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Book of Abstracts

PLENARY SESSIONS

Sensing Quantum Entanglement

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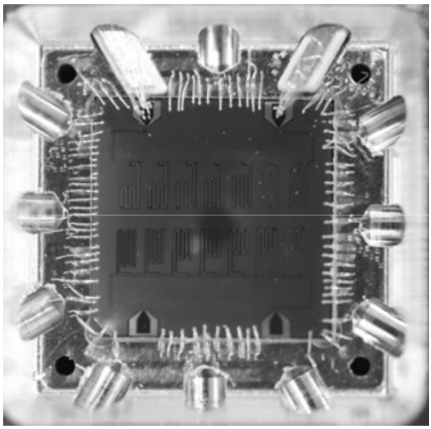

Quantum entanglement provides a signature difference between coherent quantum systems and coherent classical systems; it enables for example Einstein's famous "spooky action at a distance", wherein a distant quantum measurement can immediately affect a local quantum state. The experimental violation of the Bell inequalities, the gold standard for quantum behavior, yields statistically-based violations of classical logic, providing e.g. experimental observations such as if A is true and B is true, A+B is however false. Quantum entanglement holds promise for new modalities for sensing and communication, in the former case possibly unparalleled sensitivity, and in the latter case a method for theoretically uncrackable encryption of transmitted information. However, practical systems that take advantage of this unique but relatively unexplored resource are only in the developmental stages. I will provide simple examples of how quantum entanglement works, and how it can be used for novel sensing and communications techniques.

Disruptive Sensing Capabilities for Defence

Dr Alex Zelinsky

Defence Science Technology Group, Australia

Sensing is a critical enabling function for Defence. Its impact on Defence ranges from the detection of chemical and biological toxins for personnel safety to situational awareness, through to intelligence and surveillance, and enabling front-line operation of military jets.

Defence Science and Technology (DST) actively researches sensor technologies to provide Defence with a significant capability advantage. The Over-the-Horizon-RADAR remains a standout example. DST has also developed world-leading fibre laser strain sensors as highly sensitive sonar arrays.

The 2016 Defence White Paper identified sensing technologies as one of the priority areas under the Next Generation Technologies Fund which aims to develop game-changing defence capabilities.

This keynote will present DST research in advanced sensing technologies along with their potential applications. DST's research interests include quantum gravitational and EM sensing, photonics, the role of advanced materials in sensors and hyperspectral sensing. Furthermore, fusion of multiple sensors, along with processing advances, machine learning and integration with other technologies, are opening up new opportunities to maximise the utility of sensor data for Defence.

Arbsense – a selective sensor for nitro-containing explosives and taggants

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We have developed Arbsense, which is a paradigm shift in fluorescence-based detectors for explosives. Until the development of Arbsense there has been a dichotomy in detection technologies for explosives – on the one hand it is possible using sophisticated non-portable analytical equipment to accurately detect and identify an explosive while on the other hand user friendly, portable low cost sensing technologies struggle to provide the required selectivity. Luminescence-based explosive detection is in principle the simplest and most portable sensing technology. By developing methods to probe how explosives interact with the fluorescent sensing elements we have been able to engineer at the molecular level a new class of materials (dendrimers – branched molecules with structures akin to trees) for the rapid detection of explosives. The fluorescent dendrimers feature high selectivity for explosive vapours over common interferents such as coffee, humidity, perfumes and mothballs. In this presentation we will describe the science behind Arbsense and how we have achieved both high sensitivity and selectivity [1]. Arbsense showcases the potential of luminescence-based detectors in general with its compact form factor, low power consumption, wireless connectivity and capability to be deployed in sensor arrays.

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Biosensor Platform Based on Organic Field-Effect Transistors

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Electronic sensors based on organic field-effect transistors (OFETs) are interesting devices not only for biosensors, but also for chemical sensors, because their output signals are amplified and processed as the electrical signals. Recently, wearable sensors have been receiving considerable attention since they can enable continuous monitoring of health or medical condition, while uploading user information to the internet. Most of the approaches for wearable sensors have been based on physical sensor devices that assess vital signs, such as heart rate, rate respiration rate and skin temperature. However, more advanced chemical and biosensors are able to monitor chemical constituents within the human body, providing for significant insights into a person's overall health status. OFET devices can be fabricated using printing methods on a thin, lightweight plastic or paper film substrates. The advantages of the printing are low production cost and environmentally friendliness, and are well suited for producing flexible and wearable electronic devices. Our final goal is realization of the smart biosensors that combine integrated circuits with the OFET-based biosensors, while connecting wirelessly to the Internet.

The primary components of an OFET-based biosensor are the bio-recognition element and the transducer, which are comprised of a receptor electrode and an OFET device, respectively. A representative biosensor configuration is an extended-gate type, where the OFET device connected with an extended gate electrode where the receptors are immobilized on the surface of a gold layer. We used antibodies, enzymes, artificial molecules for the receptor. Once the receptors capture analytes (for example, biomarkers) the characteristics of OFET device can be changed depending on the amount of captured analytes since the potential of the gate electrode should be changed. Typical features in the characteristics are shift of the transfer curve, and decrease or increase of the drain current, so we are able to obtain the quantitative data of concentration of analytes in the aqueous solutions.

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Wireless Sensing of Human Activity – A New Frontier in Sport and Health

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Sports engineering is an emerging discipline. The discipline integrate mechanical engineering, electronic engineering, signal processing and biomechanics, with the objective of maximising human performance, maximising human health benefits, maximising human participation and minimising injury. The audience experience is also an important, financial consideration in monitoring elite sport.

As sporting activities involve multiple, complex systems of movement and elite athletes perform best when their movements are highly reproducible, regardless of fatigue, injury and mental state, measuring performance under confined laboratory conditions becomes less useful compared to wireless monitoring during training and, if allowed, in competition. In many sports symmetry is highly desirable (eg breast and butterfly strokes in swimming, weight lifting, pliés in ballet) and 180 degree symmetry (eg walking, running, cycling, freestyle and backstroke in swimming). In other sports, random movements are highly desirable (eg all team sports, boxing, fencing, tennis) in order to outwit and outplay the opposing team.

There are the additional challenges related to applying sensor technology to assess athletes who might be under the influence of health related impairments such as disease, drugs, concussion and fatigue.

The major challenges now target reducing the number of sensors, improving the interpretation of data and providing immediate feedback to athletes and coaches.

This presentation will outline previous work in this area in addition to describing a number of strategies addressing these issues with particular applications to running, swimming, boxing and dance.

Multisensor Systems and Data Fusion for Unmanned Aircraft Navigation and Tracking

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Modern Unmanned Aircraft Systems (UAS) employ a variety of sensors and multi-sensor data fusion techniques to provide advanced operational capabilities and trusted autonomy (i.e., required levels of safety, integrity, security and interoperability), when sharing the airspace with other manned and unmanned platforms. Low-cost and high-performance Navigation and Guidance Systems (NGS) for UAS have been developed at RMIT University by employing a combination of compact and lightweight sensors to satisfy the Required Navigation Performance (RNP) in all flight phases. Additionally, recent research at RMIT has focused on the development of a unified approach to separation assurance and collision avoidance suitable for UAS cooperative/non-cooperative sensor architectures and allowing for an extended range of operations both in mission-essential and safety-critical tasks. The Sense-and-Avoid Unified Method (SUM) developed at RMIT provides an innovative analytical framework to combine real-time measurements (and associated uncertainties) of navigation states, platform dynamics and tracking observables to produce high-fidelity dynamic geo-fences suitable for integration in future avionics, Air Traffic Management (ATM) and defense decision support tools.

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Novel Polymer Optical Fiber Bragg Grating Sensing System

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Polymer optical fiber Bragg grating sensors offer many benefits for medical applications because polymers do not produce shards, are biocompatible, and potentially low-cost, allowing single-use in-vivo sensors to be realized. The two main issues that impede on the cost of polymer fiber Bragg grating sensing systems are the coupling of light to single-mode polymer optical fibers (POFs), and the long inscription time of Bragg gratings polymer optical fibers. A novel implementation of a polymeric sensing system integrating light source with fiber Bragg grating sensors will be introduced. The development of single mode polymer optical fiber photosensitized with Trans-4-stilbenemethanol to allow rapid inscription of fiber Bragg gratings will also be described.

