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Burns masks produced with 3D technology

Scientists from Morriston Hospital in Swansea are helping burns patients to heal with pioneering technology

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Advances Wales showcases the latest news, research and developments in Welsh science, engineering and technology. This edition and past editions can all be viewed online.

THE JOURNAL FOR SCIENCE, ENGINEERING AND TECHNOLOGY
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Advances Wales highlights groundbreaking innovations in science, engineering and technology across Wales.

This edition features scientists using pioneering technology to create 3D masks for burns patients (page 6) and exploring a new treatment that could prolong the life of patients with incurable breast cancer (page 8). Wales-based researchers are also working on a landmark project to improve breeding techniques for coral reef fish (page 12).

Environmental innovations in this edition include a device that can convert waste heat into electric power (page 10) and new colouring technology that allows black plastic to be more easily recycled (page 11).

Drone technology is also in the spotlight in this edition, with a Welsh company developing ways of making drones safer and more reliable (page 16). Meanwhile, there are digital innovations including systems designed to analyse road damage (page 18), monitor people at risk of falls in the home (page 19) and detect problems on railway tracks (page 20).

This edition of Advances Wales, as well as past editions, can be viewed online.

Sophie Davies
Editor

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Advances raises the profile of the technologies and expertise available from Wales in order to facilitate collaborative relationships between organisations and individuals interested in new technologies and innovation.

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New centre for innovation in AI and robotics

A centre for cutting-edge technologies, from robots and automated vehicles to virtual reality and artificial intelligence, is to be opened at Cardiff University.

The new interdisciplinary centre for Artificial Intelligence, Robotics and Human-Machine Systems (IROHMS) intends to position Cardiff and South Wales as a hub for emerging and innovative technologies. It will build on the research expertise at the University's Schools of Engineering, Computer Science & Informatics and Psychology, as well as the experience of leading large-scale research programmes in these areas. Previous high-profile projects have included the development of semi-autonomous robots to support elderly people at home and a portable early-detection and treatment device for traumatic brain injury.

IROHMS will focus its research on many sectors of strategic importance for Wales, including high-value digital manufacturing, wireless factory machinery, aerospace, autonomous vehicles, and the societal challenges facing healthcare and assisted living. The funds will also help to strengthen the critical mass in artificial intelligence and robotics that currently exists across South Wales, fostering new collaborations with industry experts and increasing investment across the area.

State-of-the-art facilities at Cardiff University will be enhanced, with the further development of a robotics lab, motion capture lab, Internet of Things lab and other investments.

"This new centre draws on a vision of the world that is human-centric, interactive, interconnected, data-rich, knowledge-intensive and smart. By bringing together our collective expertise under one banner, we will maximise our research expertise and drive forward innovations that tackle some of the most pressing societal challenges. Our aim is to make South Wales an area of excellence in AI, Robotics and Human-Machine Systems, that is known across the world, attracting further investments and the very best research expertise."

Professor Rossi Setchi
IROHMS
Cardiff University

www.cardiff.ac.uk

Breakthrough in bovine TB testing

Research by two scientists from Aberystwyth University has paved the way for a possible breakthrough in the worldwide fight against bovine TB.

Two skin tests for cattle have been developed to distinguish between animals that are infected with bovine TB and those that have been vaccinated against the disease. The combination of essential proteins which enables this differentiation was established by the teams of Professor Glyn Hewinson and Professor Martin Vordermeier from Aberystwyth University, whilst working at the Animal and Plant Health Agency. Building on their work, the two skin tests have now been created by an international team of scientists from Ethiopia, India, the Netherlands, the UK and the USA.

A significant drawback of the traditional skin test is that it shows a positive result for cows that have TB as well as those that have been vaccinated against it. By distinguishing between vaccinated and infected cattle, the new tests will facilitate the implementation of vaccination programmes globally, which could considerably reduce the transmission of this infectious bacterial disease from cattle to humans.

"Development of these tests is a crucial step on the long and challenging journey to implement cattle TB vaccine programmes that can reduce the burden of this intractable disease. Without such tests, traditional test and slaughter control strategies could not be pursued alongside vaccination, nor could vaccine efficacy and disease prevalence be effectively monitored in vaccinated animals in countries where such control strategies are unaffordable or societally not acceptable."

Professor Martin Vordermeier
Centre of Excellence for Bovine TB
Aberystwyth University

The new test will now be evaluated in field trials to a level recommended by the World Organisation for Animal Health, and regulatory issues including demonstrating their safety will also be addressed. Such studies are already underway in the UK and in India.

www.aber.ac.uk

Cutting-edge privacy software in development

Anglesey-based tech company Cufflink is developing new software with the aim of revolutionising the way we manage and share our personal information.

"The work being done by Cufflink is exactly the reason M-SParc was established. This is cutting-edge work, being done in North Wales by a local team, and benefiting a global issue. We're proud of Cufflink and aim to continue supporting them, and all our tenants, as they continue to grow."

