able to accommodate each other’s business interests to allow this collaboration.

2. The executive body in CAPE is the Steering Committee, which commissions all CAPE research. Members are from both academic and industrial partners, with equal voting rights between the academic and industrial interests, i.e., sharing the governance of all CAPE research within the University with the industrial partners.

3. All financial contributions to CAPE are spent on jointly commissioned research that is directly for the benefit of the CAPE Partners, apart from a small percentage that is set aside for CAPE operations. Each CAPE Partner will invest a minimum contribution per year in CAPE (some of which may be in-kind). Apart from the small percentage set aside for CAPE operations, all this resource will be available for jointly-commissioned research over which CAPE Partner has direct control through their representation on the CAPE Steering Committee.

4. CAPE offers wide access to engineers, scientists and postgraduate students within the Electrical Engineering Division, the Engineering Department and other areas of the University and in the other CAPE Partners.

5. CAPE seeks to engage with business development processes in CAPE Partners. Exchange of scientists and engineers between the industrial and academic partners, including the possibility of the placement of an embedded researcher within the Electrical Engineering Division, is a rule rather than an exception.
CAPE Organisation

CAPE Steering Committee
The CAPE Steering Committee (SC) is the arbiter of every aspect of CAPE activity. It comprises leading academics who represent the University and senior representatives of each of the CAPE Partners. Each CAPE Partner has an equal vote on the SC, and the total number of votes from the academic SC members matches the total number of CAPE Partner votes, with the SC Chairman (chosen from the academic members) holding the casting vote.

CAPE Technology Focus Groups
On behalf of CAPE SC, the four CAPE Technology Focus Groups (TFGs) oversee CAPE technology issues and roadmapping. Appropriate representatives from the University and all the CAPE Partners sit on each TFG with the option for an academic or an industrial member to chair either. Each TFG covers a specific technological area and oversees CAPE project progress, either at detailed or executive level as appropriate. The current four TFGs are:

1. Materials and Manufacturing Processes TFG

Postulate: CAPE must sustain an oversight of the materials and process needs of the broader electronics and photonics markets. Through a technology focus, this requires a strong engagement in understanding the manufacturing processes, as well as the materials physics and chemistry and the influence of process variables and methods on component and system performance (inclusive of cost). Furthermore, as new physics or materials science offers new opportunities, this TFG will maintain a competence to consider how this may enable new approaches to solutions in technology for the electronics and photonics sectors.

There will be a broad adherence to CAPE-established principles of securing an oversight of the concerns of the supply-chain and value-chain participants in this market. The TFG will ensure that it maintains an appropriate level of due diligence and secure confidentiality of its discussions and reports appropriately to the circumstances.

In the field of radical materials advances and in manufacturing paradigms, University of Cambridge (CU) is well respected, particularly in respect of low-temperature deposition and additive process evolution. In order to sustain the necessary level of competency in the TFG, active support for the discussions to be sought from participants drawn from the wider community, both CU and industrial, though this will be balanced with CAPE needs to sustain due diligence and good control of intellectual property.

2. Devices and User Interfaces TFG

Postulate: The cross-supply chain relationship between the CAPE Partners offers a unique opportunity to take an overview of the developments in the display, user interfaces and sensors industries in general. It also enables us to ensure that the research projects undertaken are timely and effective in building a basis of intellectual property, technology demonstrations and prototypes to facilitate business development cases in our CAPE Partners.

The display industry constitutes a large and strategic part of the global photonics market and is important to the business interests of CAPE Partners. It is also an area where both the UK generally and the University of Cambridge, in particular, have in-depth skills and long-established core competence, e.g., in active matrix circuitry, liquid crystals, OLED and field emission technology.

Significant developments proceeding within CAPE now include:

- Next-generation active matrix technologies (organic and inorganic) for plastic display structures
- Holographic image projection devices using liquid crystal over silicon (LCOS)
- Investigations of liquid crystal laser technology for potential applications display systems
- Bright reflective colour systems for electronic posters and signage and electronic print displays
- Novel complementary metal-oxide-semiconductor (CMOS) sensors

The degree of success achieved now could enable CAPE to influence the industry bodies that are setting the future agenda (subject to the judgment of the CAPE Partners and the TFG Chairmen).
Communication Network and System Design TFG

Postulate: It is desirable for CAPE to maintain a wide-reaching knowledge and influence in the field of optical and electronic communications. This should embrace all of guided wave/signal (wired, traces and optical waveguides and microwave coaxial or waveguide communications) and free-space (‘optical’ and ‘wireless’, point-to-point and broadcast) signalling in the deployment of both telecommunications and data communications systems.

There will be broad adherence to CAPE-established principles of securing an oversight of the concerns of the supply-chain and value-chain participants in this market. The TFG will ensure that it maintains an appropriate level of due diligence and secure confidentiality of its discussions and reports appropriately to the circumstances.

There is already much activity in this area, pursued through the research interests of CAPE and the Electrical Engineering and other Divisions of Cambridge University Engineering Department. It is also more generally a strong core competence in the wider university; proposing that the Communications and Networking TFG will seek expertise from inside and outside CAPE to secure a knowledgeable community of interest to participate in the discussion and review of CAPE strategy in this area. This wider community will also receive invites in certain cases to participate in project review.

CAPE Communications and Networking TFG will review and have oversight of the proposed communications test-bed, together with low-cost telecom and networking solutions, and their usage by CAPE Partners and others. The TFG will produce reports and guidance on key developments or trends in the field. Subject to approval processes at CAPE Steering Committee level, these will be provided to CAPE principles and published.

Energy and the Environment TFG

Postulate: CAPE Partners are engaged with many of the technologies and market sectors that will be harnessed to address the societal needs of reducing energy usage, and adopting a responsible attitude towards environmental issues. They also have corporate policies to support these aspirations. We believe that there could be significant benefit to the processes of business development in taking a strategic overview of this area. It is proposed to seek the help and support of appropriate supply chain partners and take an active role in participation in relevant thematic initiatives such as Smart Façade and Energy City programs.

The CAPE White Paper, ’A Vision for the 21st Century Built Environment’, outlines these proposals in more detail and asserts that technology, by manipulating wavelengths across a wide section of the electromagnetic spectrum, can actively control aspects of a building’s fundamental operation, its aesthetics (appearance and outlook), the communication of information within and without it (including internal and external optical and wireless communications, privacy and municipal signage), and the energy and illumination balance between the building and its environment. Focusing on the scattering and control of radiation by the facades and apertures of buildings offers new insights into the impact of photonics and electronics on the environmental impact of the built environment.

We note that there are strong links between the enabling materials developments and fabrication processes involved in such areas as light-control films, thin-film photovoltaics, active wave-plate and antennae structures, transflective displays and advanced transparent conductor technology, and that CAPE is already heavily involved in most of them. The use of nanostructured materials is being proposed in several of these areas. Stable laminated plastic structures, containing active polymeric and/or liquid layers are a common feature across this application space.