Integrated photonic smart sensors for air-quality sensing and biomedical applications

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Integrated devices are everywhere: chip-scale electronic processors in our phones and computers now penetrate every aspect of our lives; optoelectronic devices using photons, the fundamental particles of light, enable ultrahigh bandwidth data networking, thus sustaining the Internet's constant growth; on-chip acoustic devices that exploit phonons, (the sound-wave analog of photons) underlie small radio frequency filters that enable mobile phones to communicate efficiently with cell towers. However, extraordinary opportunities stem from the realisation that light, sound and electrons are so fundamentally different and that their capabilities are complementary: light is uniquely suited for data transport, microscopy and imaging; high-frequency sound waves can exert very strong forces to move fluids and mechanical components, or to mix chemicals; while only electronics can perform sophisticated analog and digital information processing. To achieve maximum impact on our lives, the next great challenge is to develop integrated devices in which these three complementary physical phenomena work together.
We are now uniquely positioned to make the key discoveries that will finally bring photonics, phononics and electronics together on the same chip by exploiting these new fundamental understandings and fabrication capabilities. By accomplishing the tight integration of all three classes of wave onto a single platform, our new class of chips will reach out to the world, becoming active devices that sense, analyse, respond to, and manipulate their environment. This revolutionary approach to integration presents an opportunity for unprecedented control over matter, energy and information. It will enable new and disruptive technologies that will significantly impact on our national priorities in health, cybersecurity, advanced manufacturing, energy, food, and soil and water.

Sensor Network and Pathways to Market

Jugdutt (Jack) Singh

Swinburne University of Technology

The presentation will address issues related to the design of low power smart sensors and application of these sensors in agriculture, transport, energy and environment sectors. The talk will highlight number of case studies on application of sensor technology in real world challenges and pathways to market.

Will we be surrounded by sensors monitoring every molecule polluting our air?

Lidia Morawska

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We live in an interesting world where the emergence of new technologies in general, and for atmospheric sensing in particular, is much faster than could be comprehend, little alone utilised. Stationary and dynamic networks of low cost sensors for air pollution monitoring are being established, sensors are inbuilt in mobile phones and travel on drones. However, the field is still in its infancy, and requires significant scientific efforts to mature. The presentation will explore the challenges in application of mini and nano sensors for air quality and personal exposure monitoring, and in managing and interpreting the vast amounts of data, which such monitoring will generate. Further, it will discuss the likely future scenarios for how we will use these, and the new generations of sensors.

Human gas sensor capsule

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We have developed a novel low-cost and non-invasive medical device called "human gas sensor capsule" which has applications in diagnostics of gastrointestinal disorders and assessing dietary effects on the gut. The product is a capsule size indigestible electronic device that leaves the body after normal bowel transient. The capsule consists of gas sensors, micro-electronic circuits, small-sized harmless batteries and telecommunication components. The capsule allows for the accurate measurement of the concentrations of four vital gases including O_2, H_2, CO_2 and CH_4 and also temperature. Intestinal gas profiles are then transmitted to an external small handheld device that communicates with a smart-phone that allows a real-time data display and analysis. We have successfully finished the animal and the first phase of human trials. The outcomes show some extraordinary phenomena that can potentially revolutionise the fields of gastroenterology and food sciences. The gas profiles have been benchmarked with RNA sequencing and metabolic analysis which are in great agreements. The outcomes of these trials will be presented in detail on behalf of the team involved in the development of the capsule.

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CONCURRENT SESSIONS

Concurrent session 1: Biosensing

Biosensing with Highly Ordered Gold Nanowires Array

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The unique electronic, chemical and physical properties of nanomaterials have attracted a considerable interest for fabrication of chemical sensors and biosensors in recent years. Nanomaterials, such as metallic nanoparticles, graphene and carbon nanotubes, have particularly attracted the most interest The specific advantages of using these nanomaterials for fabrication of sensors include high surface energy, high surface-to-volume ratio, and their abilities to act as electroconducting pathway for accelerating electron communication. In more recent years, the synthesis and use of nanowires array has attracted a renewed interest in their use for fabrication of novel enzyme-based nanobiosensors. These nanomaterials not only have the ability to act as a bridge between the active sites of enzymes and the electrode surface to promote fast electron transfer, but are also capable of reaching the active enzyme sites.

In this talk, I will give an overview of some of the reported approaches for the synthesis of biocompatible nanowires array. More specifically, the use of anodised aluminium oxide templates for synthesis of highly ordered gold nanowires array in our laboratories and their use for fabrication of novel, highly sensitive and selective nanobiosensors will be discussed. The successful detection of glucose, nitrate, penicillin and sulfite with these devices and applications to real samples will also be presented. I will also highlight some of the future prospects for wider application of nanowires array for fabrication of nanobiosensors for much larger range of inorganic and inorganic substances.

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Ultra-sensitive, Label-free Gene Detection with Novel Conjugated Polymers

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Biosensing and in particular gene sensing is a rapidly expanding field. However, sensitivity, high labour cost and false positive/negative signals are still unresolved issues in gene sensing and have propelled the development of new sensing methodologies and devices. To address some of these issues, we present here a label-free, electrochemical DNA detection platform based on novel conducting polymers recently synthesized by us, using several different designs of the sensing electrodes. One of the electrode design includes a high surface area, electrospun, conducting fiber mat, formed by the method recently reported by us[1], with added steps of converting the fibers from hydrophobic to hydrophilic and then attachment of DNA probes. These result in robust sensing systems, with high sensitivities. The DNA detection experiments with the conductive microfiber mats showed an impressive detection limit of 1 aM concentration of the target gene.

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Wearables to Thinkables: Decoding Brain States using Deep Learning and IBM's Brain-Inspired TrueNorth Chip

Stephen Harrer
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Wearables will be transformed into Thinkables offering continuous, cognitive, real-time analytics of measured biometric and biological data at the point of sensing. Thereby ultra-low power neuromorphic platforms - such as IBM's recently introduced TrueNorth chip - could play a key role in connecting on-body nanobiosensors directly with deep-learning technology for instant analytics, prediction and interfacing with artificial intelligence systems.

Vision-based Tracking for Sports Performance Analysis

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Sport performance analysis is at the heart of ever improving performance in a variety of sports, ranging from individual sports to team sports, from professional elite athletes to amateur athletes. Technology ranges from sensors worn by individuals (e.g. Fitbit, GPS sensor) to video analysis, some requiring a dedicated hardware setup in a stadium, while others are self-contained. A recent study [1] estimates the global sports analytics market to reach US$4.7B by 2021. With the world of professional sports shifting towards employing better sport analytics, the demand for vision-based performance analysis is growing increasingly in recent years. In addition, the nature of many sports does not allow the use of any kind of sensors or other wearable markers attached to players for monitoring their performances during competitions.

This provides a potential application of systematic observations such as position tracking information of the players to help coaches to develop their visual skills and perceptual awareness needed to make decisions about team strategy or training plans. Furthermore, current technological solutions focus on the post-match / post-session analysis, not providing real-time analysis; focus on the individual athlete even in team sports, rather than analysing the team as a whole; and focus on whole-of-match statistics (e.g. average velocity and distance covered by each team member), rather than short-term dynamic group events that are often the real match defining moments in team sports. In this talk, a scalable and affordable solution will be presented to assist coaches in close-to-real-time analysis of dynamic match situations, post-match analysis, in addition to the traditional individual measures of distances and velocities.

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Concurrent session 2: RADAR sensing

Nano-radar Sensors

Rob Evans

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It is becoming increasingly possible to build fully integrated radar systems operating at millimeter wave frequencies and above. These low cost, lightweight radar systems will become important in a range of consumer, commercial, industrial and military applications. This talk sets nano-radar systems in the context of existing radar science outlines new research challenges created by nano-radar systems. The talk also offers the possibility of a new performance theory for nano-radar.

Robust Radar Processing for Sensitivity and Resolution Enhancement

Joe Fabrizio

Microwave Radar Systems, National Security & Intelligence Surveillance and Reconnaissance Division (NSID), Defence Science and Technology Group

Current radar systems require greater sensitivity to detect smaller targets in noise and greater resolution to discriminate useful signals from clutter and interference. Conventional radar signal processing based on Fourier analysis employs window functions to trade off losses in resolution and sensitivity for lower sidelobe levels. Recovering these losses by simple means is not always possible in practice. For example, improving Doppler resolution by increasing the coherent integration time may not be feasible due to coverage and coverage rate requirements. Similarly, improving range resolution by increasing the transmitted signal bandwidth may not be possible due to the lack of spectrum availability or radar hardware limitations. Improving angular resolution by increasing the electrical size of the antenna aperture may be prohibitive due physical constraints or system cost. These factors motivate the need to improve radar resolution and sensitivity without increasing the system's time-bandwidth-aperture product.

Due to the importance of this problem, many elegant techniques have been developed over the years to alleviate the limitations of conventional signal processing. However, these high-performing techniques often have extremely high complexity for real-time applications. They can also be very sensitive to modelling assumptions. Indeed, high-performing methods are typically "over-optimised" with respect to presumed signal models. Consequently, their practical performance can be fragile to random errors caused by instrumental imperfections and environmental uncertainties. This talk presents some recent advances in applied data-extrapolation methods that can achieve significant resolution and sensitivity enhancement relative to conventional processing while at the same time retaining the speed and robustness of the venerable FFT. Practical application of these methods in all three canonical radar dimensions of Doppler, range, and azimuth is illustrated on experimental data acquired by Australia's high frequency Jindalee over-the-horizon radar system.

