T H E E L E C T R O N

N E W S L E T T E R O F T H E I N S T I T U T I O N O F E L E C T R O N I C S

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AROUND THE JOURNALS

Welcome to the Spring 2018 issue of *The Electron*. As we enter a new year The Institution would like to thank all of the publishers who have kindly granted us complimentary subscriptions to their journals during 2017.

In this issue we have compiled a selection of articles from these journals so as to provide a representative sample of topics across the broad spectrum of the electronics industry.

NEW DATA MANAGEMENT PROJECT FOR LONDON UNDERGROUND

London Underground's ticketing data system measures the number of people entering and leaving stations and data analytics can reveal how this varies according to the time of day, but this only shows the volume of customers travelling from station A to station B. It does not show the interchange paths and until recently this has limited Transport for London's ability to measure how crowded particular areas are in the stations and on the trains.

In the October/November issue of *RTM* (the independent trade journal for the UK rail industry), Laura Sager Weinstein, Chief Data Officer for Transport for London, in her article 'How Data keeps London moving faster', describes how a four-week project undertaken at 54 stations in November and December 2016 aimed to provide an answer to this question.

She states:

'We gathered Wi-Fi connection requests from devices on our network and used data science techniques to create movement patterns. More than 500 million depersonalised connection data requests were collected in order to see if we could spot patterns of how groups of customers move through our stations and interchange between Tube lines. We also wanted to see if we could use this data to observe more precisely how and where crowding happens.'

The results of this pilot are described as 'outstanding' and revealed a number of key factors that were not previously known about how people travel on London Underground:

'Our analysis showed that despite a large amount of people (32 per cent) changing at Oxford Circus when travelling from King's Cross to Waterloo (as you might expect), there are a number of other ways people travel between the stations.

Our surveys of our customers' journeys told us about the most popular ones. But our data revealed so many more intricate movement paths across the network - in fact, we observed at least 18 different route options. This insight is not only interesting, but useful, as it allows us to see what other routes people might take during disruption or planned improvement works.'

Benefits have included enabling staff to notify passengers of the best routes to take to avoid disruption and unnecessary crowding, including in real-time so that advice can be altered as conditions change, and enabling better journey planning through TfL's website providing options to tailor routes better to avoid crowding:

'Teams operating on our Tube network could have better information and a way to measure the impacts of disruption, so that we can feed that back into improving our operations and reliability.'

Plans are now underway to make data collection a permanent occurrence across the whole London Underground network.

THE FUTURE OF ENCRYPTION

This subject is covered by Davey Winder in *Infosecurity Magazine* Q1, 2017, Volume 14 Issue 1, and examines the capability of neural networks to learn how to keep data safe before envisaging the future for encryption technology.

The author begins as follows:

'The neural nets of Google Brain have worked out how to create encryption, without being taught the specifics of cryptographic algorithms. We do know the encryption was shared key, symmetric stuff; but we don't know exactly how it works, which limits the practical applications.

However, encryption based on machine learning alone is impressive enough to make us wonder where else encryption might go in the future.'

It is argued the Data Encryption Standard, once the gold standard for symmetric cryptography, is no longer adequate for today's commercial applications, and that 'something has to change as far as encryption is concerned'.

This naturally leads into a discussion on quantum cryptography:

'Simple photons are fired along a fibre optic cable at a rate of a million per second between the network nodes. Light detectors will determine a secret key from these photons to encode the data across the communications channel, but if anyone tries to eavesdrop on that channel then Heisenberg kicks in, which scrambles the photons and alerts to the presence of an observer. That will close down that link and another effort will be made to establish a connection, and this can go on until either the unwanted observer goes away or at a pre-determined cut-off point.'

This system, however, has limitations in that for it to work in the real world every entity has to possess a direct and uninterrupted optical link with every other entity, and implementation is a problem:

'The development of computers capable of breaking the encryption we use today, and doing so with ease, poses a major problem for data that is supposed to stay secret for the next twenty years.'

The article quotes Maarten van Horenbeeck, Director of the Forum for Incident Response and Security Teams (FIRST) as follows:

"Cryptographers have been investigating algorithms that would be resistant to quantum computers, making progress using new techniques such as lattice-based cryptography and hash-based digital signatures."

Further research has been undertaken by Google into how secure the connections between Chrome on the desktop and its servers in a post-quantum world, the author noting that 'if you use Chrome Canary you might already be part of that experiment with the "New Hope" post-quantum key-exchange algorithm.'

The article then moves on to the concept of Fully Homomorphic Encryption, developed by Craig Gentry in 2010, which 'could solve some pressing privacy problems with the likes of the cloud'.

The author states:

'Within an FHE ecosystem, arbitrary computations could be performed upon your encrypted database whilst still within the cloud, but without that data ever being visible to the cloud host, as it wouldn't have to be decrypted first, thus solving the privacy versus functionality conundrum.'