Pryderi ap Rhisiart
Managing Director
M-SParc

Personal Information is currently stored by many third parties, meaning it is stored and duplicated numerous times. This not only increases the costs for these third parties to store and secure this information, but also the risk of your information being hacked or accessed illegally.

Cufflink, based at the Menai Science Park (M-SParc), is developing a new application for iPhone and Android devices that will provide a safe and secure place to store and share personal information online. This means it will be possible to register for websites and services, with only a reference to this data needing to be stored. It will also enable sharing of information with friends, family and colleagues.

The app and integrated service will ensure that the user is in charge of when and with whom they share their personal information.

The company's co-founder Billy Williams explained: "We firmly believe that people should be able to manage and control their own personal information, without fear of what some companies or individuals might do with it, without their knowledge or permission. To that end, the support we've received will also let us carry out more ground-breaking research into developing a new consumer-led global personal information market. We'll provide the consumers with the tools to manage their own personal information securely and, ultimately, ensure that they're rewarded for sharing it - something that isn't currently happening in today's digital environment."

www.cufflink.io

Publication highlights Welsh achievements

On a global scale, Wales is a small but smart country. From the past to the present, an impressive list of achievements in science, technology and engineering can be found in the latest edition of Welsh Achievements.

The publication explores Welsh success stories, from the historic to the more recent, in areas including environmental sciences, health, engineering, telecommunications and transport. A section of the publication also highlights notable Welsh figures, including Nobel prize winners.

"Great scientific discoveries are an inspiring testament to the profound capabilities of the human mind. The recognition of such talent in Welsh Achievements is designed to inspire young academics and future generations, by demonstrating what is possible when ability is recognised, nurtured and given the opportunity to flourish."

Prof Peter W Halligan
Chief Scientific Adviser for Wales

www.businesswales.gov.wales/innovation/news-0/welsh-achievements

IN BRIEF

Tech firm joins aerospace hub

A space technology firm has signed up to a Gwynedd airstrip to develop its launch service for small satellites. Newton Launch Systems is the latest tenant at the Snowdonia Aerospace Centre at Llanbedr, driving forward the site's ambition to become a Centre of Excellence for Space and Remotely Piloted Air Systems. The company aims to develop space access technology appropriate for the fast-growing small spacecraft market, with an initial focus on the rapidly emerging cubesat, nanosatellite and small microsatellite platforms. Newton chairman Dr Martin Heywood said: "I used to watch aircraft taking off and landing at Llanbedr from the school field. I would have loved to have stayed locally, but I was forced to move from the area after university to pursue my career. I hope that the development of the Aerospace Centre over the next few years will allow today's generation of young people to develop a quality career within their own communities."

Investment to tackle corrosion

Hexigone Inhibitors has secured £1 million investment, which will support its plans to become the industry standard in anti-corrosion technology. Corrosion costs the world economy 2.5 trillion dollars every year, and the EU has recently banned its most effective inhibitor, hexavalent chromate, due to health concerns. Hexigone Inhibitors aims to plug the gap by offering a new additive for metal coatings that is safer and can be up to ten times more effective than chrome-free alternatives, so that buildings, cars and aeroplanes can be protected for longer. The technology uses 'chemically intelligent' micro reservoirs that make the coatings responsive to the environment, triggering release of the inhibitor on demand. This innovative approach to tackling corrosion has now secured investment which will help the company to achieve full-scale commercialisation and distribution.

Funding to improve lung cancer detection

Dr Charles Brilliant, a researcher based at Swansea University, has secured £35,000 funding to further his research using infrared light to determine the molecular structure of sputum to detect lung cancer. It means that patients could get an initial diagnosis in their GP surgeries, rather than waiting to attend a hospital appointment, using a method that is faster and non-invasive. Dr Brilliant explained: "Lung cancer can cause structural changes to airway mucus, which is how it can be detected through the use of infrared spectroscopy. Sputum is a horrible and thick substance and when it dried, it would dry with a bumpy pattern which would scatter the infrared light. We had the idea of using a mesh that the mucus would be forced into it, rather than being on a flat surface, which encourages the mucus to dry flat, and reduced the scattering of light. It opens up so many possibilities of moving what is currently an expensive technology into the clinic."

Wave power firm thrives in West Wales

Australian-born company Bombora, the developer of a membrane style wave energy converter called mWave, is thriving in its new Welsh home. The company say that Pembroke Dock, with its enviable natural and industrial resources, has been a key enabler in the rapid acceleration of their full-scale technology validation project, as well as giving them access to an experienced supply chain. They have engaged with nearly 50 local suppliers since opening their offices in Pembroke Dock in 2017. The largest two local fabrication contractors alone, Mainstay Marine Solutions and Altrad Services, will have 35 staff working on the project between them over the next six months. Bombora is currently mid-way through completing a 1.5MW mWave product validation project in Pembrokeshire, alongside developing a global pipeline of commercial wave farm projects. Located 10 metres beneath the ocean's surface, similar to a fully submerged reef, the company's technology is invisible from the shoreline. As ocean waves pass over the mWave, the membranes deflect pumping air through a turbine to generate electricity.