Multi-sensor Association/Fusion in Linear and Nonlinear Systems

Ting yuan

Mercedes-Benz Research & Development North America (USA)

Autonomous driving poses unique challenges for vehicle environment perception due to the complex driving environment where the autonomous vehicle should accurately find itself in and simultaneously connect/differentiate itself with remote vehicles. Classic data association/fusion approaches (say, in aerospace applications) can be adapted in the automotive systems in a straightforward-but-delicate manner. In this talk, we aim to explain how to feasibly apply classic tracking and track fusion for autonomous driving from a theoretical point of view. We will use implemented important vehicle applications to illustrate/discuss the state of the art techniques, such as heterogeneous track fusion, interacting multiple model approach, and sequential multiple hypothesis test in the multiple-stage multiple-sensor estimation analysis. We will try to give out an outline on future requirements for autonomous driving from the our personal point of view and an overview of handling statistical information (e.g., covariance) in linear/nonlinear sensor fusion systems for vehicle environment perception.

A Review of Photonic RF Arbitrary Waveform Generations

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In this paper, a tutorial and review of techniques for photonic generation of arbitrary RF waveforms, particularly the generations of those waveforms that are difficult and/or challenging to generate using electronic techniques are presented. Four major photonic approaches to generate RF waveforms are reviewed namely Fourier Transform Pulse Shaping and Frequency to Time Mapping [1, 2], Direct Time Synthesis [3], Discrete Space to Time Mapping [4] and Microwave Photonic Filtering [5, 6]. For each technique, we will study the operation principle, consider the technolog used for implementation and examine the demonstrated results and performances. We will analyses the advantages and disadvantages of each implementation and investigate their ability to integrate as compact photonic chips. Finally we suggest possible directions for further improvements and future researches.

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Concurrent session 3: Imaging

Very High Resolution Acoustic Remote Sensing

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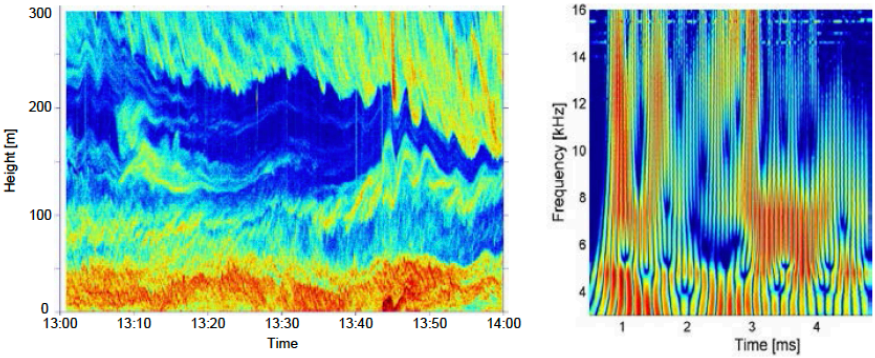
Acoustic sensing has advantages over EM/optical sensing in situations where attenuation is less, scattering is greater, EM fields are invasive, or cost is an issue. Acoustic methods are often considered to have poor depth (propagation direction) resolution (due to long pulse duration), and poor lateral spatial resolution (due to diffraction). We describe methods which overcome these limitations and illustrate using three examples.

Acoustic sounders obtain reflections from turbulent density fluctuations and, by sensing the Doppler frequency changes, also derive winds to about 300m above ground. Single- frequency pulses are generally used with a depth resolution of 20m. We describe an approach which linearly sweeps frequency over 1s and, through novel processing, obtains a depth resolution of 0.5m. Such FM chirps are common for radars, but in this case the significant Doppler shift poses a real challenge.

A second example uses phase-encoded ultrasound pulses to improve depth resolution from 70 mm to 1 mm. For an encoded pulse the improved depth resolution is obtained by increasing the bandwidth. But this means that both the beam width and scattering cross section evolve with time. We explore what the compressed return signal actual represents in these cases. Finally we describe broadband ultrasound measurements on trees in which the frequency dependent time of flight allows profiling within the trunk.



Left: 0.5m resolution FM chirp acoustic sounder. Right: dispersion in wood.

Shrinking the Telescope: replacing bulk optics with 3D integrated photonics

Michael Withford

Macquarie University, Sydney, Australia

Integrated photonic chips represent a vital part of modern society. Indeed the Internet is enabled by photonic chips that convert an optical signal into the electrical one that connects with our computers. Photons, the elementary particle of light, can be characterised by 6 different traits: velocity (or phase), brightness, wavelength, polarisation, spatial mode and orbital angular momentum. Many applications that require compact size, low loss, thermal and vibration stability, AND seek to exploit one or more of these traits can only be realised using photonic chips that manipulate light in all 3 spatial dimensions.
Ultrafast laser inscription has been shown to be a viable fabrication platform for realising 3D photonics. This field has grown significantly in the last 10 years with over 50 research groups and several commercial enterprises currently active in this pursuit world-wide. Their target applications encompass classical and non-classical optics, waveguide and fibre lasers, telecommunications, astronomy, bio-photonics and sensing.

3D photonics has triggered new innovation in the design and engineering of next generation telescopes. An Australian team comprising members from Macquarie University, the University of Sydney and the Australian Astronomical Observatory have been pioneering the development of new photonic based devices that will ultimately reduce the size and cost of the detection and analysis instruments used on major astronomical facilities, both terrestrial and space based platforms. These devices include integrated photonic spectrographs and integrated interferometric imagers, both intended for exo-planet discovery and tested on large diameter telescopes on Mauna Kea, Hawaii. The same concepts are now being pursued via a new collaboration involving Lockheed-Martin and University of California-Davis, and numerous European consortia. In this presentation I will review the emerging international effort developing novel 3D photonics based imaging systems and discuss other emerging applications exploiting 3D integrated optical chips.

Microwave photonics for high performance sensing

Xiaoke Yi

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The emerging field of microwave photonics has attracted immense research interest for sensor applications owing to various state-of-the-art techniques to conveniently convert the change in the optical domain to a corresponding shift in the microwave frequency. Recent new methods in microwave photonic based high preformance sensing are reviewed in the paper, where optical domain immunes to electromagnetic interference and microwave domain provides superior method for monitoring miniscule changes.

Low-cost mosaic pixel infrared sensor arrays

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The introduction of smart sensors and Internet of Things (IoT) devices is creating new applications and markets in infrared (IR) detection and environmental monitoring. Smart sensing devices for applications like people counting or zero-false alarm intruder detection require highly accurate detectors at low fabrication cost.
IR Sensors is presenting integrated infrared sensor solutions based on its patented mosaic pixel infrared microbolometer technology enabling versatile low cost IR sensing devices[1].
IR Sensors' patented mosaic pixel technology allows clustering of microbolometers and fabrication of infrared detector arrays with an enhanced sensitivity. Mosaic pixel technology is set to enable the advancement of infrared detectors into novel smart ubiquitous sensing markets.

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Concurrent session 4: Chemical sensing

Ion-transfer across soft interfaces as a chemical sensing mechanism

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Pushing ions across the interface between water and oil liquid phases, or between water and an organogel phase, provides a very simple way to chemical detection. The movement of ions provides an electrical current that can be measured, and the applied potential used to force ion transfer, via the ion's Gibbs energy of transfer, can be manipulated to selectively transfer target ions. As a chemical sensing mechanism, this approach enables the detection of non-redox active ions or ions whose redox activity has associated complications. These interfaces are usually referred to as the interface between two immiscible electrolyte solutions (the ITIES). Some possibilities for the use of the ITIES in chemical sensors and biosensors will be discussed in this presentation.

The traditional ITIES suitable for laboratory experiments is fragile. Miniaturization of the ITIES to microscale or nanoscale by use of porous membranes placed between the two phases has opened up possibilities for the detection of ionized biomolecules, such as drug substances and neurotransmitters, whilst also providing a more stable interface. We have developed glass microporous membranes prepared by laser ablation to pattern the ITIES into an array of microscale interfaces, and also used focused ion beam (FIB) milling to prepare nanoporous membranes to form nanoITIES arrays. The behavior and use of such interfaces for the detection of proteins and other polyelectrolytes will be discussed. Combined, these results illustrate the possibilities for chemical/biochemical sensing using ion-transfer detection strategies at soft interfaces.