CAPE Intellectual Property Group (IP Group)

The SC Chairman is chair of the CAPE IP Group which comprises legal and technical representatives from the University and each CAPE Partner. On behalf of CAPE SC, the IP Group manages the CAPE IP portfolio and other legal and contractual issues. To facilitate the provision of a neutral forum for the discussion of company-sensitive IP when appropriate, each IP Group member signs a specific IP Group confidentiality disclosure agreement, which restricts wider dissemination of that information within his or her own organisation to a need-to-know basis.
Company Overview

BIACD is involved in the development of fibre optic sensors, satellite communication system and IoT system, used in Chinese smart grid as well as in petroleum, emergency communication and intellectual manufacturing. They have 3400 employees, of which more than 40% have a postgraduate degree or higher.

In the spirit of mutual learning, sincere cooperation, harmonious development, and win-win relationships, BIACD joins hands with the domestic and overseas counterparts and all sectors of society, to make unremitting efforts for the promotion of development and application of photoelectric sensing technology.

The company’s mission is to develop advanced technologies using photoelectric sensors and IT integration in pursuit of being a first-rate industrial company in China and the world.

Supported by Professor Daping Chu, Professor Ian White and Professor Richard Penty, BIACD and CAPE have “incubated” many university–industry cooperation projects and achieved substantive results. I wish both sides will achieve a win–win situation in terms of future cooperation and contribute to science and technology innovation in relevant field.

Collaboration with CAPE

On basis of world-leading equipment and solid professional foundation, CAPE builds partner relationship with enterprises which are engaged in photonic and electronics, and provides a “vertical integrated” cooperation mode for university and enterprises.

BIACD and CAPE jointly researched many projects such as smart in-building wireless system and smart manufacturing system. BIACD has dispatched more than 10 technical staff to CAPE to research. In the meantime, many experts from the University of Cambridge came to China to promote the cooperation projects and provide guidance for young technical staff.

BIACD and CAPE worked together and efficiently finished the prototype and network test of smart in-building wireless system. At the present, this project is in industrial condition. At the same time, BIACD and CAPE strive to make technological breakthrough on fibre optic cable development, optoelectronic oscillator and smart manufacturing system, which lays a good foundation for the following product research and industrial development.
CRRC

Company Overview
China Railway Rolling Stock Corporation Zhuzhou Institute Co., Ltd. (CRRC Zhuzhou Institute) was established in 1959, formerly known as Zhuzhou Electric Locomotive Research Institute of Ministry of Railways, and currently is the first-class wholly-owned subsidiary of CRRC Corporation Limited. With 60 years of development, CRRC Zhuzhou Institute has witnessed the science and technology progress and industry development of railway electrification in new China. It has always insisted on science and technology-oriented and applied innovation as the banner to promote the rapid growth of the industry. At present, CRRC Zhuzhou Institute has already formed four industry platforms (namely Electrical Transmission and Automation, Application in Polymer Composites, New Energy Equipment, Power Electronics (Basic) Device), 10 business subjects, two listed branches, nine national science and technology innovation platforms, two enterprise postdoctoral research stations, five overseas technology R&D centres and 11 overseas branches. The sales revenue in 2018 was 29.5 billion RMB. CRRC Zhuzhou Institute has already finished the construction of its independent innovation R&D platform in the field of traction drive and control system in railway transportation equipment. Other fields include possessing advanced electric system integration, conversion and control, vehicle-mounted control and diagnosis, power electronics devices, engineering application in polymer composites, train operation control, integration of wind power equipment, integration of electric vehicles and critical components, engineering machinery and its electric control, communication and information application and other key technologies. The Institute has also completely built design, manufacturing and testing platforms.

Collaboration with CAPE
CRRC Zhuzhou Institute has been working with CAPE since October 2015. CAPE is a unique form of joined partnership between the University of Cambridge and a number of strategic companies of international importance in the supply chain for the photonics and electronics industries. Through cooperation with CAPE on the HUD project (phase I), we have proved the concept of applying the HUD system to different train type vehicles with different tilting angles and windscreen types. On vehicle tests were also verified to show HUD with good image quality. In phase II of the project, our aim is to improve the display image quality and system capacity of current HUD system. Based on these improvements, extended functions will be developed to increase the safety level of Autonomous Rail Transit (ART).

The researchers we are working with are Dr Yuanbo Deng and Dr Kun Li, both of whom have extensive experience in photonics and electronics fields so their knowledge delivers excellent benefits for us. Both the University and enterprise could make good use of their own advantages (university for theoretic study and enterprise for engineering application) during cooperation. The joint university-industry research for Train Head-up Displays – phase I and II expect to go into commercial use in the near future.

The CAPE Partnership is defined by a CAPE Partnership Agreement (CPA), negotiated between the University and the CAPE Partners, on which all CAPE strategy and procedures are based. Through joint governance and joint sponsored research, the CAPE Partnership has developed a research portfolio at the cutting edge of contemporary technology. CAPE Steering Committee Meeting are held quarterly to keep all partners informed on all CAPE activities. CAPE also offer prizes for the students with innovative ideas and financially assist them to make their ideas visualised.

CRRC Zhuzhou recommends that more subsidiaries of CRRC work with CAPE in order to build greater shared understanding of research and business interests. New areas for potential mutual benefit can be identified and moved forward.

Huawei Technologies

Company Overview
Founded in 1987, Huawei is a leading global provider of information and communications technology (ICT) infrastructure and smart devices. We have more than 194,000 employees, and we operate in more than 170 countries and regions, serving more than three billion people around the world. We committed to bringing digital to every person, home and organisation for a fully connected, intelligent world. To this end, we will: Drive ubiquitous connectivity and promote equal access to networks; Provide the ultimate computing power to deliver ubiquitous cloud and pervasive intelligence; Build digital platforms to help all industries and organisations become more agile, efficient, and dynamic; Redefine user experience with AI, making it more personalized for people across all scenarios, whether they’re at home, in the office, or on the go. Huawei has a strong focus on Research & Development and has five R&D sites in the UK including: Ipswich, Cambridge, London, Edinburgh and Bristol. The company will continue to increase its investment and collaborate with partners in the future.

Collaboration with CAPE
We have collaborated with CAPE for several years. We bring real research problems, scenarios and world class challenges in the industry to researchers via CAPE and exchange ideas. That is why we have invested in the multi-party committee and in bilateral one-to-one collaborations with CAPE professors. We very much appreciate our collaboration with CAPE over the past years. We work together with CAPE to provide a platform for young talent and other partners to share ideas, explore opportunities and support each other in solving research issues. With CAPE, we have worked on several projects, for example the prototypes of head-mounted displays. Initially we liked this idea but it was immature, and we invested for further research. Many young PhD and Masters Students bring good ideas through the CAPE Acorn Fund and we are willing to support young talent. In the future, we can open up student internships in our R&D centres, where students can develop their ideas in many research areas such as optics, electronics, displays, lasers, memory, sensors, materials, batteries and many others.