Celebrating award-winning Welsh tech

Winners have been crowned at the Wales Technology Awards 2019, celebrating the best and brightest in the thriving Welsh tech sector. The Start-Up Award went to Drone Evolution, who feature in this edition of Advances, and Innovative Product of the Year was awarded to Glyndwr Innovations. Bipsync UK Ltd received awards for Best Tech Workplace and International Impact (Software), while Best Application of Tech went to Vizolution and International Impact (Hardware) went to TXO Systems. Gerard Church and Jackson Hull of GoCompare were named Best New Talent and Technology Leader of the Year respectively. Avril Lewis, managing director of ESTnet who organise the awards, commented: "Across the whole of Wales, there are innovative companies doing truly great work, and it has been an honour to bring the industry together and celebrate their achievements at the biggest night of the year for Welsh technology."

Wearable device to aid Parkinson's mobility

The Centre for Advanced Batch Manufacture (CBM), established by University of Wales Trinity Saint David, has assisted London-based company Walk With Path in developing a wearable device for Parkinson's disease. Many people with Parkinson's suffer from freezing of gait, which makes them unable to initiate or continue walking (the foot can feel 'stuck' to the ground) and is a major cause of falls. The new device attaches to a shoe and projects a horizontal line on the ground, at a set distance from the feet. This gives the wearer a visual cue to step across, acting as an external stimulus to trigger walking. After a simple prototype had been produced, CBM was brought on board to help develop this into a commercial product. Company founder Lise Pape said: "CBM helped us to prototype multiple iterations of our product, carrying out user testing at each stage by using their rapid prototyping services to make devices our users could interact with." Less than 12 months after the first meeting, Walk With Path has launched the Path Finder device.

Sustainable food packaging in development

Wrexham-based company BioPaxium Technologies is developing eco-packaging solutions that provide an alternative to the non-recyclable black plastic trays often used in ready meal packaging. Its recyclable tray formulation is a combination of fibre and a special bio-coating, allowing the tray to achieve the desired temperatures for microwave and oven applications and exhibit the necessary barrier properties. Peter Davies founded BioPaxium in 2017 after working in the industry for more than a decade and learning about the materials and limitations of the technology surrounding plastics. The company has now received a grant, covering a 16-month period commencing March 2019, to continue the development of a biopolymer coating to be applied to a wood pulp tray.

Progress for cancer research project

A project aiming to improve diagnosis and treatment of ovarian cancer is going from strength to strength. Epigenetics involved studying chemical changes to DNA and associated proteins that can lead to genes being turned on or off. In some cases, this can go wrong and lead to disease such as cancer. The Cluster for Epigenomic and Antibody Drug Conjugate Therapeutics (CEAT), based at Swansea University's Medical School, involves the University working closely with industry partners to develop drugs that can control epigenetic signals. These can be targeted specifically towards ovarian cancer cells where such changes have occurred. Thanks to the success of the project so far, one of the University's key collaborators, Porvair Sciences, has been able to expand its operation from its incubation phase at the Institute of Life Science in Swansea to create a base in North Wales. The project has already resulted in a new research tool called Chromatrap, which is now being manufactured at Porvair's new biosciences facilities in Wrexham.

Technology to tackle loneliness

Monmouthshire County Council has launched two innovative projects aimed at finding solutions to loneliness and limited public transport in rural areas. The first involves a digital platform called Thrive, created by Box Clever Digital, which has the potential to help people in remote areas by improving transport options. The company has said that the platform could provide users with information on public and volunteer transport, as well as dial-a-ride services, and should give people a wider choice at a variety of prices. For statutory care services, it could reduce costs by making people in need of support more resilient and encouraging other members of the community to help. The second project, named Connector, will be led by the Behavioural Insights Team. It aims to increase the council's understanding of loneliness at a local level and make it easier for people to get involved with community activities. The project is based on behavioural science and will look into the underlying mental and physical barriers that prevent people from taking part in community events and groups.

Innovation in precision agriculture

Usk-based company Patchwork Technology, a developer and manufacturer of GPS systems for agriculture, is working to create a next-generation sprayer controller for farmers. Using geo mapping techniques and advanced sprayer controls, the new technology will help farmers to more accurately apply chemical and liquid fertiliser. The aim is to reduce the environmental impact and chemical usage associated with crop spraying, helping to protect both food production and the environment. This project will see the development of an automated boom control to revolutionise sprayer control, which will require a GPS control box for which a complex algorithm will be developed to enable the use of available information from the GPS.

Burns masks produced with 3D technology

Scientists from Morriston Hospital in Swansea are helping burns patients to heal with pioneering technology.

When someone has been affected by facial burns, they may need to wear a burns pressure splint soon after initial healing. The purpose of this splint, often referred to as a mask, is to prevent further facial scarring and to flatten and soften any scarring that has already occurred. This is achieved via gentle pressure applied over several months of wear, and sometimes up to a year.

Traditionally a full face impression is required to create the model on which the custom splint is formed. However, this procedure is time-consuming and can be unpleasant for the patient, as it sometimes needs to be done under general anaesthetic.