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AlGaN/GaN transistor sensors: an on-chip reference-electrode free approach to ion detection

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Ion-sensitive field effect transistors (ISFETs) are a solid-state approach to ion detection in water with the advantages of compact size, on-chip integration and high sensitivity [1]. However, to date the majority of investigations use Si-based ISFETs. While they have shown promise, the gate dielectrics are highly sensitive to charging effects/breakdown, can be chemically unstable in aqueous solutions and require a reference electrode. AlGaN/GaN high electron mobility transistors (HEMTs) are an attractive alternative to Si-based sensors, with vastly improved chemical, mechanical and thermal stability, diminished charging effects, and superior membrane adhesion [2]. A few years ago, we demonstrated a reference electrode free nitrate sensor based on AlGaN/GaN FET structures functionalised with a polymer membrane developed for nitrate-selective ISEs [3]. This presentation will include our recent work on mercury and calcium ion detection using AlGaN/GaN sensors. It will also include results from a recent study on the mechanism for pH monitoring with the oxides of AlGaN and GaN as a sensing layer. We will also discuss our progress in obtaining drift-free sensing which is critical for long-term commercial viability.

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Nanostructure Based Gas Sensors Operating at Room Temperature

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A revolutionising technological trend is the rapid growth of mobile sensors for different applications including health and environmental monitoring, robotics and security. Low power consumption is essential for long term operation of mobile gas sensors providing real-time data about ambient air quality. In the emerging fields of Nanoscience and Nanotechnology, research and development in gas sensors has achieved significant progress. However, the development of gas sensors with high performance operating at room temperature (RT) is still challenging. A gas sensor working at RT is indeed appealing because the absence of a heating stage decreases drastically the power consumption, also simplifies the fabrication process and, importantly, reduces operational costs.[1]

Recently, we have developed highly sensitive nanostructure based gas sensors operating at RT. These sensors are based on CuTCNQ, pristine and Pt nanoparticle decorated $CuTCNQF_4$ nanostructures, functionalised reduced graphene oxide (rGO), 2D TiO_x nanosheets and hybrid rGO-WO_3 films. The developed conductometric sensors were tested to NO_2, CH_4, NH_3, acetone and ethanol gases with different concentrations. They exhibited reversible response to a number of target gases at RT. A detection limit of 600 ppb was measured. The experimental results show that these nanostructures are promising candidates for highly performing gas sensing devices operating at room temperature.

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Modifying and Optimising Polymer Films for Molecular Sensing of Hydrocarbons in Aquatic Environments

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The use of polymer films and coatings for sensing hydrocarbon and organic-based compounds in environmental waters has been hampered by their limited molecular selectivity. In recent years, research has shifted towards the development of composite materials for enhancing the analytical and physicochemical properties of various types of hydrocarbon sensors [1, 2]. It has been shown that the addition of plasticizers to some polymers can significantly improve its sensitivity towards aromatic-based hydrocarbons [3]. However, very few studies have been performed on other additives and the development of polymer hybrid materials has been proposed as an alternative approach for addressing the challenges with respect to sensor selectivity and sensitivity. In this study, attenuated total reflectance infrared spectroscopy was used to evaluate the sorption and sensing properties of polymer films doped with various additives (i.e., calixarene, metal nanoparticle). The polymers were modified with different types and amounts of calixarenes, and the sensor response was investigated in water as a function of hydrocarbon concentration. It was shown that under certain conditions, calixarene additives can improve the polymer response and that calixarene-polymer films can be tailored to respond to certain hydrocarbons.

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Concurrent session 5: RF sensing

Sensing in the terahertz regime

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Advances in ultrafast femtosecond laser technology have opened up the terahertz (or "T-ray") region of the spectrum usually defined as 0.1 to 10 THz. Many substances, including biomolecules, have distinct resonances in this region leading to a wide range of potential applications in security, quality control, and biomedicine. This presentation will review the challenges, the opportunities and highlights of our group's recent achievements in the area. Biography: Professor Derek Abbott is a physicist and electrical engineer based at the University of Adelaide. He won a 2004 Tall Poppy Award and the 2015 David Dewhurst Medal, Engineers Australia. He is a Fellow of the Institute of Electrical & Electronic Engineers (USA), a Fellow of the Institute of Physics (UK), and an Australian Research Council Future Fellow. In 1997, he launched Australia's first terahertz program and presently leads the largest terahertz laboratory in the Southern Hemisphere.

Printable Chipless RFID Sensors for future Track and Trace Solution

Emran Md Amin

Radio Frequency Systems

The Topic of this talk is on passive, chipless radio frequency identification (RFID) sensors with special focus on smart polymer materials and RF circuit design. A chipless RFID tag is a passive microwave device that can be directly printed on polymer with conductive ink. The aim of chipless RFID tag is to replace the existing barcodes used for item level tagging. Moreover, a chipless RFID sensor provides identification data as well as monitors a number of physical parameters of tagged objects. The tag sensor is a passive microwave device that uses intelligent/ smart polymer materials for environment sensing. The tag sensor is designed by integrating the Microwave and Materials Engineering and realized through nanofabrication facilities.

I will discuss this interdisciplinary research area where mm wave circuit design is combined with smart materials to develop a low-cost, high sensitive, fully printable passive sensor for environment monitoring. This calls for new challenges such as RF characterization of materials, enhancing sensitivity, roll to roll printing and also RFID reader development.

Partial discharge in High Voltage Systems and Early Detection using RF sensors.

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Partial Discharge (PD) is a major problem in High Voltage Systems. It exists in most components of a power system, including transformers, switch gear and power lines. PD causes damage to electrical hardware, power losses, fire and issues with power quality. PD activity can be an indicator of impending power line insulator failures, leading to catastrophic events such as pole top fires, bush fires and power outages, potentially causing damage to power infrastructure worth of millions of dollars and can put the safety of people at risk. The prevention, detection and eradication of PD are hence vital to avoid such failures and consequences. Current PD detection methods include visual inspection, infrared thermography, Corona camera, leakage current and acoustic emission measurements. Unlike the methods mentioned above, RF sensors can detect PD faults at its early stages and relatively easy to integrate to an existing system. The Electromagnetic (EM) Emission due to different types of PD activities has been studied [1]. These studies show EM emission due to PD activity is dominant in the UHF band and propose a PD detection system or overhead power lines. RF sensors have been used commercially in the power industry. However the use of HV systems on maritime platforms has been increased due to increase use of electrical propulsion [2]. This has increased the PD activities on maritime platforms due to premature aging [2]. However there is no real time PD detection and localization system designed for maritime environment. Therefore it is important to investigate PD activities on maritime platforms and design suitable PD detection and localization system for them.

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Metamaterial-inspired Microwave Microfluidic Sensors

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Metamaterial resonators have attracted great attention in designing sensors. The split-ring resonators (SRRs) and complementary split-ring resonators (CSRRs) provide concentrated electromagnetic fields at their resonance with high quality factor characteristic. These electromagnetic fields are very sensitive to the environment changes such as displacement, rotation, dielectric property. Any change in these factors affects the resonance characteristics of the SRRs and CSRRs. Therefore, they can function as sensors with a compact footprint. This talk presents an application of metamaterial inspired resonators to high-sensitivity microfluidic sensors. Towards this aim, two high-sensitivity microwave microfluidic sensors are introduced. Firstly, amicrofluidic sensor is designed based on amicrostrip-line-coupled CSRR for measuring the ethanol concentration in water solutions. Secondly, a complementary electric-LC resonator coupled with a microstrip line is investigated for determination of glucose concentration in water.

Concurrent session 6: Biomedical sensing

Simultaneous Mapping of Cancer Drug Transport, Metabolic Variables, and Drug Efficacy at Single Cells, Cell Monolayers, and in 3D Multicellular Model Tumors Using Electrochemical and Optical Micro-Sensing

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Drug resistance is the most important factor leading to failure of cancer therapy. There are multidrug resistance, MDR, mechanisms that manifest at the cellular level. MDR is determined by the genetic makeup of the individual tumor cells. To study MDR therefore measurements at single isolated tumor cells are required. An entirely different class of drug resistance is derived from the interaction of tumor cells with each other and their environment in 3D tumor tissue, called multicellular resistance, MCR. Yet typically sparse 2D cell monolayers are used in mechanistic studies and drug development: a cell construct that does not replicate either MDR or MCR.

We used electrochemical and optical microsensors and different microscopies to elucidate mechanisms of MDR and MCR *in vitro.* We compared data obtained from single cells and 3D constructs with phenomena seen at the commonly used monolayer.

Dynamic intracellular drug distribution was assessed using the diffusional microburet developed in our laboratory in combination with confocal microscopy. A carbon microdisc electrode and special voltammetry protocols were used to obtain information on drug transport between the extracellular and intracellular space. These measurements led to unique quantitative information on MDR.

Drug penetration and distribution in 3D tumor tissue was studied using the multicellular tumor hemi-spheroid model developed in our laboratory. Oxygenation and acidity, the two most important metabolic parameters in cancer pharmacology have also been mapped in depth using a micro-oxygen-electrode array and a pH optode membrane, respectively. Depth-resolved information never before seen has been obtained in these experiments.