We are now No.1 delivery in smartphone market, No.1 in both optical and radio access networks. We have a big platform with many customers and many challenges. We can introduce and open up more and more challenges to professors, researchers and industrial partners via the collaboration with CAPE.
We are now focusing on three areas:

1. **Better Perception and Interaction**
   For example, we hope mobile phone cameras can see 100-times further than the human eyes, to capture clear long-distance images such as craters on the moon. We also want to create clear pictures in the dark night by using spectra that are 100-times wider spectrum than conventional cameras, not just in the visible RGB spectrum, but also in ultraviolet and infrared spectra.

2. **Better Connection**
   With wireless and optics, we hope to develop solutions to enable augmented and virtual realities (AR, VR). We are participating in the development of connected autonomous and flying cars. Ten years from now, we hope most families are able to afford one of these vehicles. We are also developing new battery technologies, such as metal-air batteries and solid batteries, to enable long-lasting performance.

3. **Better Intelligence**
   Increase computing performance by 100-times, to provide performance close to human brain. As well as CAPE, we are collaborating with many companies in Cambridge, including ARM and several SMEs.
CAPE is incorporated at the Electrical Engineering Division of the Department of Engineering, University of Cambridge, with the active participation of its academic staff and researchers and direct access to its start-of-art facilities. It also involves researchers from a range of other departments including the Cavendish Laboratory, the Computer Lab, Chemistry, Materials Science and Metallurgy among others.

The Electrical Engineering Division is one of the six academic divisions within the Department. The Division pursues fundamental electrical, electronic and photonic research at the material, device and system levels with a focus on creating integrated solutions in the fields of nanotechnology, sensing, energy generation, energy conversion, displays and communications, bioelectronics and internet of things. With 26 academic staff and over 250 researchers, technicians and administrators, the division offers end-to-end research provision from basic research for early-stage invention, process development and proof-of-concept demonstrator through to application deployment. The Nanoscale Centre and Cambridge Graphene Centre are part of the Electrical Engineering Division. In 2019, the division had a portfolio of active research grants of £53.3M.

Research Themes
Our research covers all aspects of electrical engineering from the nano-scale to heavy-duty power applications, organised across six cross-cutting themes:

1. **Communications, Pervasive and Intelligent Systems**
   - Systems-level perspective to consider the emergent properties of complex interconnected systems
   - Understanding of the underpinning physics combined with appropriate mathematical abstraction

2. **Functional Nano and Layered Materials**
   - Application driven exploration of new device materials
   - Fundamental discovery and characterisation of properties to functional device integration and manufacturing pathways

3. **Multiscale Power and Energy Systems**
   - Future energy systems from grid scale power to small scale energy harvesting
   - Power semiconductor devices, power conversion systems and superconducting electrical machines

4. **Photonic and Quantum Technologies**
   - Future photonic devices based on silicon and III-V materials
   - Quantum technologies for communications and computing

‘The world we live in today has been enabled by electrical engineering — processing, displays, power, communications.’
Facilities

The Electrical Engineering Division offers state-of-the-art photonics and electronics research and prototype development facilities with 5,000m² of research, cleanroom and laboratory space at its purpose-built site in West Cambridge, including 440m² of Class 10,000, Class 1,000 and Class 100 cleanroom areas.

Some of the equipment available to support CAPE research projects includes:

- 7 thin film deposition systems
- >5 nanomaterial growth systems
- 2 reactive ion etch systems
- Deep reactive ion etcher
- Rapid thermal annealer
- Bioruptor
- Ink-jet printing system
- Wire bonding facility
- 0.5µm double-sided mask aligner
- E-beam lithography system
- Wet chemical processing facility
- Optical and stylus profilometers

People

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<th>Postgraduate Students</th>
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<td>Administrators</td>
<td>11</td>
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<tr>
<td>Academic Related Staff</td>
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</tr>
</tbody>
</table>
Views from the University

‘The mission of Cambridge University is to contribute to society. To make this contribution – especially at scale – the University needs to collaborate with world-class organisations. Organisations that want to take ideas and insights being developed in the University and use them to improve the products and services they offer. CAPE is a great model to enable such collaboration. Bringing together world leading firms with researchers in the University, CAPE supports collaboration and research that makes a real difference.’

Professor Andy Neely
Pro-Vice-Chancellor, Enterprise and Business Relations, University of Cambridge

‘CAPE has had an immense and lasting impact on my research, stimulating new ideas, making possible innovative research, and providing the lasting support and industrial expertise to allow ideas to be turned into real engineering solutions that have impact. In my view, CAPE has been an outstanding success and I pay great tribute to its leaders and industrial partners for their excellence.’

Professor Ian White
Formerly Deputy Vice-Chancellor of the University of Cambridge and currently Vice-Chancellor of the University of Bath

‘The strength of Cambridge University Engineering Department is built on a combination of pure research excellence and external relationships that enable us to focus our work and apply it effectively. CAPE has pioneered the development of industry-university research collaborations and has inspired many other consortia in Cambridge and beyond. It remains an exemplar as it continues to nurture young innovators, drive fundamental research and deliver commercial impact.’

Professor Richard Prager
Head of Cambridge University Engineering Department

‘CAPE has been at the heart of the Electrical Engineering Division in Cambridge for over a decade. Its unique structure allows industry partners not only to tackle major research challenges with academics in the University but with each other as well. This collaborative environment has delivered real economic benefits to the industrial partners, enabled outstanding research in the University and helped to inspire new generations of professional engineers. I have no doubt that the collaborative CAPE ethos will continue to flourish in the years ahead.’

Professor Andrew Flewitt
Head of Electrical Engineering Division, Cambridge University Engineering Department

‘CAPE is an excellent model for collaboration between the University and industrial partners, Cambridge Enterprise values in particular the long-term partnerships which allow exploration of routes to market for leading-edge, early stage technology originating in the University.’

Dr Malcolm Grimshaw
Head of Physical Sciences, Cambridge Enterprise

‘CAPE has been a pioneer in fostering the University–industry relationship in a successful way. CAPE has been an example for other academics in the University to liaise with industrial partners and form a long-term relation.’

Lisa Wears
Assistant Director of Technology, Research Operations Office, University of Cambridge

‘CAPE has had an immense and lasting impact on my research, stimulating new ideas, making possible innovative research, and providing the lasting support and industrial expertise to allow ideas to be turned into real engineering solutions that have impact. In my view, CAPE has been an outstanding success and I pay great tribute to its leaders and industrial partners for their excellence.’