This too, however, is limited in that it would take around a trillion per cent increase in computing time to perform a simple Google search using encrypted keywords. At present only Partially Homomorphic Encryption is available, which does not permit the arbitrary computations on the encrypted data that could be obtained with FHE.

With this backdrop, the author turns finally to the concept of Honey Encryption, currently being pioneered by Ari Juels, a former chief scientist for security vendor RSA, and Thomas Ristenpart of the University of Wisconsin:

'Honey Encryption serves up a bunch of fake data whenever an attacker gets a key or password wrong. That fake data is close enough to the real data that the hacker can't tell if it is real or not. Indeed, if the hacker does get the right password and access to the real data , they won't know as it will just be lost within all the similar fake data. The problem holding it back right now is working out how to produce believable data fakes for all data types. If they can get that right then Honey Encryption could reduce the threat surface significantly.'

MAINSTREAM ADOPTION OF LIFI WIRELESS OPTICAL DATA TRANSMISSION NOW POSSIBLE

The article 'LiFi ready for its Moment in the Spotlight' in *Commercial Micro Manufacturing (CMM) International*, the magazine for micro, high-precision and MEMS manufacturers (December 2017) considers the potential for LiFi, or light fidelity, being used to transmit more secure, high-speed wireless data at rates well beyond those that are currently achievable with WiFi.

The new development results from the introduction of the first LED 'light bar' fixtures equipped with the required transmission technology and designed to replace fluorescent tubes.

The article states:

'With an estimated 3 to 4 billion installed fluorescent tubes throughout the world, the integration of built-in LiFi transmission technology in new and retrofit LED light bars is now moving LiFi beyond the pilot stage to full scale implementation in offices, schools, warehouses and other facilities.'

LiFi is a high-speed, secure, fully networked wireless communication technology that is similar to WiFi, but uses the entire light spectrum instead of radio frequencies.

LED light fixtures are fitted with a module that controls the light for optical data transmission, such that invisible high-speed light pulses are able to transmit data at extremely high speeds to a receiving device located in a laptop, computer tower, cell phone or other smart device. In the future it is envisaged that LiFi will be embedded into everyday mobile devices, as well as playing a key role in machine-to-machine communication and the so-called 'Internet of Things' (IoT).

The utilisation of visible light is noted to 'provide a host of intriguing benefits that far outpace what is currently possible with the radio frequency waves used by WiFi and cellular networks:

'When compared to the overloaded full RF spectrum, the light spectrum is 1,000 times larger and is currently unregulated with no licensing fees.

In lab conditions the technology is already capable of 10 Gbps speeds, and with the available bandwidth potential, data transmission speeds up to 100 times faster will be possible in the near future as the technology advances.'

LiFi is noted to be especially beneficial where security is paramount, for example in federal government, defence, financial institutions and hospitals:

'LiFi is a far more secure form of data transmission than WiFi because a receiving device must be directly within a cone of light to receive a broadcasted signal. Visible light, including near-infrared wavelengths cannot penetrate opaque objects such as walls, which means that the wireless signal is constrained to within a strictly defined area of illumination.

WiFi, on the other hand, utilises radio waves that are widely broadcast even outside a building where it can be easily intercepted for malicious purposes.'

The traditional encryption and authentication protocols used for WiFi are noted to provide an additional layer of security for the LiFi network and the so-called man-in-the-middle attacks, where an attacker has to be able to intercept all relevant messages passing between the two victims and insert new ones, are countered:

'Because visible light is easily containable within a space, it could eliminate classic man-in-the-middle attacks where eavesdroppers located outside an area are able to intercept communications from radio waves emanating.'

Manufacturers Linmore LED have led the way by introducing the first LiFi enabled LED light bars that replace fluorescent tubes and a complete functional LiFi system that uses the new technology.

The company's CEO, Paul Chamberlain, is quoted as follows:

"Utilising an existing part of a building's infrastructure - lighting - opens up endless possibilities for many other technologies to have a deployment backbone. The Internet of Things, product and people movement systems, facility maintenance, and a host of other technologies are taken to the next level with LiFi available throughout a facility."

OPEN SOURCE ROBOTICS

It is difficult to imagine any production line today not having some form of automation, but robotics has not yet achieved quite the same level of saturation. This, however, is poised to change according to the article with the above title by Paolo Carnovale of RS Components in the February 2017 issue of *Industrial Technology*, the magazine for design engineers, machine builders and systems integrators.

A new initiative from RS Components now enables users to deploy open source resources and controllers to develop a robotic arm that is able to be used in relatively sophisticated industrial automation applications.

The author states:

'By selecting an open source design and associated code from Ruc Fablab and combining it with Arduino-based PLC from Industrial Shields, users can take the first steps on the road to a fully featured robotic solution. RS offers numerous design file downloads and lists all the other components used in the build, including the servo motors, the power supply and the wiring.

Users can take the concept further within the deployment of an Igus Robolink D industrial mechanical arm. Using the same open-source processor users can quickly develop an even more capable solution, backed by the capabilities of the Igus components, which are based on existing industry-proven hardware and materials.