Finally sparse 2D tumor cell monolayers have also been studied with carbon disc micro-voltammetry for drug transport. Very large differences were seen relative to the single cell and 3D constructs which questions the validity of the usual monolayer-based experimental approach.

Microbubble Acoustic Resonance Interference Spectroscopy

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Contrast-enhanced ultrasound (CEUS), based on the strong echogenicity of microbubbles, is commonly used for clinical medical imaging. Targeted delivery of therapeutics loaded on microbubbles is currently under vigorous investigation. Ultrasonic or acoustic response can be used to monitor bubble equilibrium size, mass loading and surface layer properties; and liquid medium properties such as viscosity and local pressure. This could lead to new and powerful medical and industrial sensing modalities.

A method of ***acoustic resonance interference spectroscopy*** **(ARIS**) has been developed to monitor bubble and liquid medium properties. It is based on the resonant response of a bubble to acoustic excitation and the interference between the source (reference) and bubble response acoustic pressure fields. Unique analytical expressions are presented for system properties such as bubble equilibrium size, surface mass loading and liquid medium viscosity in terms of the frequencies of these acoustic features.

Theoretical ARIS signatures are shown for several types of commercially available ultrasound contrast agent (UCA) used in CEUS. The sensitivity of the method to microbubble equilibrium size, attached mass loading and viscosity of the liquid medium are demonstrated. ARIS simulations suggest lipid attached mass as small as an order of a picogram may be detectable on a micron radius microbubble. Results from ARIS monitoring experiments with streams of unencapsulated air bubbles in water are also discussed.

The potential for the ARIS signature of medical microbubbles to estimate the rheological properties of biological liquids is explored. The sensitivity of the ARIS method for detection of the progressive detachment of therapeutic agents or attachment of analyte species to microbubbles is also discussed.

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(Bio)Sensing platforms for monitoring personal and environmental factors

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The use of personal and environmental monitoring devices will become more and more prevalent in the future, as sensing platforms are improved by advanced technology. This talk will introduce a series of sensor concepts that cover biomedical, chemical and environmental applications, with the aim of providing real time feedback to the users.

Biomedical sensors: Nanostructured, optically responsive, porous silicon architectures are demonstrated as a viable substrate towards an implantable biosensor [1]. *In vivo* mouse studies have shown how the nanostructured silicon chips can be implanted subcutaneously and their optical signal measured through skin. *Ex vivo* results demonstrate the optical detection of selected analytes using this material.

Chemosensor: A rapid chemosensor for organic vapours has been developed based on similar nanostructured silicon materials [2]. In this case the silicon surface was chemically pattered with hydrophilic and hydrophobic chemistries, allowing the selective adsorption of (hydrophobic) organic vapours. A dual optical signal was measureable from the porous silicon that enabled an internal reference capability to the sensor platform.

Environmental monitoring: A process for the rapid monitoring of water filter performance and efficiency is also be presented. Fluorescence spectroscopy has been used to determine the relative concentration of dissolved organic matter (DOM) in filtered water samples over the reported filter lifetime. The amount of DOM has been shown to correlate with the concentration of dangerous trihalomethanes that break through the filter at equivalent time points. Such monitoring can indicate the optimal time for filter change to ensure the highest purity water is delivered.

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Wearable Glove Type Driver Stress Monitoring with Steering Wheel Control Behavior and GSR

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The growing of driver mental stress is risk factor that cause increment of traffic accidents in recent decades. These negative stresses could escalate the drivers to perform risky driving operations that might hurt others and themselves. In order to prevent such incidents, this paper aims to develop a non-intrusive driver stress monitoring system by observing the driver's physiological and physical reactions.

The system is built with low-cost sensors by a wearable glove. The physiological reaction is measured from driver palm by means of galvanic skin responses (GSR) [1] sensor in the glove. Meanwhile, physical reaction is observed via steering wheel movement (SWM) [2] which is derived from reading of a motion sensor (inertial motion unit, IMU) placed on the glove. Those sensors are then connected to a wearable electronic MCU platform. Subsequently, the sensors readings are received by the mobile application via Bluetooth low energy (BLE).

Meanwhile, a support vector machine (SVM) classifier is developed in the mobile application to classify the driver stress state based on the received signals. As such, features are extracted from the GSR and IMU (linear acceleration (m^2/s) and orientation (deg/s)) sensors to serve as inputs to train for the SVM classifier. Experiments are conducted with Euro Truck driving simulator and data is collected from 16 subjects recruited from the university. On the other hand, to reduce the classifier complexity, number of features for classification is a critical factor. Therefore, a feature stepwise selection method is adopted by adding features one by one to the classifier and at each step the feature that increases performance criteria the most is retained. Consequently, the average true positive and true negative of stress classification accuracy rate could be reached up to 94.62%.

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Microwave Nanoantenna-Nanobiosensors for Asymtomatic Cancer Detection

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Scientists have developed highly sensitive and specific detectors of disease-associated proteins. Determination of the spectral signatures of the protein biomarkers of interest provided the basis for detection and identification. In vivo and in vitro detection paves the way to early diagnosis of important diseases for preventive and therapeutic treatment to improve patient outcomes. This finding will potentially have an immense impact on the general public, aiding disease detection at its earliest stage/asymtomatic before patients show symptom. The new methodology also has possible applications in the identification of numerous molecules, especially for drug development research, both as targets and the treatments. The breakthrough is made possible through the use of an optical sensing device 'Nanoantenna-nanobiosensors' to enhance the signal i.e. a Surface Plasmon Resonance (SPR). SPR and localized SPR have brought a lot of attention because of the strong localized EM field. The oscillation of free electrons at the metal-dielectric interface coupled by electromagnetic wave could be used for many other applications such as metamaterial in sensing, active optoelectronic components etc. Other technique of nanoantenna transducing/excitation is a microwave nanoantenna(disease related signal),a microwave radiolocation and recognition for determining the characteristics and locality of an object's chemical biomarkers, will also be discussed. Another important component of this nanobiosensing system is a bioreceptor,which is responsible for a high specificity and sensitivity of molecular/protein recognition and quantification in-vivo and in-vitro through a Microfludic Nanobiosensor Microwave Dielectric Spectroscopy [1-2].

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Concurrent session 7 Optical sensing

Smart devices and photonics for sensing and diagnostics

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Smart device technologies are revolutionising diagnostics for sensing across medical, agricultural, industrial, consumer and many other industries. In early days the integration of photonic components has been limited to optical components such as LEDs but inevitably the smart device platform will absorb future optical and quantum chips, such as those based on self-assembly in silica [1] or inscribed by femtosecond waveguide [2], once they come on line. Nonetheless, modern active matrix organic LED screens can themselves be used as large area optical sources [3] that can be potentially patterned using the various RGB combinations in *x,y* space. The massive consumer market that is producing stunning electronic devices at historically low costs is today enabling lab-in-a-phone technologies to come to fruition [4-6], including laser beam profilers [7], which in turn is creating new internet concepts such as rapid forensic mapping for incursions impacting societal infrastructure [8].

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Taming the light in optical fibres for sensing

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This talk reviews the light-based chemical and physical sensing approaches developed at the Institute for Photonics and Advanced Sensing (IPAS) and the Centre for Nanoscale BioPhotonics (CNBP) at Adelaide University utilizing novel optical fibres[1]. Suspended-core[2] and hollow-core[3] microstructured fibres and hybrid material optical fibres[4] offer important benefits compared to traditional techniques such as small sample volumes, high sensitivity, remote sensing, field-deploying capability and multiplexing. Depending on the intended application, a host of sensing modalities have been utilized including labelled fluorescence techniques, and label-free methods such as spectroscopy, surface plasmon resonance, fibre Bragg gratings, and Raman scattering[1]. The use of various fibre surface functionalization techniques adds specificity to the ions and molecules to be sensed[2].

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Cooperatively-Enhanced (Superradiance) Atomic Dipole Forces in Optically Trapped Nanodiamonds Containing NV Centres, in Liquid

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Nanodiamonds (NDs) containing colour centres are remarkable objects which find applications in a wide range of disciplines spanning from quantum information technologies to quantum metrology and bio-sensing. In life sciences, fluorescent nanodiamonds containing colour centres are implemented as non-toxic biomarkers for biomedical imaging [1] and drug delivery [2, 3]. While in recent experiments they have been tracked within living HeLa cells [4], and optically manipulated in liquid [5], their manipulation in a 3D biological environment remains beyond reach. Currently, classical optical tweezers cannot trap particles smaller than ~100 nm.

Here, we propose a new approach that stems from cold-atom trapping experiments [6]. We exploit artificial atoms – specifically colour NV centres incorporated in the nanodiamond host (~10^3 NVs/particle) – to enhance the trapping of the whole crystal via near-resonant forces acting on them. While holding the diamond nanoparticle (~150 nm) at the focus of classical optical tweezers in liquid [7], we employ a second near-resonant laser beam, slightly detuned from the dipole transition of the target colour centres. We measure a change in trap stiffness of ~10%, which is the signature of atomic dipole forces [8]. Most interestingly, we show that our findings can only be ascribed to the existence of collective effects – 'superradiance' (SR) – between colour centres, which has never been reported before for solid-state systems at room temperature in a system archetype of that originally proposed by Dicke in his seminal paper on superradiance [9].