View from the University
CAPE Activities

CAPE Activities

CAPE Principal Investigators
(from 2011)

- Prof. Daping Chu (UoC)
- Prof. John Clarkson (UoC)
- Prof. Neil Dodgson (UoC)
- Dr Tim Flack (UoC)
- Prof. Simon Godsill (UoC)
- Prof. Stephan Hofmann (UoC)
- Prof. Richard McMahon (UoC)
- Prof. Richard Penty (UoC)
- Prof. Peter Robinson (UoC)
- Prof. Kenichi Saga (UoC)
- Prof. Ian White (UoC)
- Dr Bashar Ahmad (UoC)
- Dr Yun Bai (CRRC Zhuzhou)
- Dr Atanas Boev (Huawei)
- Dr Jhen-Si Chen (UoC)
- Dr Zhaozhong Chen (UoC)
- Dr Young Tea Chun (UoC)
- Dr Terry Clapp (Dow Corning)
- Claire Cubinsiki (Dow Corning)
- Dr Tony Davey (UoC)
- Dr Yuanbo Deng (UoC)
- Eduardio Dias (Jaguar Land Rover)
- Dr Andriy Dyadyusha (UoC)
- Dr Shaorui Gao (Huawei)
- Dr Gernot Goeger (Huawei)
- Dr Enyi Guan (BIACD)
- Dr Jon Hannington (Dow Corning)
- Dr Jia Jia (UoC)
- Dr Houqiang Jiang (Huawei)
- Dr Patrick Langdon (UoC)
- Dr Jin Li (UoC)
- Dr Kun Li (UoC)
- Dr Shunpu Li (UoC)
- Dr Tongyun Li (UoC)
- Dr Hsin-Ling Liang (UoC)
- Dr Jiaming Liang (UoC)
- Dr Teng Long (UoC)
- Valerian Meijering (Jaguar Land Rover)
- Dr John Moore (UoC)
- Dr Hector Navarro Fructuoso (Huawei)
- Dr Mike Pivnenko (UoC)
- Dr Matthew Pryn (UoC)
- Dr Brian Robertson (UoC)
- Dr Pawan Streesha (UoC)
- Dr Lee Skrypchuk (Jaguar Land Rover)
- Dr Quin Smithwick (Disney Research)
- Dr Phillip Stanley-Marbell (UoC)
- Kasia Surowiec (UoC)
- Ashutosh Tomar (Jaguar Land Rover)
- Dr Peter Vasilyev (UoC)
- Dr Chris Williamson (UoC)
- Dr Haining Yang (UoC)
- Dr Jun Yao (Huawei)
- Dr Özgür Yontem (UoC)
- Dr Qin Zhang (Huawei)
- Dr Jiong Zhou (Huawei)
- Dr Liangjia Zong (Huawei)
- Dr Ashutosh Tomar (Jaguar Land Rover)
- Dr Quin Smithwick (Disney Research)
- Dr Phillip Stanley-Marbell (UoC)
- Dr Chris Williamson (UoC)
- Dr Haining Yang (UoC)
- Dr Jun Yao (Huawei)
- Dr Özgür Yontem (UoC)
- Dr Qin Zhang (Huawei)
- Dr Jiong Zhou (Huawei)
- Dr Liangjia Zong (Huawei)

CAPE Researchers

Project PIs and Researchers

The Centre for Advanced Photonics and Electronics (CAPE)
Acorn Fund
Supporting innovative research from young researchers
CAPE has created a special funding scheme, the CAPE Acorn Fund, to support innovative research initiatives from young researchers, in parallel or complementary with their current research.

The circulation of a new call occurs three times a year for three categories of researchers:

1. Postdoctoral Blue Sky Award
   For Research Associates from the Cambridge University Engineering Department. The award is £20,000 for a 12-month Blue Sky research project. The deadline is at the end of August with up to two of the most innovative projects awarded.

2. CAPE Postgraduate Award (CAPA)
   For PhD students from all University of Cambridge Departments. The deadline is in March and multiple winners – individuals or small teams can receive awards up to £2,000 for 6-month projects.

3. CAPE Undergraduate IIB Award (CAUPA)
   For Engineering 3rd year undergraduate students who are aiming for IIB project in their upcoming year. The prize is £500 (£250 is a cash prize and £250 towards research). Applicants may enter with any topics they would like to pursue for their 4th year Type-B engineering project in the next academic year as part of their studies towards their degree. The duration of the project is 9 months and the deadline to apply for this call is in January in the applicants’ 3rd year.

Thus far, the Acorn Awards have received positive feedback from students and research associates. The CAPE Office, in collaboration with departments and the Teaching Office, is raising awareness of the awards.

Blue Sky Research Award Winner
‘The experience of winning the CAPE Acorn Blue Sky Research Award has been very rewarding, it’s a huge encouragement for me personally and I feel confident to pursue the proposed work when the CAPE committee affirms our proposed concept. The award provides financial support that was required to develop the concept for a “Full 360° 3D Light Field Capture and Display System”. More importantly, the award provides me with experience, the experience of working on research of my interest and the experience of managing my time and resources.

Within an everyday work schedule, I need to think harder on how to work more efficiently and when I can spare a few hours to work on the research of my interest. The key is to do it consistently and once we did, the results were rewarding. This year, we managed to carry out simulation and experimental works, file patent applications and publish an invited journal article in Journal of the Optical Society of America A.’

Dr Kun Li, Research Associate, Electrical Engineering

The Centre for Advanced Photonics and Electronics (CAPE)
CAPE Activities

Recent Acorn Fund Winning Projects

1 Postdoctoral Blue Sky Award

Dr Jin Li:
Large field of view 3D holographic displays using wavefront shaping of multiple light-scattering fields (2019)

Dr Matt Pryn and Dr Pawan Shrestha:
Multi-stable terapixel GASLM for the updatable holography-based 3D display (2018)

Dr Kun Li:
Solid-state holographic LiDAR with a 360° field of view (2018)

Dr Wei Tan:
Structural supercapacitors using hybrid carbon fibre/carbon nanotube composites (2017)

Dr Özgür Yöntem and Dr Kun Li:
Full 360° 3D light-field capture and display system (2016)

Dr Guofang Zhong:
Liquid crystal on Si with carbon nanotube IC driver (2016)

2 CAPE Postgraduate Award (CAPA)

Liam Bird and Dylan Maxwell:
Three-electrode electrochemical cell with integrated pressure sensor (2020)

Malar Chellasivalingham:
Mastery of microchip technology to tackle air pollution (2020)

Phoebe Gao and Alkausil Tamboli:
Simulation and modeling of piezoelectric nanoscale resonators for sensing application: nano bulk acoustics wave resonators (NBARs) (2020)

Jamie Lake, Peter Christopher and Ralf Mouthaan:
Focal depth tracking for improved 3D holographic displays (2020)

Mengyuan Tian and Jiabin Yang:
A wireless power transfer system using high-temperature superconducting capacitors (2020)

Hanchen Wang:
3D deep learning for large scale point cloud process (2020)

Daoming Dong:
Interfacing a high-speed ferroelectric spatial light modulator (2019)

Dean Kos:
Integrated adaptive exposure control for imaging cameras (2019)

Murat Kuscu:
Micro/nanoscale molecular communication system with graphene bioFET-based receiver towards Internet of Nano Things (IoNT) (2019)

Angkur Jyoti Dipanka Shaikeea:
Architected cellular metamaterials hold the future of surgical meshes (2019)

Agavi Stavropoulou-Tatla:
Drug-releasing magnetic scaffold for eradication of post-surgery residual glioblastoma (2019)

Shahab Akhavan:
Flexible photodetector for smart textile applications (2018)

Yin Chang:
Diversity of natural photonic crystals and their inspirations for industry (2018)

Continued...
CAFE Activities

Isabella Miele and Oliver Burton: Speech-to-braille communicator for deafblind people (2017)