In order to make the transition into a robot-equipped workplace, laboratory or classroom even easier, RS has created robotic "bundles", each of which comprise the parts required to build an Igus Robotic D robotic arm - one with a 1kg capacity and another with a 4kg capacity and longer reach. The kits include four articulated joints, ready assembled with NEMA stepper motors; two pressed-steel connection arms; a connecting component for the base motor to the arm; a robot base unit with Harting connectors, and an assembly kit, which contains mechanical, electrical and assembly componentry, fixtures and fittings.

By using popular industrial formats for the connectors, users have an incredible freedom of choice regarding onwards connectivity and integration with wider systems.'

COBOTS FLIP BURGERS

The March 2017 issue of *Industrial Technology* (p.10) contains an interesting short feature on the recent application of collaborative robots (cobots) to America's burger chains, an industry with annual sales of over $75 billion.

Slips, trips, burns and cuts are all common health and safety risks in this industry and to help reduce them Universal Robots have developed a set of cobots specifically tailored to the cooked burger market.

The article, 'Collaborative Robots provide Burger flipping Assistance', explains the innovative application as follows:

'Combining a UR cobot with its own Artificial Intelligence technology, Miso Robotics says it is helping to solve the pain points in restaurants and food preparation. In particular, it is focused on the dull, dirty and dangerous work around the grill, the fryer and other preparation work such as chopping onions. The idea is to help restaurants to improve food quality and safety without requiring a major kitchen redesign.

Miso Robotics describes its mission as developing technology that assists and empowers chefs to make food consistently and perfectly at prices that everyone can afford. Designed for real working kitchens, its Flippy kitchen assistant is portable, collaborative and adaptable. It can assist with grilling, frying, prepping and plating. On board cameras and sensors help the robot to determine when a burger is cooked.

The technology is initially being rolled out in collaboration with Cali Group, and will work alongside kitchen staff at CaliBurger restaurants to grill burgers. The success of a trial at a CaliBurger location in Pasadena will see the programme expanded to more than 50 CaliBurger restaurants worldwide by the end of 2019.'

ROBOTIC CAMERA DOLLY REVOLUTIONISES FILM INDUSTRY

Another innovative robotic application is described in the October 2017 issue of *Industrial Technology* in the article 'Servo Drives key for High Speed Robotic Camera Dolly' (p.34-35).

In this case writer and film director Howard McCain had the idea for an extreme action shot, only to be told by the studio that it could only be achieved with computer generated imagery or CGI at a cost of $1 million. Convinced that there was a better way he and VFX supervisor David Kuklish investigated conventional dolly systems, crane systems, helicopter shots and drones, but found nothing suitable.

The two men then applied their own ingenuity to produce the world's first semi-autonomous, high-speed robotic dolly system, the MX500, that is now revolutionising the film industry by enabling high-speed live action shots to be achieved without recourse to the expensive provisions of CGI.

The article states:

'With credits spanning large-scale films (Outlander), franchise films (Underworld), television shows (Conan) and theme park attractions (Universal Studios), McCain and Kuklish know a thing or two about extreme live action, and what the MX500 would need to be capable of. At the heart of the MX500 they employed the Elmo advanced, high-voltage Gold Drum servo drives, tuned with Elmo's Application Studio II (EASII) motion designed software.'

Howard McCain is quoted as follows:

"Elmo's servo drives were the only ones that could handle the power and motion control requirements that we needed to deliver extreme action shots with our robotic dolly system."

This is followed with a quote from John McLaughlin, President for North America for Elmo Motion Control:

"Mega Trax's requisites for high power for acceleration and extreme power density outlined a unique and complex configuration that could only be achieved with a powerful, advanced motion control solution."

Four high-voltage, lightweight, extreme power density Gold Drum HV servo drives each handle up to 100A/800V and are capable of delivering over 65kW of continuous output power.

The compact Gold Drum HV's extreme high voltage is vital in enabling the robotic dolly to achieve high speeds and fast acceleration, whilst the EASII software's flexible programming environment makes it simple and efficient to quickly create and implement motion, and intuitively program and fully manage Elmo's servo drives and motion controllers.

The article concludes:

'Elmo's complete motion control solution for the MX500 reduced overall power consumption and extended battery life, and enabled the robotic dolly system to consistently and efficiently reach extreme performance metrics.

The Mega Trax MX500 semi-autonomous robotic dolly system can safely go from 0 to 62mph in 3 t0 3.5 seconds, and reach speeds of over 90mph. It can decelerate, switch directions and again accelerate without hesitation, thanks to perfect synchronisation among four motors, enabling the MX500 to capture ultra-smooth camera shots at top speeds.'