Beyond advancements in efficient photon-detection and quantum sensing, our approach could lead to accessing new nano-manipulation regimes for biomedical research, with sizes (~tens of nm) and forces (~hundreds of pN) currently unattainable with conventional optical traps [10]. Moreover, our findings on superradiance open up a playground for studying SR in well-controlled settings with the possibility of both engineering the NV centres and the photonic and phononic nanostructures the NV centres are embedded in. The prospect of quantum engineering a purpose-tailored SR system at room temperature makes the NV diamond system a prime candidate for potential applications of SR in quantum metrology [11] and light harvesting [12]. Beyond applications, the nanodiamonds studied here provide a novel testbed to study the influence of dipole-dipole interactions on SR.

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CMOS integrated nanophotonic sensor

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The widespread applications of nanophotonic sensors in daily life is hindered by the so called “chip in a lab” bottleneck due to requirement of large and expensive equipment such as an optical spectrum analyzer (OSA) for read-out of nanophotonic sensor chips. Now is the time to transform laboratory based nanophotonic sensors into a portable sensor system which can be achieved by their monolithic integration with detectors to have direct electrical read-out. In this work, we report monolithic integration of a plasmonic sensor composed of periodic array of gold nanodiscs with a photodetector (PD) made by CMOS technology, as shown in schematic in Figure 1a. By doing so, the resonance wavelength shift of the plasmonic structures on application of an analyte is read out directly as a change in PD output voltage and hence the need of an OSA is eliminated. The performance of the integrated sensor is evaluated by sensing different concentrations of glycerol solution in DI water as shown in Figure 1b. An optical sensitivity of 275 nm/refractive index unit (RIU) of the resonant nanophotonic sensor translates to an electrical sensitivity of 5.8 V/RIU in the integrated sensor. In a similar way that CMOS technology has revolutionized the electronics industry, we anticipate that integration of nanophotonic sensors with CMOS technology will also ensure great success in commercializing nanophotonic sensor technology with particular applications in point-of-care diagnostics.

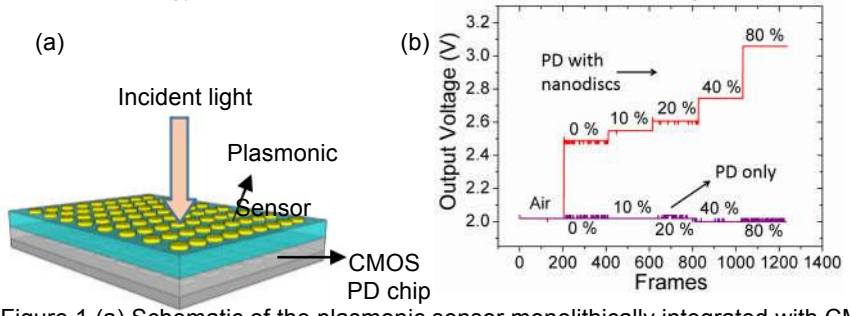

Figure 1 (a) Schematic of the plasmonic sensor monolithically integrated with CMOS PDs. (b) Electrical readout of refractive index changes corresponding to different concentrations of glycerol by the integrated sensor.

UK Quantum Technology Hub for Sensors and Metrology

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The UK Quantum Technology (QT) Hub for Sensors and Metrology, one of four hubs that comprise the UKs National Quantum Technology Program, has been established to produce quantum sensors that outperform existing classical devices. Our sensors will be translated into new applications in areas such as medical imaging and brain diagnostics, locating pipes and detecting leaks, archaeological surveying, navigation, assessing rail tracks, network timing, detecting sinkholes and groundwater and space missions.

Quantum superposition allows atoms to coexist in two classically distinct and exclusive alternate states. This well tested cornerstone of quantum mechanics is exploited to produce quantum sensors based on laser cooling and trapping methods. Tailored laser or microwave pulses are used to create superposition states in trapped atom populations, enabling determination of interference levels upon recombination in final state populations. The form of the pulses, laser geometry, and traps determines the measurement type. Separating the paths linearly or in circular patterns enables the measurement of acceleration and rotation respectively. Superposing different spin states allows magnetic fields or time to be determined with results read out by state-selective detection of the relative population of the final states.

Key to the success of applying these technologies is working jointly with industry to support the development of smaller, lighter and cheaper components to make quantum devices a commercially viable reality.

To this end the Hub has 12 areas of activity, including systems prototyping focused on timekeeping as well as gravity, rotation magnetic and imaging sensors; development of supporting supply chain technologies including laser and electronic packages, atom chips, packaging systems and market building; and development of supplier and systems engineering and technology translation networks.

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Concurrent session 8: Optical sensing

David Lancaster

Quantum sensing and imaging of magnetic fields using spins in diamond

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Imaging the fields of magnetic materials provides crucial insight into the physical and chemical processes surrounding magnetism, and has been a key ingredient in the spectacular development of magnetic data storage. Magnetic imaging techniques are generally characterized by their spatial and temporal resolution, but criteria such as sensitivity, field disturbance, sample damage, field of view, cost, and ease of use, are critical for broad applicability which ultimately drives future development of our understanding of magnetism in advanced materials and applications. Solid state spin systems offer a new approach for magnetic imaging, based on the sensitivity of quantum spin states to external magnetic fields [1]. Here we show how the optical response of a 2D array of negatively-charged nitrogen-vacancy (NV) spins in diamond can be used to image and map the sub- micron stray magnetic field patterns from thin ferromagnetic films and 2D magnetic devices. The 2D NV imaging array can be used in a variety of modalities to perform all optical magnetic imaging, quantitative magnetic imaging [2] as well as electron spin resonance imaging [3]. This work establishes practical diamond-based wide-field microscopy for rapid high-sensitivity characterisation and imaging of magnetic devices, with the capability for investigating various magnetic phenomena.

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Optical Sensing: Current Trends to Future Applications

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Fibre-Optic Sensing [1-3] has played a key role in many commercial and defence applications since the introduction of these technologies some decades ago [2] and has matured to conventional approaches; (a) electrical and (b) microwave technologies. it has impacted significantly to the global market share in recent times due to its niche applications where it is implemented for security, health and structural monitoring compared to many other fundamental approaches and technologies.

These optical technologies have; (a) immunity to electromagnetic interference; (b) use of low cost telecommunication fibre cables; (c) long distance; and (d) not susceptible to harsh environment [3]. Coherent Optical Time-Domain Reflectometer (COTDR) [4-5] has been used in many applications such as leak detection, vibration/perimeter detection and health monitoring due to its high sensitivity and localisation with sub-metre spatial resolution.

Recently, Coherent OTDR [5] has gained much needed improvements to the basic principles of operation (or reduced technology complexity), lower cost to end user(or lower component cost) and novel signal processing techniques to identify and classify events with minimal nuisance detection.

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Sensing the magnetic near-field of light with an aperture probe

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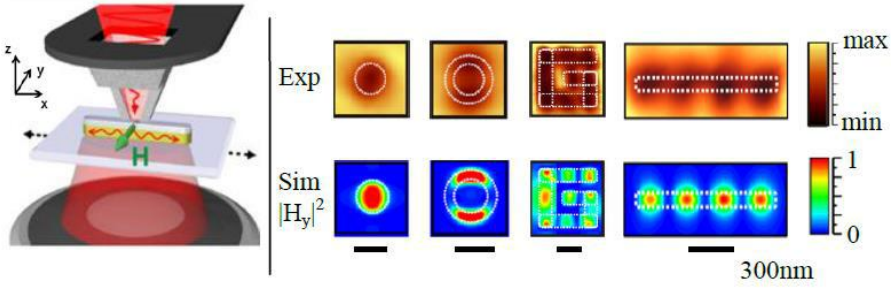
Last years, the field of artificial optical (meta-) materials is demanding a technique capable of sensing all components of the *magnetic* field of light, in addition to the traditionally measured *electric* field components.

To address this need, we show that the aperture probe of a scanning near-field optical microscope (SNOM) can be considered as a tangential optical magnetic field sensor. We experimentally demonstrate and confirm by numerical simulations that such a probe can be used for imaging the tangential magnetic field of light of various metallic antennas.



This newly developed approach complements the existing sensing methods and fills in the last standing gap for achieving full electromagnetic field mapping of light-matter interactions at nanoscale.