Tien Chun Wu: Development of multi-sensor platform for real-time air quality monitoring (2017)

Lu Bai and Jingyun Zhang: The digital distributed antenna system (DDAS) over Internet Protocol (IP) (2016)

Kenichi Nakanishi: Free-standing three-dimensional graphene network (2016)

Robert Nishida and Richard Görke: Air filter — ultraviolet electrostatic precipitator (UV-ESP) (2016)

Yuwen Dong and Pawan Shrestha: Computer-generated holography with reduced zero order (2015)

Gareth Funk: Precise short-range control of a quadcopter in the presence of unknown disturbances (2016)

Edward Chalklen: Molecular transport through nanoporous single-layer graphene (2015)


Benjamin Moss: Predicting modes of instability for high-drag parachutes (2014)

Aidas Liaudanskas: Exploring explainable artificial intelligence by employing generative adversarial networks (GANs) (2017)

Henry Makiings: Multi-plate wet clutch modulation modelling and simulation for off-highway transmissions (2017)

Sam Willis: Lens for AMD vision recovery (2017)

Ajeck Ndifon: Development of sensorized phantom organ for robotic and medical applications (2018)

Benjamin Moss: Exploring explainable artificial intelligence by employing generative adversarial networks (GANs) (2017)

Tien Chun Wu: Development of multi-sensor platform for real-time air quality monitoring (2017)

CAPA (CAPE Postgraduate Research Award) Winners

Isabella Miele and Oliver Burton – Postgraduate students

Speech-to-braille communicator for deafblind people

Deafblindness is a combined sight and hearing loss, causing difficulties with communication, access to information and mobility. This unique disability affects an estimated 384,000 people in the UK and varies in degrees of severity. Either or both of the disabilities that form deafblindness can be congenital or acquired in later life. The combined hearing and vision loss significantly affects the life of an individual even if, when taken separately, each single sensory impairment can be relatively mild. Thanks to CAPE Acorn Postgraduate Research Award 2017, we have developed a proof-of-principle speech-to-braille communicator to give deafblind people the ability to understand spoken words. We have created a novel, cheap and open-source prototype for a refreshable braille cell that is scalable to a full braille keyboard. By combining the new haptic interface with open-source speech-to-text recognition software we created a new assistive technology system. We thank the CAPE Acorn committee for the generous financial support, which has enabled us to work on an extremely interesting project with the potential to improve the very challenging lives of people with deafblindness.

Tien-Chun Wu – PhD student in Electrical Engineering

Development of multi-sensor platform for real-time air-quality monitoring

The project involves the establishment of distributed wireless networks consisting of multiple miniaturised MEMS-based sensors to enable remote monitoring of local air quality in real-time. I developed cloud-based analytics algorithm and interface for recognition of pollutants and particle matters components using low-cost sensors that have not only allowed for visualisation of ubiquitous spatial mappings of both metropolitan and indoor air quality index (AQI), but also enabled transmission of timely alerts of detection of toxic and combustible analytes. Furthermore, the multi-sensor array approach I employed has also promoted development of algorithms to compensate for interfering effects for improvement of detection accuracy. Throughout the course of the Acorn project, the development of expertise involving communications protocol, cloud-based interface, and recognition algorithms has made important contributions towards my PhD research on the topic: mobile-embeddable breath analysis for personal healthcare monitoring, representing a significant step towards internet of things (IoT) realisation of miniaturised ultralow-power inkjet-printed graphene-based CMOS-integrated sensor arrays.
CAPE Activities

Yin Chang — Postgraduate student, Dept of Chemistry

Biomimetic diamond structured photonic crystals and the inspirations for industry

Pachyrhynchus weevils have photonic crystal structures that are able to display colours from blue to red. Our research found these jewel-like weevils have a single diamond structure lattice with lattice constant of 400-500 nm. The single diamond lattice is an attractive structure for engineering because it has the widest open bandgap for whole crystal orientations. With the CAPA award fund, we characterised the optic spectrum with optic fibres and the nanostructures with SEM and TEM. Different oriented crystal models were constructed and simulated with FDTD. Band diagram of different diamond lattice constants and chitin-air filling fraction were then constructed which provides important information for future optic device designs. Moreover, this study is inspiring for self-assembly mechanisms of large-scale (400-500 nm) single diamond structure, which cannot be achieved by engineering techniques so far.

Acknowledgements:

Pachyrhynchus weevils are captive and bred in Taiwan. The researchers thank Dr Hui-Yun Tseng for providing the species and for biology and genetics discussions.

CAPE Lectures

Several times a year, CAPE organises CAPE Advanced Technology Lectures at the Electrical Engineering or Computer laboratory. Lectures that have taken place since 2011 include:

- Dr Thomas Popham and Kris Kobylinski (Research Engineers at Jaguar Land Rover): “Self Learning Car” (2014)
- Andrew Foster and Dr Lee Skrypchuk (Chief Engineer and Research Engineer at Jaguar Land Rover): “Jaguar Land Rover — Technology Trends and Future Direction” (2014)
- Dr Michael Campbell (Particle physicist from CERN): “Hybrid pixel detectors — from hunting the Higgs Boson to medical X-ray imaging” (2015)
- Carlos Lee (General Director, EPIC — European Photonics Industry Consortium): “Photonics, Enabling the Next Revolutions” (2015)
- Prof. Ashwin Seshia (Prof. of Microsystems Technology, UoC): “Vibration energy harvesting for low-power autonomous sensing” (2016)
- Prof. Jong Min Kim (Prof. of Electrical Engineering, UoC, former Vice-President of Samsung): “Nanotechnologies and its convergence for the applications” (2016)
- Dr David Cole (Reader in Mechanical Engineering, UoC): “Driver-vehicle dynamics and the internal model hypothesis” (2016)
- Prof. Malgorzata Kujawińska (University of Warsaw): “Different faces of digital holography: from displays to holographic tomography” (2016)
- Tish Shute (Director of AR/VR, Corporate Technology Strategy, Huawei USA): “XR and The Future of Communications: From Silicon to Human Photonics” (2016)
- Yupar Myint, Head of Entrepreneurship Programme (Impulse for tech Innovators), Maxwell Centre: “The role of serial entrepreneurs in Cambridge ecosystem” (2017)
- Dr Andreas Georgiou (Research Engineer at Microsoft): “Near Eye Displays — HoloLens” (2017)
- Dr Bryan Reimer (Research Scientist at MIT AgeLab, Associate Director of The New England University Transportation Center): “A robot in my driveway?” (2018)
- Prof. Peter Shien Kuei Liaw (Distinguished Professor & Vice Dean of NTUST, President of Taiwan Optical Society and Secretary General of the Taiwan Photonics Society): “Free space optic WDM bidirectional transmission: Design and Evaluation” (2018)
Views from PIs and Researchers

‘My research has greatly benefitted through collaboration with Jaguar Land Rover (JLR), facilitated by CAPE as one of its partners. We have developed new technologies such as active rectifiers for vehicle alternators, which improve the efficiency and power density of these devices; a new energy storage method to mitigate against the spikes in power demand in active anti-roll bar control systems; a new type of integrated starter-alternator for mild hybrid vehicles. Regular contact with JLR engineers has kept the research fresh and exciting, knowing that it is solving real difficulties in vehicle electrical power systems design. The collaboration has meant that a number of postdocs and PhD students have benefited from industrial visits and input, which has been a great opportunity for them and their future careers. The research has led to a number of conference and journal papers, all of which have been partially credited to our main link person at JLR due to his detailed knowledge of the sector, and hence research priorities. It is this expertise, as well as the ongoing input, which has made the collaboration so valuable.’