NEW BLOOD ANALYSER USES ADVANCED MOTION CARDS AND DIGITAL DRIVES

In the April 2017 issue of *Industrial Technology* the article 'Precise Actuation on Compact Blood Analyser' (p. 40) describes how advanced motion cards and digital drives have been applied in order to overcome the challenges presented by the need for an efficient and cost effective motion control architecture for a new design of compact blood analyser.

Critical areas for control were identified specifically as the centrifuge system and the transport assembly that carries containers between the incubator station, centrifuge and analysis station, plus the pipette assembly that draws and dispenses samples, reagents and dilution fluids to produce solutions for testing.

This required multiple axes of coordinated motion, including single-axis point-to-point operations, multi-axis point-to-point operations and velocity controlled rotation, for which the designers looked to PMD motion technology. This used different motion card formats and digital drives to suit the needs of different parts of the machine.

The article states:

''The blood analyser was well suited to individual cards and digital drives. The PMD Prodigy Machine Controller motion card was selected for the 2 and 3 axis arms in the sample storage carousel and incubator. Prodigy motion cards combine up to four amplifiers and a positioning controller on a single PCB, providing convenience and space saving as well as reduced assembly costs. The card controls the torque, velocity and position of a number of different motor types, including DC brushed, brushless and stepper motors.

Based on PMD's industry leading Magellan motor processor, the Prodigy cards provide user-selectable profiles modes, including S-curve, trapezoidal, velocity contouring and electronic gearing. The cards accept parameters such as position, velocity, acceleration and jerk, either from the on-board C-motion engine or from an external host to generate a corresponding trajectory on the fly. Servo loop compensation utilises a full 32-bit position resolution, and a PID loop with velocity and acceleration feed-forward, integration limits and dual biquad filters for sophisticated control of complex loads. A digital current loop utilising field oriented control gives users complete control over BLDC and DC brushed motors and seriously reduces noise in stepper motors.

The same card was used to meet the needs of the various transport systems throughout the machine, again enabling a high degree of flexibility in the design of different models of the unit. Further, the multi-motor support means that the designers could optimise motor selection in the system for both cost and performance.'

EXHAUST GAS TEMPERATURE SENSING GOES DIGITAL

In the September 2017 issue of *Industrial Technology* (p.26-27) Patrice Flot, Chief Technical Officer for CMR Group, looks at advances in digital technology in the field of exhaust gas temperature measurement in the article 'Exhaust Gas Temperature Sensors: The Future's Digital'.

Whilst purely digital engines are noted to "lie in the future", the first steps to their creation are now being taken by some manufacturers who are starting to place digital sensors alongside traditional ones in their engines. This is being partially driven by the restrictive number of analogue input ports available on ECUs.

The author states:

'Now, digital technologies are offering an advantage: any additional number and combination of CAN exhaust-after-treatment, turbine inlet/outlets, cylinder head outlet, combustion chamber temperature and liner wall temperature sensors can be connected to the existing ECU.

These sensors can incorporate unique series numbers embedded in their software and delivered with temporary addresses, or with pre-set ones. And when plugged into the CAN loop, they can easily be recognised as different sensors because of their series number, despite "carrying" the same address. Software tools enable the engine builder to create the address in the factory via a PC and a single CAN interface address that is uniquely allocated to a given and unique function on the engine.

The superior "intelligence" digital sensors offer is set to herald a whole new world of possibility when it comes to new functionalities. For example, it will be possible to have the various sensors communicating with each other, sharing their respective values. This will enable them to calculate an average value and deliver pre-alarm and alarm when an individual value starts to stray too far from the norm.

The EGT sensors can also record the number of low frequency cycles (start/stop of the engine; start/stop of voltage supply to the sensor) and the high frequency combustion cycle. It can then perform residual lifetime estimation and provide the expected "date for change" information, which delivers improved condition-based maintenance and longer term cost savings. Eventually, considering that similar intelligence will be embedded in every sensor, this approach will see the possibility of splitting the software of the ECU into sub-programs that, if one sensor fails, will re-route to another one, delivering improved reliability and all round system performance.'

In looking to the future the author highlights the potential for the capability to release the ECU from its high load and support CBM systems while offering an IoT sensor that can deliver clever data to remote parts of the world regardless of time zones.

BREAKTHROUGH ANTISTATIC COATING FOR HAZARDOUS AREAS

A new nanotechnology antistatic coating for hazardous area enclosures is described as a 'breakthrough' in protecting against sparking and damage from ultraviolet radiation in the article with the above title in the May 2017 issue of *Industrial Technology*.

Developed for Intertec by chemical engineering specialists BUFA, the new nanotechnology-based coating offers extended maintenance free lifecycles for field-based control and instrumentation equipment in processing industries such as oil and gas and petrochemicals.

The article states:

'Dubbed GO-Antistatic, the new treatment is based on an advanced carbon nanotube material that is applied as part of a surface gelcoat. Polyester gelcoats are widely used to add glossy and highly durable surface finishes to the exterior of GRP enclosures. The advanced nanomaterial provides a degree of conductivity for the outdoor enclosure that dissipates any static electric charges safely to ground to protect against sparking. Such treatments ensure safety in hazardous areas of processing plants, where a spark caused by the build up of an electrostatic charge can cause an explosion of gas, vapour or dust in the local atmosphere.