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Ultra-fast and ultra-sensitive colorimetric humidity sensors

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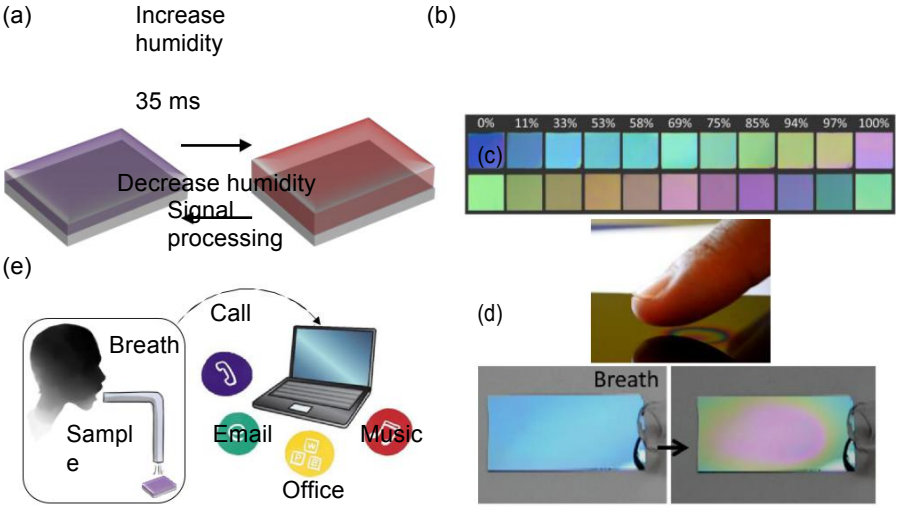
Humidity measurement is very important for manufacturing processes (e.g. coatings, packaging, glass) and indoor environments (e.g. museums, heritage buildings, hospitals, cleanrooms, greenhouses, vehicles, smart bandages/clothing) where excessive or insufficient moisture can affect the quality of the products or structural integrity. We present a new type of polymer-based visually readable humidity sensor that uniformly changes color through thickness and refractive index changes (a) depending on the local humidity. It features extremely fast responses and a wide range of vibrant colors (b), which are individually amongst the best reported in the literature and market. Furthermore, the fabrication procedure is simple and requires no electronic components to operate, unless advanced applications such as touchless control systems (c, d, e) are desired for convenient/disabled access. Highly humidity-sensitive fiber-optic sensors, both point and distributed, can also be developed from this enabling technology for leak detection and agriculture monitoring.



Remote sensing and spatiotemporal analysis of surface water dynamics and environmental change at subcontinental scale

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Existing and emerging geospatial technologies (e.g. drones) and new satellites (Sentinels, SWOT) and access to high performance computing continue to expand our capabilities to sense earth systems. Three main things have come together recently, allowing us to quantify and improve understanding of spatiotemporal dynamics of water dynamics in unprecedented ways, which include: (1) An ever pressing need of quantifying environmental change and change attribution given climate and changes in the way we use our land; (2) The availability of free archives of satellite data (e.g. the longest civilian archive of satellite data, the Landsat archive that monitors the earth every 16 days at 30m resolution since the 1970's) and new sensors and (3) The availability of supercomputers.

In Australia, competing water demands, combined with changes in climate and the way we use our land as well as multi-year droughts, such as the Millennium Drought that ended in 2009, have led to water shortages, particularly in the Murray-Darling Basin (MDB). The MDB is a large (>1million km^2), semi-arid basin that experiences extreme hydroclimatic variability and competing water demands, of high economic importance given that it accounts for 40% of Australia's gross value in agricultural production.

In this talk I will present (1) the development of a statistically validated surface water and flooding extent dynamics data product (SWD) based on 3 decades (1986-2011) of the seasonally continuous Landsat TM and ETM + archives and generic random forest-based models (an ensemble classifier, necessary when mapping targets with high spectral variability such as floods); (2) the quantification of key drivers of surface water extent dynamics, and (3) on going applications of the SWD, including the quantification of vegetation response to flooding, as well as river red gum communities, an iconic riparian eucalyptus species that has suffered die-back and (4) spatiotemporal connectivity dynamics.

Concurrent session 9: Imaging

Optical MEMS Technologies for Infrared Spectroscopy, Sensing, and Imaging

Lorenzo FARAONE

The University of Western Australia

Current research efforts to further improve state-of-the-art infrared (IR) detector and imaging focal plane array (FPA) technologies are focused on reducing system cooling requirements, developing larger-format 2-dimensional imaging FPAs, extending the technology to longer wavelengths, and/or adding so-called multi-colour/hyper-spectral capability, which allows real-time spectral information to be gathered from multiple wavelength bands. Multi/hyper-spectral imaging in defence & aerospace scenarios provides enhanced target detection, improved target recognition, and reduced false alarm rates. In civilian, industrial and commercial arenas, such a technology is applicable to numerous remote sensing spectroscopy/imaging applications in agriculture, medical diagnostics, process control, food security, etc.

This presentation will focus on recent advances in optical MEMS technologies that are capable of providing reduced size, weight and power (SWaP) solutions for field-portable and airborne drone/UAV applications. In particular, a number of micro-electromechanical systems (MEMS) based electrically tuneable Fabry-Perot filter technologies will be presented that are compatible with either individual detectors or large format 2-dimensional imaging IRFPAs. Such a technology can be hybridised with any existing optoelectronic detector/sensing/imaging technology, and is capable of low-voltage tuning across the NIR/SWIR, MWIR or LWIR wavelength bands for field-portable or airborne spectroscopy and/or imaging applications.

Wataru Takeuchi

The NRL multi-aperture SAR: system description and results

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[1]DST Group
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High fidelity imaging of moving targets is a well-known challenge for synthetic aperture radar (SAR), especially in ocean environments. Standard SAR processing methods assume the entire scene is stationary, and interpret the Doppler histories in the data accordingly. Any Doppler shifts introduced by target or scene motion will be misinterpreted and the corresponding backscatter will be misplaced in the image. The classic example of this is the 'train-off-the-track', in which the signature of a range-traveling train appears displaced from the signature of the track upon which it is running. More serious distortions can occur when vessels are moving on a dynamic ocean surface. It can appear that different parts of the target are moving at different speeds and consequently the target's signature will be smeared as well as displaced. Advanced techniques utilizing multiple-aperture SAR (MSAR) systems have been developed to detect moving targets, estimate their velocities, and correct their positions within the image. The apertures in these systems are arranged along the flight axis to provide measurements of the scene at slightly different times but from the same vantage point in space, thereby allowing separation of the scene motion from that of the SAR platform. However, all these techniques assume the clutter is stationary, and thus they have limited applicability to ocean environments.

The Naval Research Laboratory (NRL) MSAR is an airborne test bed designed to investigate remote sensing and surveillance applications that exploit multiple along-track phase centres, in particular, applications that require measurement of scene motion. The system operates at X-band and supports 32 along-track phase centres through the use of two transmit horns and 16 receive antennas. As illustrated in this presentation, SAR images generated with these phase centres can be coherently combined to directly measure scene motion using the Velocity SAR algorithm. In September 2014 and 2015, this unique radar was deployed on an airborne platform, a Saab 340 aircraft. This presentation presents a description of the system and the results of coherent analyses to produce estimates of scene and target motion. These images were collected over an ocean inlet and contain a variety of moving backscatter sources, including automobiles, ships, shoaling ocean waves, and tidal currents.

Multimode fibre based imaging and sensing

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Biology, medicine and clinical diagnostics critically rely on imaging and sensing techniques capable of visualising chemical pathways in internal organs of living organisms. Currently available methods are far from perfect and imaging deep tissues with sub-cellular details remains an elusive goal and a major challange. Gold-standard imaging techniques such as X-Ray, CT, MRI and PET offer internal organ imaging, but at a level of detail far from subcellular features. In contrast, state-of- the-art optical microscopes offer subcellular resolutions but only less than 1mm deep. This capability gap is partly addressed by optical endoscopes that allow deeper probing. However, their resolution is currently cellular-level at best, and their large diameters (1 -10mm) present a major barrier for their use in sensitive tissues, such as the brain.

I will present a revolutionary approach, greatly miniaturizing the endoscope volume footprint while significantly increasing its resolution, based on multimode optical fibre(MMF). MMFs have been recently identified as optical elements with immense potential for minimally invasive in-vivo imaging and spatially resolved sensing[1]. Their volume footprint is two-orders of magnitude smaller than the current state-of-the-art endoscopes, and their resolution can potentially compete with highest NA objectives. MMFs also have the ability to support advanced imaging modalities, such as light-sheet, two-photon and structured illumination microscopy, in endoscopy setting. This forms the foundation for ultra- compact endoscopes suitable for imaging and chemical sensing in the brain of live animals.