Dr Tim Flack
University Lecturer in Electrical Power and Energy Conversion

The Department of Computer Science and Technology worked with Jaguar Land Rover on research into Enhancing Driver Experiences through Vision Research (Endeavour) from 2015 to 2018. CAPE helped establish contact with the right people and made it easier to set up a contract. The project resulted in nine publications and a couple of invited keynote addresses. Several promising lines for further work have emerged, for which funding is still being sought.

Professor Peter Robinson
Department of Computer Science and Technology, University of Cambridge

‘The smart in-building wireless system using flexible transmission technology (SWIFT) project is a CAPE project in collaboration with Beijing Institute of Aerospace Control Devices (BIACD). The project aims to deliver a world leading in-building wireless solution based upon Cambridge’s digital distributed antenna system (DDAS) architecture and its embedded processing algorithm.

Over the past three years, the research teams in Cambridge and Beijing have worked together to develop an industrial level DDAS prototype. This has been transformed into a series of real-life products, including a wireless distribution system that can combine 14 mobile services/bands onto a single network infrastructure for indoor coverage. Such a system can achieve over three times higher data transmission efficiency than the current industrial standards in an optical network, and thus has lower cost and power consumption than existing solutions.

The system has the potential to carry digitised RF carriers over standard IP network infrastructure together with conventional digital data, allowing a cloud and converged network architecture to be built for multi-service and multi-operator wireless coverage in a highly efficient way. The project has also enabled business activities in both organisations collaboratively to allow DDAS products to be commercialised in both China and the UK. These include a successful patent application and a licensing agreement signed between the University and BIACD. Currently, a follow-on project is under negotiation, aiming to bring the research outcome to a new level in order to meet the new challenges of the next-generation wireless communication networks.’

Dr Tongyun Li
Collaboration of CAPE with BIACD

The Centre for Advanced Photonics and Electronics (CAPE)
The Engineering Design Centre and the Signal Processing Group have been working together with Jaguar Land Rover (JLR) under the CAPE Partnership since 2011. During this time, it has been a facilitating channel for two PhDs, and more than five years’ worth of collaborative projects looking at key issues and technology opportunities in automotive Human Machine Interface area. The CAPE Partnership has acted as an enabler to conceive jointly applied research projects that service the needs of JLR with a short lead-time to realisation of results.

The work has covered a wide range of research topics. One of the first and most successful has been the Motion Adaptive Touchscreen System for Automotive (MATSA), started in response to a JLR visit to the Cambridge University Engineering Department. Based on work done previously by Dr Patrick Langdon on compensation filtering for input devices for people with Cerebral Palsy, this aimed to develop a vibrating-acceleration compensation and intent recognition algorithm to be implemented as a high-quality visualisation platform for each persona; carrying out ethnographic interviews on obtaining market research to generate a persona; carrying out ethnographic interviews with real people matching the persona. The project identified and enumerated future HMI prototypes and subsequently patented. These developed technologies substantially benefit and aid JLR efforts to deliver a more personalised, safer and pleasant driving experience. It also enables additional JLR smart vehicle functionalities in the future especially for autonomous driving where knowing the driver-to-vehicle position (inside and outside the vehicle) and his/her profile as well as preferences can be crucial.

Through working with CAPE, a number of important generic benefits have been established.

1. The CAPE Partnership allows the customisation of the working relationship for experimental and logistic facilities
2. Once new technology innovations have been identified, working with JLR through CAPE greatly facilitates the patent procedure
3. CAPE provides an “Industrialised” collaboration framework that encourages a close collaborative working environment with regular reviews and deliverables
4. CAPE provides contact and cross-fertilisation of ideas and results between multiple projects ongoing within JLR
5. Formulating novel solutions amenable to practical applications

In Driver Intent and Preferences Prediction and Profiling using Bayesian Learning from Asynchronous-heterogeneous Data (DIPBLAD), several technologies that are key to intelligent vehicles were developed and trialled using prototype implementations and subsequently patented. These developed technologies also offers an effective means to easily interact with emerging display technologies, such as head-up and 3-D displays, in automotive applications via its mid-air, contactless, selection capability.

Following the initial success of MATSA, two very different projects show the scope of the potential for collaboration:

The Inclusive Human Machine Interfaces (iHMI) project researched, developed and delivered a new method for developing technologies that offer opportunities to inclusively customise and personalise the in-vehicle experience. The approach was based on obtaining market research to generate a persona; carrying out ethnographic interviews with real people matching the persona. The project identified and enumerated future HMI technology likely to be usable by 2025, identifying existing inclusive design usage cases with cars in 2035. The booklets were then used as a high-quality visualisation platform for each persona usage case, presenting the same usage cases with future designs using cars with extrapolated future HMI interfaces. The main project deliverable was a box set of eight Doculets. A series of two internal JLR workshops on the use of the approach accompanied this, and a Techfair Display. This project was widely distributed in JLR and the method perceived as very useful. The box sets became a permanent resource found on most desks in R & D in Coventry.
I have been working with CAPE industrial partners for six years, two years (2013-2014) with Huawei and four years (2015-2018) with Jaguar Land Rover (JLR). Projects I have been involved in are:

**Huawei:** Auto-stereoscopic mobile 3D display, developing novel methods in achieving full resolution auto-stereoscopic (glass-free) mobile display.

**JLR:** Automotive Immersive Head-Up Display (iHUD), developing next-generation head-up displays for automobiles with a large projected image plus high resolution, high brightness and depth perceptions.

Compared to fundamental research for non-industrial sponsors, research for industry is more application driven; the industrial project needs to demonstrate developed concepts. The project deliverables may also change according to the industrial partner’s needs and new mini-projects could evolve.

I did not think that I could file this many patent applications (14 PCTs, 2 granted). Paper publications, however, often need to wait until the patent applications have been filed. Still, if I find research highlights during the project I am often able to publish them.

I have seen direct impacts of my research: the developed demonstrator has been installed in a prototype car and was used for various tests both for our research and other research such as production teams within the industrial partner.

I have established personal contacts with the industry and we work closely with our contacts in the company. We meet as often as every two weeks and the partner company has been supportive, providing parts we need to carry out the project more efficiently.

I would highly recommend this type of experience to others within the University as it enables me to get a different perspective from industry and an appreciation for my effort. We work with company contacts as a team and it is very important for the applied work that is likely to be adopted by the industry.

I am currently developing a new concept for Light Detection and Ranging (LiDAR) through the CAPE Acorn Blue Sky Research Award 2018. I plan to demonstrate my concept at the end of this year and wish to extend it into a CAPE project.