Gelcoats are a premium form of protection, and form a chemical bond on the surface of the GRP. Most of the antistatic treatments applied to GRP enclosures today rely on the addition of conductive materials into the surface gelcoat (or conductive paint) by employing carbon/graphite, tin or other metals. However, if the gelcoat contains antistatic material, this can have a detrimental effect on its performance, notably in terms of reducing its smoothness and ultraviolet protection, and limiting the colouring possibilities. Extended exposure to high UV levels can then damage the GRP enclosures, leading to minor surface roughening.

Intertec and BUFA worked together to develop the new antistatic coating. BUFA chose single-wall carbon nanotubes (SWCNTs) to provide the required conductivity and has developed proprietary techniques to disperse the SWCNTs in the coating material. This approach provides numerous benefits largely because SWCNTs are incredibly small - around 1-2nm in diameter - which increases smoothness at the surface level of the coating. The gloss retention (smoothness) after accelerated weathering tests is about 50 per cent better than the previous formulation, and is on the same level as non-antistatic gelcoats. This significantly improves UV resistance, and additionally virtually eliminates any effect on the use of any decorative colourings.

The latter advantage means that Intertec can also now provide hazardous area enclosures in a much broader range of colours than was previously possible. Options will include almost pure white, for example, which will further aid solar protection - something that is very difficult or impossible to achieve with many current antistatic treatments.'

THE FITNESS PROJECT

The Future Intelligent Transmission Network Substation (FITNESS) is a project funded by the RIIO NIC (Network Innovation Consortium) which aims to develop a fully integrated multivendor digital substation solution for both retrofit and new build projects.

It is described in the May 2017 issue of *Electrical Review* (p.27-29) by Danny Lyonette, Business Development and Innovation Manager for ABB's Grid Automation Business Unit of the Power Grids Division in the UK, in the article 'Witness the FITNESS for Digital Substations'.

The main driver for the project is the need for change in the way in which substations are controlled and protected, particularly as low carbon generation and high voltage direct current (HVDC) interconnections increase. Conventional substations also offer little flexibility to adopt the necessary new monitoring, protection and control functions, especially where these need to be linked with external measurements and information systems such as wide area monitoring systems or WAMS.

A key part of the project has been the creation of the UK's first multivendor digital substation monitoring, control and protection systems at the Scottish Power Energy Network 275kV Wishaw substation.

The author explains:

'The project will equip two bays of the existing Wishaw substation with new fully integrated digital protection and control equipment. The site has been selected as it is in an area of special interest with a large wind power infeed that presents challenges in terms of variability and inertia. The project will also trial new sensor technologies for voltage and current measurements. The substation will be designed with digital communications using fibre optic cables - instead of analogue signals using copper cables - from switchyard to control building.'

The author notes particularly that the potential to reduce copper wires in a substation by 80 per cent could alone justify a change to digital:

'Every piece of copper in a substation represents a potential risk. For example, where current is incorrectly disconnected, such as with an open secondary current transformer, arcing may occur as dangerously high voltages build up and a copper line can suddenly carry high voltage, putting operators and equipment at risk. Reducing the amount of copper increases safety.

A digital substation dispenses with copper by using the digital process bus, based either on fibre optics or a wireless network.'

Projections suggest a 10 per cent saving in substation costs and a 15 per cent footprint reduction when digital technology becomes adopted as the UK norm.

The author concludes:

'The FITNESS project will help develop different approaches and flexible solutions to enable utilities to adopt digital substation technology that is the right fit for their infrastructure.'

FIRST UK INTELLIGENT CAMPUS MICROGRID CONTROL SYSTEM

Peter Jones, Technology Strategy Manager for ABB, explains how ABB is developing the first intelligent microgrid control system for a UK university at the University of Chester's new Energy Centre at Thornton Science Park in his article 'First Intelligent Campus Microgrid Control System for the UK' in the *Electrical Review* Annual Specification Guide 2017.

The microgrid aims to play a key role in the Energy Centre's mission to provide a demonstration environment where new energy technologies can be developed and tested. In particular it is sought to demonstrate how distributed energy resource (DER) technologies can work together to minimise fuel costs and emissions within a closed grid. It will also maximise the penetration of renewable energy in a mature grid, potentially avoiding the need for major investment in infrastructure reinforcement as the site's power demand increases.

The author explains:

'The microgrid control system for the Energy Centre is based on ABB's Microgrid Plus system, a distributed control platform developed to automate and manage microgrids that consist of fossil-fuelled generators and renewable energy generation from one or more sources. It also integrates all other microgrid components such as energy storage and grid stabilisation systems, and distribution feeders. Furthermore, in grid-connected microgrid systems it connects and communicates with the local power grid.