Making the process quicker, more painless and also more accurate, scientists from Morriston Hospital's Maxillofacial Laboratory Unit are using static 3D cameras to capture the facial contours. The resulting data can be manipulated and then printed to produce the model on which the mask can be formed.

Traditional full-face impression

> *"We are one of the few maxillofacial laboratory units UK-wide to employ this technology for burns masks, which is recognised by the Katie Piper Foundation as setting the standard for the way burns patients should receive their splints. There is great disparity in the services provided throughout the UK, but hopefully digital technology can help to reduce this by providing services remotely and at less cost. The current system is static, but we are looking at portable cameras that can be posted to local clinical staff to use, so that patients wouldn't need to attend hospital to access this service."*
>
> **Peter Llewellyn Evans**
> Maxillofacial Laboratory Services Manager
> Morriston Hospital

3d scan stage

3d printed model

Advances

The unit has long been an early adopter of digital technologies in head and neck reconstruction, using 3D models for surgical planning. It has now become possible for them to use advanced technology for burns masks due to a drop in the cost of reliable 3D printing, which has made the process more affordable and repeatable.

The ability to more easily capture a patient's facial shape, as well as the lower cost of printing, means that masks can also be re-made more frequently than before, as the patient's face develops over time. In the past, only one or two masks were made during treatment because of the difficulty in obtaining an impression. With the digital technology, multiple new masks can be produced as the scarring changes, resulting in a faster and better outcome for the patient.

The team at the Maxillofacial Laboratory Unit aims to someday have a 3D printing and design centre within Morriston Hospital itself, so that surgeons and medical staff can access it from all areas of the hospital and significantly improve patient care.

The finished mask

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Swansea

New breast cancer treatment prolongs life

Welsh-led research has established that a new treatment can extend the life expectancy of patients with a type of incurable breast cancer.

Breast cancer cells often have receptors that hormones can attach to, stimulating the tumour to grow. When breast cancer has receptors for the hormone oestrogen, this is known as oestrogen-receptor positive (or ER positive) breast cancer, which accounts for around 75 per cent of new breast cancer cases in the UK each year.

Oestrogen-receptive positive breast cancer can be treated with hormonal therapy drugs, such as fulvestrant, which interfere with the action of oestrogen. However, although this treatment is usually effective for a while, the cancer can become resistant and so the drugs stop working.

The FAKTION trial was set up to investigate whether this resistance to hormone therapy could be reversed or delayed. The trial involved 140 patients (post-menopausal women whose cancer had spread) from 19 hospitals across the UK and was sponsored by Velindre University NHS Trust. It was jointly led by Dr Rob Jones from the Velindre Cancer Centre and Cardiff University and Dr Sacha Howell from the Christie NHS Foundation Trust and University of Manchester.

One particular protein, AKT, is known to drive resistance to hormone therapy, so the researchers combined a new drug, Capivasertib, with fulvestrant for the first time, seeking to neutralise the protein. In the trial, they measured how long the treatment was able to prevent cancer growth, as well as whether it resulted in shrinkage of the cancer and how long the patients lived for.

They found that patients who received fulvestrant together with Capivasertib had their cancer controlled for an average of 10.3 months, whereas for those who received fulvestrant with a placebo it was 4.8 months. In addition, 41 per cent of patients who had Capivasertib experienced a significant shrinkage in their cancer, compared to 12 per cent of patients who had the placebo. The trial data also suggests that patients treated with the new combination live for an average of six months longer.

Leaders of the study hope that the research will progress to a phase three trial next, where the combination will be tested with a larger number of patients, and that it could be recommended as a new standard of treatment on the NHS in the future.

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Cardiff

Innovative method of collagen production

ProColl has developed a new way of producing collagen that makes it more accessible and reliable for medical research, with no need for animals in the process.

In recent times, there have been significant advances within regenerative medicine based on tissue engineering, wound healing or cell therapy, intended to meet the challenges of modern healthcare. Colla8gen and related biomaterials have a crucial role to play in regenerative medicine, providing structure and functionality to guide cell and tissue growth and development for the treatment of disease.

Collagen is one of the most industrially important proteins, with applications in the medical, cosmetic, food and beverage sectors as well as in research. The global collagen market was estimated at $3.71bn in 2016, with expectations that it will reach $6.63bn by 2025.

However, researchers have become frustrated by poor supply of collagen that is expensive and often comes with compromised functionality and purity. This has prevented the application of collagen in medicine reaching its full potential. There is also a growing desire to move away from animal products in medical research. To address these issues, Swansea-based company ProColl has developed new methods of collagen manufacture, which can produce a range of established and novel collagens at scale with a high degree of fidelity and purity, and with no need for any form of animal in production.

Dr Chris Wright and Dr Jonathan Widdowson, researchers from Swansea University's College of Engineering, applied advanced biochemical engineering techniques to the extraction and production of collagens, culminating in the production of human collagens in yeasts. The biomaterial is produced using a genetically engineered process, allowing for scalable production, and can be collected through continuous processing. This enables the material to be used commercially, ensuring that researchers can access what they need for their research without being hindered by high costs or batch to batch variation.