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Dr Kun Li
CAPE research with Jaguar Land Rover and Huawei

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Dr Matthew Pryn and Dr Pawan Shrestha
CAPE collaboration with Jaguar Land Rover

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Dr Jin Li
CAPE collaboration with Disney Research

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‘CAPE has provided us with an ideal opportunity and platform to work on industrial projects. As a researcher, this collaboration gives us a unique insight into the strategy, mindset, and tools used by world-leading technological companies. As an engineer, it is extremely exciting to be able to turn research into functional and patentable prototypes. We also get to help develop long-term research goals, steering future industry development. CAPE allows us to work with a range of brilliant professionals from a wide variety of industries and academic backgrounds, and helps us create new and innovative ideas, allowing us to get involved in high impact academic projects.’

‘I have been working with Disney Research for three years on the project ‘Coarse Integral Hologram for 3D Images’. Through working with industrial partners, we source academic research challenges from the current non-academic projects. We can also research the non-academic project from fundamental start point. I am very happy with this type of research experience and would recommend it to other academics. In the future, I would like to continue working with Disney Research on other projects.’
CAPEable Collaboration, University/industry collaboration is enabling leading edge research in Cambridge

24 November 2009

CAPE has bought together the Cambridge University Engineering Department’s Electrical Engineering Division with several industrial partners.

“CAPE provides a new form of joint university-industry research that is leading edge and commercially relevant”
Professor Daping Chu

The CAPE formed as a way in which the university could address global issues involving open innovation, in partnership with companies of international importance in the photonics and electronics industry.

Full Article: https://www.newelectronics.co.uk/electronics-technology/cover-story-capeable-collaboration/20856/

An electronic partnership

We are on the brink of a manufacturing revolution for photonic and electronic devices, and it is vital that the UK is able to capitalise on the cutting-edge research taking place at universities such as Cambridge to attract global industries. Not content with just being a world leader for research in this field, the Centre for Applied Photonics and Electronics (CAPE) has also established a unique model for working, which takes collaboration between academia and industry to a new level.

“When CAPE was set up, we realised we needed to have a more equal and open approach when interfacing with industry”
Professor Daping Chu

Full Article: https://issuu.com/uni_cambridge/docs/annual-report-2011-report
Smart glass goes from clear to opaque and back again 27 million times
8 June 2016
Researchers at the University of Cambridge have developed a type of ‘smart’ glass that switches back and forth between transparent and opaque, while using very low amounts of energy. The material, known as Smectic A composites, has potential for installation in buildings or automobiles, reducing energy bills by avoiding the need for costly air conditioning.


Through a glass, darkly, as Cambridge scientists break new ground
13 June 2016
Researchers at Cambridge University have developed a glass that can change from see-through to opaque at the touch of a button.

The invention uses an advanced form of liquid crystal— but they say it needs much less power than previous forms of ‘privacy glass’.


Smart glass technology hands you the power to turn off the sun
17 June 2016
Smart glass that alternates between transparent and opaque— allowing people to switch the sunlight on and off — could revolutionise the energy efficiency of buildings, vehicles and advertising displays across the globe, the Cambridge inventors believe.

University of Cambridge researchers say the solar control could dramatically reduce energy bills by eliminating the need for costly air conditioning or other artificial methods of temperature control.

The patented work is being commercialised by Cambridge Enterprise, the University’s commercialisation arm, to a major industrial partner through a technology framework transfer agreement.

Full Article: https://www.businessweekly.co.uk/news/academia-research/smart-glass-technology-hands-you-power-turn-sun

‘We started making it in plastic, which meant we could attach it to things like windows in order to reduce the effects of solar radiation, since the energy is being scattered rather than absorbed’
Professor Daping Chu

PHOTO CREDIT: JAGUAR LAND ROVER

Daping Chu: The car of the future — with head-up technology
19 June 2017
Professor Daping Chu outlines his work on the car of the future and the use of Head-Up Display technology together with his Jaguar Land Rover collaborators.

Full Article: https://soundcloud.com/university-of-cambridge/the-car-of-the-future-with-head-up-technology

We’re moving towards a fully immersive driver experience in cars, and we think holographic technology could be a big part of that.”
Professor Daping Chu

Full Article: https://www.cam.ac.uk/research/features/heads-up-cambridge-holographic-technology-adopted-by-jaguar-land-rover

Cambridge researchers have developed a new type of head-up display for vehicles that is the first to use laser holographic techniques to project information such as speed, direction and navigation onto the windscreen so the driver does not have to take their eyes off the road. The technology— which was conceptualised in the University’s Department of Engineering more than a decade ago — is now available on all Jaguar Land Rover vehicles. Researchers behind this technology suggest it to be another step towards cars that provide a fully immersive experience. It could even improve safety by monitoring driver behaviour.

‘You could have smart windows in an office building that automatically became more or less opaque, depending on the amount of sunlight coming through.”
Professor Daping Chu

Full Article: https://www.cam.ac.uk/research/features/through-a-glass-darkly-as-cambridge-scientists-break-new-ground/
Scientists at the University of Cambridge and the Walt Disney Company have proposed a 3D display that exploits the orbital angular momentum (OAM) of “twisted” light. The team says that its nine-by-nine pixel display demonstrates a new and powerful technique for organizing and transmitting the massive amounts of data required for displaying 3D images – and eventually video.

Full Article: https://physicsworld.com/a/3d-display-exploits-twisted-light/

Optical physics research update – 3D display exploits twisted light
20 July 2016

"There is no problem to scale it up to a much larger number, a few tens of views, at least, in terms of coding the information into a large number of modes. However, it is technically challenging to multiplex many images as well as separate them in space."

Professor Daping Chu

3D displays momentum multiplexing
12 February 2019

Encoding and Multiplexing of 2D Images with Orbital Angular Momentum Beams and the Use for Multiview Colour Displays

Full Article: https://stj.sciencemag.org/research/2019/6564593/

Daping Chu and co-workers are exploring the opportunities for using OAM modes to carry different views of an object, which can then be demultiplexed to create a multi-view 3D display. To date, the researchers have demonstrated a three-view display based on the approach, whereby three different image patterns can be encoded into arrays of OAM beams and then spatially separated for the viewer.

Full Article: https://www.nature.com/articles/nphoton.2016.171

Cambridge researchers and Jaguar Land Rover develop immersive 3D head-up display for in-car use
20 August 2019

Researchers from the University of Cambridge are working with Jaguar Land Rover to develop next-generation head-up display technology that could beam real-time safety information in front of the driver, and allow passengers to stream 3D movies directly from their seats as part of a shared, autonomous future.

Engineers are working on a powerful new 3D head-up display to project safety alerts, such as lane departure, hazard detection, sat nav directions, and to reduce the effect of poor visibility in poor weather or light conditions. Augmented reality would add the perception of depth to the image by mapping the messages directly onto the road ahead.