ABB's MGC600 controllers are the building blocks of the Microgrid Plus system. They enable communication between all the electrical devices in the microgrid and use the data communicated by the devices to make local decisions that work cohesively for the benefit the whole microgrid. The range of MGC600 controllers is comprehensive in scope and uses a common hardware platform that runs different types of firmware according to the electrical device concerned.

These firmware packages contain the core control logic of the MGC600. They work in harmony with one another within the Microgrid Plus System. For instance, the PV Control and monitoring system (MGC600-P) schedules and controls the PV plant in conjunction with the controllers that control the diesel generators (MGC600-G) and energy storage system (MGC600-E)'

NEW TOOL TO ASSESS ACOUSTIC RISKS IN DATA CENTRES

Data centres are relied upon to store and distribute valuable information across many industries with hard disk drives (HDDs) being primarily used for such storage.

In the *Data Centre Management* Buyer's Guide 2017 (p.12-13) Alan Elder, Tyco Fellow, Tyco Fire Protection Products, in his article 'Acoustic Exposure', explains how research by Tyco, in collaboration with Michigan Technological University, has proved the link between exposure to high acoustic levels and degradation in HDD performance that has led to the development of an important new acoustic calculation tool for data centres.

The author states:

'HDD performance may be reduced or permanent damage may occur to the sensitive electronic equipment as a result of exposure to high acoustic levels. To gain a greater understanding of the impact of acoustic energy on hard drives, Tyco Fire Protection Products conducted a holistic study of HDD performance with respect to acoustic energy, room acoustics and suppression system nozzle acoustics.

The sound output of fire suppression systems is dependent on many factors. These include discharge duration, peak agent flow rate, valve technology and many others. Tyco performed extensive research and modelling of inert gas agent flow to develop an inert gas suppression nozzle with a low sound power.'

The research focused on the fact that every hazard area protected by a fire suppression system will yield varying sound path absorption properties:

'Data centres should have room acoustic calculations performed to ensure the fire suppression system installation will meet the sound performance requirement to help reduce the risk of HDD degradation should the system discharge. The sound pressure level calculation method requires the use of advanced acoustic formulas to determine the sound absorption between the fire suppression system nozzles and the HDDs.

As a result of the acoustic research study, a novel tool has been developed for performance acoustic calculations for data centres. Tyco's acoustic calculator helps generate the acoustic calculations to estimate the sound pressure level at an HDD location generated by an inert gas suppression system using the Tyco acoustic nozzle. The acoustic calculator simplifies the calculation by containing drop down menus for the suppression system parameters as well as selection of room materials and the equipment within the data centre. This enables Tyco's technical services team to perform calculations tailored to each customer installation.

The Tyco acoustic calculator used in conjunction with its acoustic nozzle is a substantial advancement in addressing the acoustic challenges for the data centre market, providing an effective solution that can reduce sound exposure to sensitive HDDs and due to its extensive area coverage may enable the designer to use significantly less nozzles and piping. Rigorous testing through hundreds of suppression system discharges offers superior sound power performance and suppression capabilities in comparison with standard suppression nozzles.'

For those with an interest in downloading the full whitepaper the reader is directed to www.hygood.com

IMPROVED TECHNIQUES FOR MICRO-DISPENSING

Claude Bergeron, Product Line Manager for Nordson EFD, provides a full feature on this subject in his article (full title: 'Component Miniaturisation is driving improved Techniques of Micro-dispensing in Assembly Processes') in *Commercial Micro Manufacturing (CMM) International* , September 2017 (p. 36-41).

In his introduction the author draws attention to the convergence of the Internet of Things with the Ethernet and the increasing possibilities of data and power connectivity for enabling devices all being made possible through the miniaturisation of components and their diminished energy draw.

He states:

'This continuing miniaturisation of components presents challenges for manufacturing, and particularly for electronics assembly. Surface mount technology (SMT), for example, is the dominant electronics assembly process used for the production of these electronic devices in diverse industries - ranging from automotive to medical devices to aerospace. The need to manufacture smaller and more complex assemblies with dense multi-layer circuitry and mixed technology boards, as well as the increasing range and mix of surface mount component sizes and types, poses challenges for SMT process engineers.

Critical to SMT assembly is the need to deposit very small and precise amounts of fluid - such as adhesives and silicones - to the tiny micro-electronics and other miniscule parts, to keep these surface mounted devices in place before and during the soldering process. These deposited fluids can also provide the added benefits of mechanical strength, thermal conductivity, dielectric strength and chemical inertness throughout the life of the assembly.'

Assessing Parameters for Micro-Dispensing

Under this sub-heading the author underlines the importance of selecting micro-dispensing methods that lend themselves well to the requirements of a specific production process, and considers specifically substrates, fluid properties and requirements for micro-dispensing as critical areas for examination prior to the selection of a particular micro-dispensing technique.