The process utilises the yeast's unique ability to formulate full chain collagen molecules with the correct post-translational modifications, producing native collagen as it would be produced in the human body itself. It allows for medical device coatings, dressings, and may allow for organ production through growing 3D bioprinting research to be realised. An added benefit of producing human collagen in yeast is that it is vegan friendly and ethically and environmentally robust.

ProColl's researchers have also developed a range of collagens that are highly soluble and can be handled without the need for aggressive solvents. This is advantageous for the fabrication of medical devices, which can be compromised by the presence of solvent residues from the biomaterial production.

The materials have already been used to produce prototype medical devices in active and passive wound healing, as well as to create bio-ink prototypes and wound closure sprays, with applications ranging from the hospital to military field use. The company wants to empower researchers to find new solutions to the most pressing medical problems, from treatment of diabetic ulcers to artificial organ development. Their collagen technologies are focused on saving lives and improving the quality of life for suffering patients, while saving money for the NHS and global healthcare institutions.

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Swansea

Turning waste heat into electrical power

Swansea University researchers have created a 3D printed thermoelectric device which converts heat into electric power more efficiently to reduce carbon emissions and cut energy bills.

Around one-sixth of all energy used by industry in the UK currently ends up as waste heat, emitted into the atmosphere. Harnessing this waste heat to create electricity could be a huge step forward in helping industry to reduce its carbon footprint and lower its energy costs.

Thermoelectric materials turn differences in temperature into electric power, or vice versa. They are used in fridges, power plants and even some smart watches that are powered by body heat. Previous research has shown that a material called tin selenide (SnSe) has potential as a thermoelectric material. However, the methods used to manufacture it require a lot of energy and are therefore expensive.

Researchers at Swansea University's SPECIFIC Innovation and Knowledge Centre have developed a technique that is potentially very low-cost for industry, because it enables SnSe thermoelectric generators to be produced quickly and easily in large quantities. The team formulated SnSe into a type of ink which they could print to test its properties. The next step was to develop a type of 3D printing technique to produce a small thermoelectric generator made out of the ink.

Experiments have shown that the new 3D printed thermoelectric device converts heat into electric power with an efficiency factor over 50 per cent higher than the previous best for printed materials.

The breakthrough could be of particular benefit to industries where high temperatures are involved in the manufacturing process. One example is steelmaking, which generates vast amounts of heat and requires immense electrical power. Therefore, recycling the heat into power has the potential to boost energy efficiency significantly. Tata Steel are supporting a PhD researcher on the team in order to explore the industrial application of the technology.

> *"Our findings show that printed thermoelectric materials using tin selenide are a very promising way forward. The device we developed is the best-performing printed thermoelectric material recorded to date, and it is also cheap to produce in bulk compared with established manufacturing methods. More work is needed, but already our work shows that this technique, combining efficiency and economy, could be very attractive to energy-intensive industries."*
>
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Swansea

Colouring technology to increase recycling rates

Colour Tone Masterbatch has developed technology that allows black plastic to be more easily recycled and could divert a significant amount of waste from landfill.

The separation of mixed consumer waste into its constituent parts is an essential part of the recycling process, without which recycling would not be possible. In the UK, waste sorting facilities use optical near-infrared spectroscopy techniques to identify and separate this mixed plastic waste for recycling. This is a proven, effective and reliable way of sorting large volumes of material.

However some components within typical polymer compounds, such as pigments, can absorb infrared light and mask the underlying polymer from the sorting machines. The most publicised example of this is plastic coloured with carbon black pigment.

> **As an infrared absorber, carbon black prevents the sorting equipment from identifying the plastic as recyclable, resulting in it being sent to landfill. Therefore the problem is not that black plastic is unrecyclable, as some people think, but that the sorting infrastructure cannot detect it as such. This issue is also not unique to carbon black, because other coloured pigments, individually or in combination, can inhibit infrared sorting and prevent end of life recycling.**

Caerphilly-based company Colour Tone Masterbatch has designed a new colouring technology known as Infra-Tone, which is optimised for infrared reflectance and end of life sorting. It allows manufacturers to have their products coloured however they want, including black, while retaining their detectability when it comes to being sorted after use.

In commercial scale trials, it has been proven that the technology can effectively close the recycling loop. The company is now seeing uptake in products on supermarket shelves, and thousands of tonnes of plastic have already been diverted away from landfill to recycling. However, they are aware that there is still more work to do, as many retail products continue to use packaging that is undetectable for sorting.

Similarly, there is currently a trend of packaging manufacturers moving to clear 'prime' otherwise known as 'virgin' polymers, due to the adverse publicity around black plastic. Although this is in some ways positive, since the polymer will most likely be detectable at end of life and therefore will be recycled, it could potentially be short sighted because these products are able to incorporate very little to no recycled plastic into them.

Black plastic on the other hand, with a sortable colouring solution, can allow manufacturers to incorporate high levels of recycled material into their products, closing the recycling loop and providing a truly sustainable solution. Furthermore this solution provides a mechanism by which packaging producers can meet the government target of incorporating more than 30 per cent recycled content into packaging.