World-first structural electronics research for in-car electronics
19 November 2019

Pioneering structural electronics research led by Cambridge PhD student Ashutosh Tornar on behalf of Jaguar Land Rover has been unveiled as a world-first for next-generation in-car personalisation.

Mr Tornar, who is also the Electrical Research Technical Manager at Jaguar Land Rover, has been working on the Lightweight Electronics in Simplified Architecture (LESA) research technology – used in flexible wearables and curved OLED TVs – for car interiors. It has formed part of his PhD research, under the supervision of Professor Daping Chu, Director of both the Centre for Advanced Photonics and Electronics (CAPE) and the Centre for Photonic Devices and Sensors.

Full Article: http://www.eng.cam.ac.uk/news/world-first-structural-electronics-research-car-electronics

CAPE in the News

The Centre for Advanced Photonics and Electronics (CAPE)

Predictive touch technology developed by Cambridge engineers in collaboration with Jaguar Land Rover has won an innovation prize
7 April 2020

The project led to the development of predictive touch technology that interacts intelligently with in-vehicle systems by simplifying pointing and selection processes. The technology uses a gesture tracker and other sensory data such as an eye-gaze tracker, along with a prediction algorithm.

The technology was developed between 2012 and 2018 by the CAPE as part of the CAPE Motion Adaptive Touchscreen System for Automotive – MATISA (1 and 2) project. The research team included Professor Simon Godsill, Dr Bashar Ahmad, Dr Lee Skrypchuk and Professor Pat Langdon.


AI-based ‘no-touch touchscreen’ could reduce risk of pathogen spread from surfaces
23 July 2020

A ‘no-touch touchscreen’ developed for use in cars could also have widespread applications in a post-COVID-19 world, by reducing the risk of transmission of pathogens on surfaces. The patented technology, known as ‘predictive touch’, was developed as part of a CAPE collaboration with Jaguar Land Rover led by Professor Simon Godsill.

Removing weight from the car is one of the key requirements of future cars, as this leads to better range and reduction in carbon emissions. While industry is looking into materials and mechanical reductions, project LESA looks into how to reduce the weight of electronics and the electrical architecture of the car. As the area of research is large, hence Cambridge CAPE and Jaguar Land Rover research came together to focus on this challenge head on. We looked into key parts and components that make up the electrical architecture of the car, like networks, computers, sensors and cables. Now we are working towards some key areas where we can significantly reduce the weight of underlying electronics. This is an ongoing research where two institutions are working collaboratively.

Dr Quinn Smithwick, Senior Research Scientist at Disney Research, has been collaborating with CAPE for several years. Disney Research’s partnership in the CAPE program ended in April 2019, but the final project will continue until August 2020.

In order to preserve Disney’s long history of fostering innovation, and continue this legacy, Disney Research, the company’s technological research arm, joined CAPE to guide and develop fundamental future display technologies. In addition to driving the increase in quality and capabilities of ubiquitous commercial displays through content and standards, Disney Research leveraged the CAPE collaboration to incorporate these new mechanics into unique displays to enrich the experiences Disney creates.

‘Jaguar Land Rover (JLR) joined CAPE in 2011. CAPE has given JLR the opportunity to work with some of the world’s leading scientists on innovative technologies for the automotive industry. The access CAPE gives to all areas of the University of Cambridge means that we can take advantage of a multidisciplinary research team. We have successfully worked with many academics across the university: Professor. Daping Chu (Engineering), John Clarkson (Engineering), Patrick Langdon (Engineering), Peter Robinson (Computer Science), and Simon Godsill (Engineering). Each has contributed significantly, from patents to prototype technologies, all generated through projects in which we worked closely with the academics to deliver technical solutions that can be used in an automotive context.

The best examples of this include the MATSA (Motion Adaptive Touchscreen for Automotive) project and the iHUD project, which through a thorough programme of research have produced high-quality technology demonstrators that JLR have used to define future technology strategy and deployment. Both have been rigorously integrated and tested in-vehicle to ensure that the theoretical principles they are trying to achieve can be realised within the automotive environment.

JLR has been involved in a number of different types of projects that either focus on a single key technological area as well as those that look at a variety of technical solutions and ways to apply existing methods differently. There are theoretical projects that focus on understanding human behaviour in the context of the automobile. PhD studies are also investigating a key research topic in detail as well as generating new concepts and building prototype systems.

CAPE differs greatly from other academic collaborators in terms of expertise and IP rights. It relies on partners being non-competitive which generates interesting projects discussions and raises the potential for collaborations between partners who have mutual interest in a specific technology but for very different reasons. The CAPE terms are favourable for a company like JLR. For any company that wishes to work with the University of Cambridge, JLR believes the partnership with CAPE is an excellent way of leveraging the world-class research staff and facilities at the University of Cambridge.

JLR will continue to work on strategically relevant projects with CAPE, in accordance with our technical synergies, international legal requirements and business priorities, where we need some of the best minds in the business that help us solve problems related to the delivery of premium vehicles globally.’
Get Involved

Work with CAPE

CAPE always welcomes the participation of new industry partners who look to leverage our expertise and at the same time provide a synergistic fit with our existing partners. Established for over 15 years, CAPE has a record of successful technology development within a robust model for university-industry collaboration. Contact us to explore ways to work with us.

Advantages of working with CAPE

Technology from science
- Work with world-leading scientists and engineers to develop innovative science into practical solutions that can be applied by your company
- Jointly commission research for the benefit of the CAPE Partners with direct control through representation on the CAPE Steering Committee
- Projects are supported by access to the cutting-edge R&D facilities within the Electrical Engineering division

Established governance structure
- Management of CAPE is by the Steering Committee with equal voting rights for the CAPE Partners and the University
- The CAPE Partnership Agreement (CPA) provides fair IP terms agreed between the University and CAPE partner
- Our pre-determined terms and conditions allow for fast project approval
- The CAPE Office provides dedicated support to partner projects and interests

Gateway to Cambridge
- CAPE is a gateway to all areas of the University of Cambridge, including researchers in the Department of Engineering, Cavendish Laboratory, The Computer Lab, Chemistry Department, Materials Science and others
- Research themes covered by CAPE researchers include AI, Batteries, Big Data, Energy, Healthcare, Graphene, Sensors, etc.
- CAPE’s track record has established its reputation among academics and the wider University, facilitating good collaborations with CAPE Partners

Partnerships
- The CAPE Partners have non-competitive market positions by design, so there are potential business opportunities between partners with a mutual interest in exploiting a technology

Other benefits
- Exchange scientists and engineers between industrial and academic partners, through our embedded researcher scheme
- Expand CAPE projects by leveraging the industrial funds invested through CAPE via external sponsors such as the UK government
- Membership of CAPE provides networking benefits from existing links between the University of Cambridge and other academic centres, in both the UK and elsewhere

Ashutosh Tomar, Jaguar Land Rover

‘For any company that wishes to work with University of Cambridge, the partnership with CAPE is an excellent way of leveraging the world-class research staff and facilities at the University of Cambridge.’
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This brochure was produced by the CAPE Office, August 2020. Except where stated otherwise, it does not necessarily represent the official views of the CAPE Partners or the University of Cambridge.