Under 'substrates' it is noted that cycle times for dot deposition and throughput rates are largely regulated by the substrate surface topography, and that as the trend towards miniaturisation continues, substrates are becoming more crowded and uneven, especially with substrates used in electronic wafers and thin film electronics, and printed circuit board (PCB) assembly.

The author states:

'Dispensing of fluids onto hard-to-access areas, uneven or irregularly shaped surfaces, or delicate substrates are key factors that need to be carefully assessed as they can considerably impact assembly production. These directly affect the Z-axis movement of the micro-dispensing system, influencing its ability to move over uneven surfaces and dispense the correct volume of fluids in the right locations.'

Jetting versus Contact Micro-Dispensing

In this section the author notes that whilst traditional contact fluid dispensing is still the predominant technology in use, it is hampered by disadvantages of speed, particularly when dispensing on irregular substrates. He therefore introduces high-speed jetting technology as ' a popular and innovative alternative to traditional needle-based contact dispensing' that is particularly well suited to automated fluid dispensing processes.

Several disadvantages of contact dispensing are highlighted and whilst jet dispensing is seen to have some disadvantages, the author clearly presents a case for adopting it:

'The ability to deposit very small and precise amounts of fluid is an ever-increasing necessity for manufacturers of tiny electronics and other miniscule parts. Jet micro-dispensing meets these requirements with the capability to deposit extremely accurate and very small amounts of fluid, with higher repeatability and greater consistency than contact dispensing.'

The author describes the technology behind jet dispensing as follows:

'High-speed jetting is non-contact - the jet valve never contacts the product or substrate surface. Because of this it offers a higher degree of flexibility, and can be used in a wider variety of applications that otherwise would require a Z-axis system with height-sensing and positioning functionality. These distinguishing features provide advantages in dispensing speed and agility, dot capability and quality, maintenance, throughput and cost of ownership.

High-speed jetting is made possible by piezoelectric technology, which enables this style of jet valves to dispense fluids at up to 1,000Hz. Modular piezoelectric jet valves that can be configured for multiple uses combine the benefits of high-speed jetting, piezoelectric technology and incredible application flexibility. This makes them a powerful alternative to traditional dispense valves, which are often limited to a single application capability.

High-speed jet valves that incorporate piezoelectric technology can achieve extremely fast open-and-close cycles that eject, or "jet", fluids onto a substrate. When pressure is applied to certain materials - such as layered structures of specialised lead zirconate titanate (PZT) ceramic stacks interleaved with electrodes - it creates voltage. Conversely, when voltage is applied to PZT, it changes its shape. In the case of piezoelectric jet valves, voltage is applied to a piezoelectric actuator inside the valve. The applied voltage causes a bulk change in the ceramic's length, allowing the actuators to be used for fast, high-force, real-time position control at the nanoscale level.'

CHIPSCOPE

ChipScope is a European research project that began in January 2017 and aims to develop a completely new, extremely small, optical microscope (microscope-in-a-chip) that will allow for the observation of the interior of living cells in real-time. In particular it will be used to make real-time observations of the interiors of cells that are present in the disease known as Idiopathic Pulmonary

Fibrosis, or IPF, which is a chronic lung disease that kills around half a million people a year across the globe.

The project is described in the June 2017 issue of *CMM International* (p.36-37), with the background as follows:

'Today, optical microscopes are limited in resolution by physical laws related to the wavelength of light, around a thousandth of a millimetre. Single proteins, DNA molecules or the interior of living cells are much smaller and cannot be directly observed with conventional optical microscopes.

At the moment, only indirect observation - that means interpretation of measured data - can be made, for example in complex, expensive and bulky electron microscopes. These devices, however, are not suitable for the observation of delicate living tissues.'

The technology behind the new innovation is then described:

'During the project, very small LEDs of 50nm (this is 1,000 times smaller than the diameter of a human hair) will be developed and used as light sources for the new microscope which will be integrated on a chip. The fundamental difference with conventional optical microscopy will be that the illumination is made by extremely small individual light sources instead of a wide illumination field and tiny detectors in the camera. This allows super-resolution (less than 50nm) optical microscopy, which could be used to investigate extremely small structures such as viruses, DNA or living cells, in real-time.'

In looking to the future the article states:

'Making microscopic images will be easy and accessible to researchers who operate out in the field, away from scientific infrastructures and they will be affordable to researchers in developing countries. In the future, these microscopes-in-a-chip could also be integrated into consumer electronic products, being as common as a camera is in a smartphone today.'

The project is scheduled to run until December 2020 and is overseen by a highly interdisciplinary project team led by the University of Barcelona. Those with an interest are referred to www.chipscope.eu

3D PRINTING AND ELECTROFORMING COMPARED

The term 'additive manufacturing' incorporates two manufacturing techniques, namely 3D printing, that is the application of droplets to construct three dimensional objects, and electroforming, that is the building up of precision metal parts atom by atom.

In the April 2017 issue of *CMM International* (p.16-18) the two techniques are compared with specific reference to precision, speed, cost, structure, lead time and materials.