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Caerphilly

Advances

Breeding boost for aquarium fish

Bangor University researchers are working on a landmark project to advance breeding techniques for aquatic species.

As the world's aquatic species face increasing threats due to climate change, overfishing, pollution and the illegal wildlife trade, researchers are seeking to increase knowledge and breeding capabilities. This type of research is difficult in the wild, so aquariums offer an invaluable platform to help scientists further their understanding of key coral reef fish species and their reproductive biology.

Bangor University's School of Ocean Sciences is collaborating with ZSL (Zoological Society of London), The Deep and SEA LIFE on a new research programme to improve aquarium breeding success. Corals are part of a delicate tropical ecosystem and require specific fish species in order to thrive, including species of butterflyfish, rabbitfish, wrasse and tangs. Therefore, the SustaiNable Aquarium project (SNAP) is focusing on selected species which are key to the health of coral reefs but are yet to be successfully bred in aquariums. In addition to investigating the reproductive biology of these species, the project explores the role that diet and the physical rearing environment can play in the success of their aquaculture.

Long-Beaked Coralfish

The breeding of aquatic animals is a complex science, and it can be particularly challenging to determine the correct diet and environment that will enable larval fish to develop into adults. The larvae of many coral reef fish species are incredibly small (typically around 2mm in length), being almost invisible to the naked eye, and their food source is even smaller.

Significant bottlenecks in their aquaculture that need to be overcome include the provision of appropriate diets for their early development as they switch from endogenous feeding, whereby they gain nutrition from an internal yolk sac, to exogenous feeding, whereby the young fish are able to feed for themselves. This requires an entire food chain to be created in a laboratory setting. It is also vital to provide optimal rearing environments that simulate natural physical and chemical conditions.

Having developed technologies appropriate to their own specific facilities, each public aquarium partner site collects eggs from their own aquarium systems, before carefully transporting these to Bangor University where researchers work to rear these fish to a stage at which they can be returned to the aquarium partners. There is an emphasis on coral reef fish species that either lay an egg mass on a hard surface (known as demersal or benthic spawning) or those that release their eggs directly into the water column (known as pelagic or broadcast spawning).

SNAP is helping to advance aquaculture techniques and boost marine species which are near threatened or endangered, while highlighting the collective awareness that aquariums have an important role to play in the future of conserving our oceans.

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Bangor

Advances

Reducing groundwater contamination in Brazil

A Welsh-led project has led to the creation of an innovative device to limit the use of pesticides on South American cotton farms.

Brazil and other South American countries have a major problem of groundwater contamination. It is particularly severe in cotton growing areas due to the large amounts of pesticide used against insect pests such as the boll weevil.

In an attempt to control the boll weevil, growers typically use 15 to 30 aerially applied pesticide sprays per season, but this often produces unsatisfactory results. The boll weevil has contributed significantly to a reduction in the area of cotton grown in Brazil. The greatest reduction has occurred in the North East of the country, where farms are generally small and cotton growing is marginal because of the high need for pesticide.

As a result of pesticide overuse, streams and groundwater directly associated with the cotton fields become contaminated. It also jeopardises the health of operators and wildlife. Therefore a project, involving academic and industrial partners in the UK and Brazil, was established to reduce the amount of pesticide used in cotton growing. This was achieved through the development of innovative 'lure-and-kill' technology where the targeted insect is lured to a biodegradable device treated with a small amount of insecticide, bringing the insect to the insecticide rather than spraying the insecticide at the insect and hoping that some of it lands. The project was led by Lisk & Jones Consultants based in Cardiff, with other partners including Monmouth-based Sentomol Ltd and Bangor University's Biocomposites Centre.

The lure and kill device has a unique 'curly flute' format. This was designed to align well with the thigmotactic (making contact with surfaces) preferences of the target insects. Varying the flute radius in one device allows for differences in insect sizes both within and between species. The length of the device can be easily changed because it is produced by extrusion, and the colour, shape and surface texture can be adapted according to the target pest. Variable methods can be used for mounting the devices depending on the support mechanisms selected, e.g. bamboo canes, there are different methods available for attaching attractant lures. The flutes can also protect the insecticide and the attractant lures from damaging UV radiation in the field.

Several new areas of research and development came together to arrive at the final device. This included the creation of an extrudable biodegradable polymer, a long-life pheromone dispenser (70 to 120 days) for luring the weevils to the device and a biodegradable gel that aids the pickup of insecticide by the insect once it lands on the device. It was also vital to devise a deployment strategy in order to maximise the impact of the devices in cotton fields.

It is estimated that successful implementation of the devices in Brazil will result in a reduction of at least 50 per cent in the use of pesticides in the short term and potentially by 75 to 80 per cent in the long term.

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Cardiff

Advancing drone technology for the future

Drone Evolution has developed new technologies to make drones safer and more effective.

Delivery drones are on their way, with Amazon expected to launch the service soon and others such as UPS and DHL looking to develop their own. Making these drone delivery systems as safe as possible will be key to ensuring that they work and are trusted by the public.

Caerphilly-based company Drone Evolution has created SafeFlight technology in order to make delivery drones safer and more reliable. The system protects the drones from being jammed and interfered with. Using a range of navigation systems, it can intelligently switch between them if it comes under attack, meaning that the drone can always stay on course for its destination. Currently anyone with the right tools is capable of bringing a drone down, but with the new system this is not the case.

The system also has a titanium shell to protect the drone from a variety of external forces, ensuring that it remains lightweight but impervious to small arms fire and laser attacks. In addition, anti-jamming systems in the motors mean that they remain resilient to electronic interference.

This technology could have a game-changing effect on the drone delivery industry and help to bring it forward, enabling a greener way of delivering goods to customers. It could also be put to use in the military delivering supplies to the front line. The company is now developing the technology further in partnership with Exsel Electronics, based in Welshpool.

Drone Evolution has designed a second innovation to address another common obstacle associated with drones – that they typically only have a battery life of around 20 minutes. The company has created a tethering system which is able to keep a drone in the air for hours. It can be powered via a ground station from a vehicle, a battery or the mains, making it a mobile solution with uses such as monitoring of hard-to-reach areas, emergency services support and temporary security at major events.

Significant interest in this drone tethering system has come from the defense industry, so the company has now developed a military prototype version. It allows any drone/camera combination to fly for six hours at a height of up to 200m, whilst transmitting data securely via a fibre-optic milspec cable. It runs off a military vehicle battery and is controlled via a portable ground station which fits into a 40mm ammo can. Development work is also underway to enable beyond line of sight capability for the system in the future.

> *"Development of SafeFlight technology means that the drone delivery industry can protect the public, the assets and the integrity of the industry itself, knowing that delivered items will always reach their destination however much anyone may want to interfere with it. This could be a game-changer for drone deliveries – one that could help to see them finally become a reality."*
>
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Caerphilly

Breakthrough in compound semiconductor technology

Researchers at Cardiff University have developed innovative compound semiconductor technology to drive future high-speed data communications.

Avalanche photodiodes (APDs) are highly sensitive semiconductor devices that exploit the 'photoelectric effect' – when light hits a material – to convert light to electricity. Faster, supersensitive devices are in demand worldwide for use in high-speed data communications, as well as in light detection and ranging (LIDAR) systems for autonomous vehicles.

A team from Cardiff University's Institute for Compound Semiconductors has worked with collaborators from the University of Sheffield and the California NanoSystems Institute to create an ultrafast and highly sensitive APD that produces less electronic 'noise' than its silicon rivals. This has the potential to yield a new class of high-performance receivers for applications in networking and sensing.

Sêr Cymru Professor Diana Huffaker, who led the research, explained: "The innovation lies in the advanced materials development using molecular beam epitaxy (MBE) to 'grow' the compound semiconductor crystal in an atom-by-atom regime. This particular material is rather complex and challenging to synthesise as it combines four different atoms requiring a new MBE methodology. The facility is designed specifically to realise an entire family of challenging materials targeting future sensing solutions."

Dr Shiyu Xie from Cardiff University added: "These devices have a wide range of applications. In LIDAR, or 3D laser mapping, they are used to produce high-resolution maps, with applications in geomorphology, seismology and in the control and navigation of some autonomous cars. Our findings can change the global field of research in APDs, because the material we have developed can be a direct substitute for what currently exists, yielding a higher data transmission rate or enabling a much longer transmission distance."

The results reported are significant as the devices operate in very low-signal environment and at room temperature. Importantly, they are also compatible with the current InP optoelectronic platform used by most commercial communication vendors.

The team is now working closely with Airbus and the Compound Semiconductor Applications Catapult in order to apply the new technology to future free space optics communication system.

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Cardiff

3D technology for pothole repair

GPC has developed a system that uses 3D technology to accurately measure potholes and other road damage.

Currently, the process of identifying and rectifying road damage relies on motorists and highway authorities reporting potholes to councils. In many cases, a manual inspection must then be conducted to assess the required level of repair work, before maintenance work can be scheduled and conducted.

The existing way of inspecting potholes can be time-consuming, ambiguous and inaccurate. Commonly used methods include rulers, pencils, levels, measuring tape and sometimes just guesses to establish the size of a pothole. It also involves the inspector walking in the middle of a road or even closing a road, and may require more than one person to make a reliable decision.

Swansea-based company GPC has developed a system that uses 3D technology to accurately measure the size and depth of a pothole, or other road damage, from a single picture taken on a mobile device such as a tablet or phone. Using a combination of AI and bespoke algorithms, a 3D model of the pothole is created. Then the edges of the pothole are automatically identified, enabling dimensions to be measured including maximum length and depth, which are used by councils to determine priority.