Under the first criterion, precision, electroforming is noted to permit the growing of material with micro-scale accuracy, offering a hundredfold improvement relative to 3D printing. When it comes to speed, electroforming is noted to permit the growing of multiple parts simultaneously using an electrolytic bath, which, when it comes to volume production, makes it 'definitely favourable'. Electroforming is also faster in that it allows for metal parts to be "just" ready once the overgrowth or thick resist process is completed, making it quicker for the fabrication of metal parts.

The article states:

'3D printing of metal parts is still in its infancy. The technique entails printing with ink that contains miniscule metal powdered parts. After printing, the metal parts in the ink need to be heated in order to suture. This process is called sintering, and takes time. In addition to the time-consuming sintering process, the printed layers also need to dry so that they don't sag.'

With lead time both techniques are seen as being roughly equivalent because both require production via a CAD file, but electroforming has the advantage when it comes to industrial scale production owing to the advantage of being able to grow copies simultaneously.

In terms of structure, 3D printing is favoured when the structures need to be completely 3D, but where it is desired to provide more structure in all dimensions there is a case for multi-layer electroforming in which the final products take the form of "stacks" of multiple 2D structures.

Under materials electroforming works principally with nickel, which makes it especially suitable for medical applications as nickel components can be coated with a layer of PdNi alloy, but where the material is not nickel or copper 3D printing has the advantage.

Under the last criterion, cost, electroforming has the advantage with high volume production, but as 3D printing equipment tends to be cheaper this makes it better for short runs. The reader is advised, however, that it is always possible to go to a professional precision manufacturing company for cost-effective electroforming.

The article concludes as follows:

'With the advent of the Laser Direct Imager, electroforming has become an even more cost-effective manufacturing technique. Here's why: with electroforming, production of metal parts depends on the creation of a perfect mould. A mould is created by applying a geometric pattern to a sensitive resist on a substrate by means of light. This was - and still is with many companies - typically done by placing a mask on a photoresist layer and exposing light to the entire mask. But the Laser Direct Imager is capable of projecting high-resolution images directly from a CAD file, which means you do not require additional tools to create your part.'

LASER ENGINEERED SURFACE STRUCTURES CLEAR ELECTRON CLOUD IN HADRON COLLIDER

A collaboration between the University of Dundee and the Science and Technology Facilities Council (STFC), in partnership with CERN, has resulted in the use of Laser Engineered Surface Structures (LESS) to clear the frustrating "electron cloud" that develops in the Large Hadron Collider thereby restricting the range of experiments that it can perform.

In the February 2017 issue of *CMM International* (p.40-43) the article 'Laser Technology to help take Large Hadron Collider to Next Level' describes how CERN is intending to upgrade the Large Hadron Collider in 2019 and needs the problem of the "electron cloud" to be addressed so that the Collider can use proton beams that are twice the intensity than currently.

The article quotes Professor Amin Abdolvand, Chair of Functional Materials and Photonics at the University of Dundee, as follows:

"Large particle accelerators such as the Large Hadron Collider suffer from a fundamental limitation known as the 'electron cloud'. This cloud of negative particles under a certain condition may degrade the performance of the primary proton beams that circulate in the accelerator, which is central to its core experiments.

Current efforts to limit these effects involve applying composite metal or amorphous carbon coatings to the inner surfaces of the LHC vacuum chambers. These are expensive and time-consuming processes that are implemented under vacuum.'

The LESS method involves using lasers to manipulate the surface of metals and relies on understanding how different metal surfaces react when they are subjected to varying levels of laser fluence or intensity.

The article states:

'Tests have shown that it is possible to reformulate the surface of the metals in the LHC vacuum chambers to a design that under a microscope resembles the type of sound padding seen in music studios. The surface can trap electrons, keeping the chambers clear of the cloud. Initial tests at the Super Proton Synchrotron, the LHC injector, have shown the LESS method is very effective at controlling the electron yield, as electron clouds have been fully eradicated.'

Peter McIntosh, Deputy Head of the STFC Accelerator Science and Technology Centre (ASTeC) is then also quoted:

"Through close working interaction between ASTeC vacuum scientists and Dundee University laser specialists, a real breakthrough in suppression of secondary yield performance has been accomplished, which could have widespread implications for high electro-magnetic field environments, where breakdown limitations are of particular concern, such as for sensor systems and applications in satellite and aerospace technologies."

CERN is the European Organisation for Nuclear Research. It is probing the fundamental structure of the universe and is using the world's largest and most complex scientific instruments to study the basic constituents of matter - the fundamental particles. These particles are forced to collide together at close to the speed of light and this process yields clues as to how the particles interact, providing insights into nature's laws.

The instruments at CERN are purpose-built accelerators and detectors. Accelerators boost beams of particles up to high levels of energy before being made to collide either with each other or with stationary targets. Detectors then observe and record the results of the collisions.