The system is available as a handheld device, on a tablet, on a phone, or mounted to a vehicle. Due to its accuracy, the technology ensures that maintenance teams can get a better understanding of the size of the problem, as well as what equipment and material is required to repair it, before they arrive at the scene. This means that resource costs can be saved, because the materials typically used to repair concrete are expensive. GPS coordinates also form part of the data, enabling teams to more quickly locate the damage. With litigations on the increase, the system can also help councils to keep more accurate records and measurements which they can use to demonstrate how they adhere to statutory requirements.

GPC originally provided 3D wound care solutions for the medical industry, before the company started to think of other applications for their technology outside of healthcare. In addition to putting the technology to use in pothole repair and highway maintenance, it is now also being applied to logistics, as it can measure irregular items of cargo and freight for more efficient packing of aircraft, trucks and shipping containers.

A version of the system for members of the public will soon be made available, continuing to make the process of reporting potholes quicker, easier and more accurate. The company has also signed an international distribution contract that will see its technology deployed on the Las Vegas Motor Speedway, a NASCAR track where drivers reach speeds of nearly 200 miles per hour.

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Swansea

Room sensing technology for senior care

Tendertec is developing a personalised safety and monitoring system that enables seniors living alone to automatically alert their carers in the case of a fall.

Of the 12 million UK adults aged 65+, a third currently live alone and 40 per cent suffer from at least one long-term condition. Around one in three who live at home will have at least one fall per year, and about half will have even more frequent falls. Falls cost the NHS more than £2bn per year and add pressure to family budgets and social care services, which are already challenged by increasing costs, staff shortages and budget restraints.

Dr Afroditi Maria Konidari and Rui Zhang founded Tendertec in Cardiff after experiencing first-hand the impact that falls and ineffective care technology can have on senior fallers and their families. Through their research and Rui's experience in the tele-healthcare industry, they identified a need for intuitive and autonomous technologies to deliver personalised senior care and ensure that falls don't go unnoticed. They came up with a new way of using state-of-the-art sensors, typically used in heavy duty industries, in conjunction with advanced Machine Learning and Artificial Intelligence (AI) capabilities.

With one wall-mounted sensor per room, the company's system uses AI algorithms to process data fed from proprietary sensors which scan the rooms to detect falls. Unlike existing technology used for monitoring, such as pendant or wrist alarms and inactivity sensors, the new system is 'fit and forget' as it does not require any end-user engagement. This means there are no pull cords, buttons or strings for the user to deal with.

The system enables carers to detect and verify falls in real-time and remotely, thereby eliminating false alarms and reducing the time seniors end up spending on the floor after a fall, which can be detrimental to their health and recovery. It helps carers to make beneficial, data-driven decisions, such as triaging an alert to the right responder and personalising care plans in order to prevent minor falls from evolving into major traumatic falls.

While developing the system, the company has involved end-users, their families and care professionals at every stage from initial research to deployment of the technology. This has allowed them to meet the needs of everyone in the chain of care provision, from vulnerable people receiving care and their concerned loved ones, to care providers and national health and social care systems.

By bringing this new innovation into the field of assisted living technology, Tendertec aims to help care providers improve service efficiency and quality of care, in addition to helping the NHS achieve significant savings through a reduction unnecessary A&E attendances, hospital admissions and stays.

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Cardiff

Rail sensor system to detect problems on the tracks

Vortex IoT has created an intelligent device to remotely monitor railways and limit delays by detecting obstructions in real-time.

Rail delays cost the industry millions of pounds every year, in addition to inconveniencing a lot of customers. Working closely with Network Rail and Tata Steel, Vortex IoT has developed the Rail Optical Detection of Intrusions and Obstructions (RODIO) system to address the complex challenge of remote condition monitoring of rail infrastructure.

The Swansea-based company specialises in creating artificial intelligence (AI) solutions to problems faced by businesses – often for harsh environments where conditions are hostile, power supply is limited, or data security is critical.

RODIO is a wireless sensor network deployed trackside in existing cabinets, utilising low-power optical LiDAR laser and AI for detection and notification. It effectively makes the rail digital and creates an 'intelligent edge' from which data-driven, actionable insights can be gained. These can then be used to inform managed interventions, with the ultimate aim of reducing delays and improving customer experience.

By enabling the detection of any obstacles that could interfere with train journeys in real-time, the system ensures that issues can be resolved as soon as possible and inconveniences can be limited. It offers high precision even in low-visibility and dark conditions, and has been built with harsh environment protection. The electronic circuit housing is designed to be dust-tight and protected against water, and all LiDAR and optical components are protected using shutter and self-cleaning mechanisms.

The new technology has been designed to automatically and remotely detect track obstructions, such as fallen trees, animals, landslides, trespassers, vehicles and maintenance workers. These are identified when the low-power optical field is breached, after which the AI determines and categories what type of problem it is. It also includes an early alert system for theft, trespass and intrusions.

The technology has taken 18 months to develop from concept to launch and has endured vigorous testing at the Network Rail RIDC Tuxford (Rail Innovation & Development Centre) facility.

Through the use of sensing technologies, wireless network and AI, the system addresses a common challenge that affects the rail industry globally. It is expected to play a key role in reducing delays across the rail network and also in improving safety for rail workers.

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