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Inland Wetland Characterization Using LiDAR Data In Ilog, Negros Occidental

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Wetlands play a dynamic role in climate change mitigation and adaptation. They serve numerous ecological uses such as in water purification systems, regulating water flow and precipitation, acts as flood control system, provides shoreline stability and aids in biodiversity as reservoirs. Hence wetlands conservation and management is necessary for sustainable development. This study aims to characterize wetlands in terms of water content, turbidity, and aquatic vegetation in Ilog, Negros Occidental using LiDAR data. Wetlands that were delineated are mostly fishponds and marshes. Results were obtained by calculating the Normalized Difference Water Index (NDWI), Normalized Difference Turbidity Index (NDTI) and Normalized Difference Vegetation Index (NDVI) using the intensity from LiDAR data and orthophoto containing red, green and blue bands. It has been observed from the analysis that wetlands in Ilog, Negros Occidental have varied turbidity content from -0.101 to 0.084 while the aquatic vegetation remains uniformly negative all throughout. Remote sensing processing techniques are used in this study to quantify the water quality parameters to be used in conserving our wetlands. Furthermore it could pave the way for larger area scale analysis in nationwide wetland classification mapping.

KEY WORDS: LiDAR, GIS, Wetlands, Turbidity, Aquatic Vegetation

Bio-inspired Navigation Sensing Using Acoustic Waves: A Review

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Current navigation sensors mostly rely on electromagnetic signals for getting the position, velocity and time information. Bats use acoustic waves, mostly ultrasound, for echolocation. Acoustic waves are also used by Cetaceans like dolphins and sperm whales for echolocation and communication. This paper investigates the bioacoustic sensors in detail and identifies the research gaps in utilising bio-inspired acoustic waves for navigation in air, ground as well as underwater. Acoustic sensors are relatively cheap and easy to deploy. Acoustic waves, unlike electromagnetic waves, are mechanical waves, which require a medium to propagate. The speed of acoustic waves varies as well according to the medium and environmental conditions. Inspired by acoustic imaging used by animals for sensing the environment, acoustic sensor systems are developed which can vary the frequency, intensity or rate of sound transmission with the surrounding environment. This adaptive navigation system can be used in conjunction with other on-board sensors in air, ground and underwater platforms, through sensor data fusion techniques.

Concurrent session 10: Biochemical sensing

Safeguarding radiotherapy and biosensing with quantitative magnetic resonance imaging

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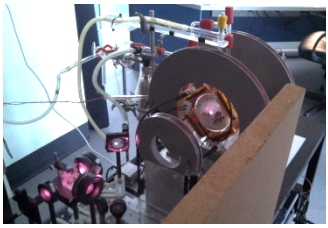
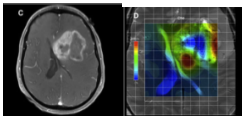
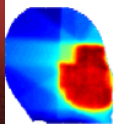
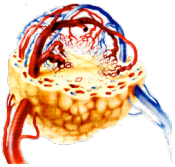
With recent improvements in cancer treatment, new medical physics and engineering challenges are on the rise. Firstly, the complexity of high-precision conformal radiation treatments has increased the need for three dimensional dosimetric quality assurance (QA) to guarantee that the radiation dose distribution in the patient matches the aimed dose distribution. Secondly, as the treatment volume is now more confined to the tumour, delineating the tumour has become more critical. In contemporary radiotherapy, the tumour volume is regarded as an invariant geometrical target during the course of the treatment. However, it is known that the tumour changes during fractionated radiotherapy. The development of quantitative magnetic resonance imaging (MRI) and spectroscopy (MRS) techniques will enable the assessment of tumour biology non-invasively, increase treatment efficiency and will give more insights in the biology of carcinogenesis.

In this overview talk of the biomedical imaging group, it will be shown how humanoid shaped hydrogel phantoms can be used to safeguard the entire treatment chain of high-precision radiotherapy. In the perspective of using quantitative MRI parameters in assessing treatment response, the physical link between tissue microstructure, tumour physiology and quantitative MRI properties will be demonstrated. Finally, a method to enhance the MRI signal sensitivity with several orders of magnitude will be discussed. This method based on hyperpolarization through spin exchange optical pumping (SEOP) will enable physiological imaging of the lungs and molecular sensing with magnetically labelled tracers.









Android Voltammetry: Use of a mobile device as an instrument for voltammetric analysis

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The rapid expansion of mobile phones and other mobile technologies is set to transform biosensing landscape. In particular the widespread availability of smartphone technology and the capabilities they offer in terms of computation, communication, networking, and imaging will allow a more extensive deployment of lab-on-a-chip and related sensing technologies. Furthermore the combination of mobile technologies with low-cost sensing concepts such as paper microfluidics could make life-changing health and environmental testing technologies available to many millions more people both in the developed and developing worlds.

Voltammetry is the cornerstone technique of electrochemical sensing, and almost all dynamic electrochemical methods can be regarded as a variation of the basic voltammetric method. The ability to provide not only sensitive quantitative information from the magnitude of the current peak, but also a degree of selectivity offered by the potential axis of the voltammogram, is the reason voltammetric methods have enjoyed such enduring popularity. In this presentation, we will show for the first time that quantitative voltammetric analysis may be carried out using only the intrinsic hardware in a mobile device such as a phone or tablet, with the aid of a suitable software application, using no external device or instrument whatsoever. We call this new approach Android voltammetry.

Mercury detection in real industrial flue gas using nanostructured microsensors

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According to the US EPA, more than 60,000 babies are born every year in the US alone with mercury-related diseases. Mercury is a neurotoxin and is shown to cause learning impediments, memory loss, numbness, loss of muscle coordination, deafness and vision impairment. Elemental mercury (Hg0) represents 66-94% of all anthropogenic mercury emissions that occur around the world. Hg0 is a persistent global pollutant which crosses geographic borders and bioaccumulates in the food chain causing serious health and congenital disorders. It is therefore critical to develop accurate detection/removal technologies to halt the toxin escaping into the atmosphere. Professor Bhargava and his team worked closely with Scientists from Alcoa World Alumina and BHP Billiton with the goal of producing a robust, sensitive and selective sensor capable of continuously monitoring mercury in industrial streams. Using novel electrochemical deposition methods to nanoengineer gold nanostructures onto a quartz crystal microbalance (QCM), they produced a highly robust, sensitive, selective and reusable mercury sensor for continuously monitoring Hg0 in alumina refineries. The sensor is capable of readily detecting Hg0 levels of the order of 22 µg/m3 (or 2.5ppbv) with 98% accuracy in the presence of volatile organic compounds and high humidity levels1. The enhanced selectivity and sensitivity of the sensor derives from the Hg0 sorption sites on the nanoengineered gold structures which have been patented, trialled and licensed. This is a significant, innovative breakthrough in air pollution control.

This talk will cover how this excellent research was translated into an innovative technology and transferred to the marketplace using an academic platform.

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Feature Extraction of ECG Signal and Information Transfer

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This Project is an integration of Medical and Telecommunication sector which aims at ECG feature extraction and Information transfer, which would help in cost saving (Information processing and Patient/Doctor interaction). Some of the research in this field has been carried out using Daubechies wavelet [1] which enables peak detection in the heart signal thus make feature extraction possible. The research carried out in [2] introduces us to the method of feature extraction using matched filters. Heart is the major organ in the human body, so it is mandatory to keep it healthy, the heart can be checked for any abnormalities. Feature Extraction of an ECG signal, would help to evaluate the characteristics of the heart signal and help to produce a confirmed decision. This project will be accomplished by using MATLAB/LABVIEW, this is due to the functions and features they would provide, and as they provide an advantage of user-friendliness. The results extracted after the signal analysis would be of great use in the Medical stages of diagnostic techniques.

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Metal-Organic Frameworks as Electrochemical Biosensor towards *L*-tyrosine Acid

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Metal-organic frameworks (MOFs) are one of the most attractive materials till now with many potential applications in the areas of environment, energy, biology and material.[1-4] In this work, three complexes based on Zn(II) ions, with the ligands 2,5-dicarboxylic acid (H_2L), 1,10-Phenanthroline hydrate (phen) and 2,2'-Dipyridyl (bpy), namely $\{[Zn_2(L)_2(\mu_2\text{-}O)(H_2O)_3]\cdot 3DMA\}_n$ (**1**), $Zn(L)(phen)(H_2O)]_n$ (**2**) and $[Zn_2(L)_2$ (2,2'-bipy) $(\mu_2\text{-}O)(H_2O)_2]_n$ (**3**), were synthesized by hydrothermal method. In order to determine their structures, elemental analysis (EA), infrared spectrum (IR), powder X-ray diffraction (PXRD) and thermal gravimetric analyses (TGA) were performed. These three complexes were prepared as modified electrodes and were studied by electrochemical impedance spectroscopy (EIS) and cyclic voltammetry (CV). **3** modified glass carbon electrode (**3**-GCE) was successfully used as biosensor in detection of *L*-tyrosine (*L*-tyr). **3** exhibits exellent electrochemical stable characterization on the glass carbon electrode (GCE), and precising detection of *L*-tyrosine acid in a biomimic environment.

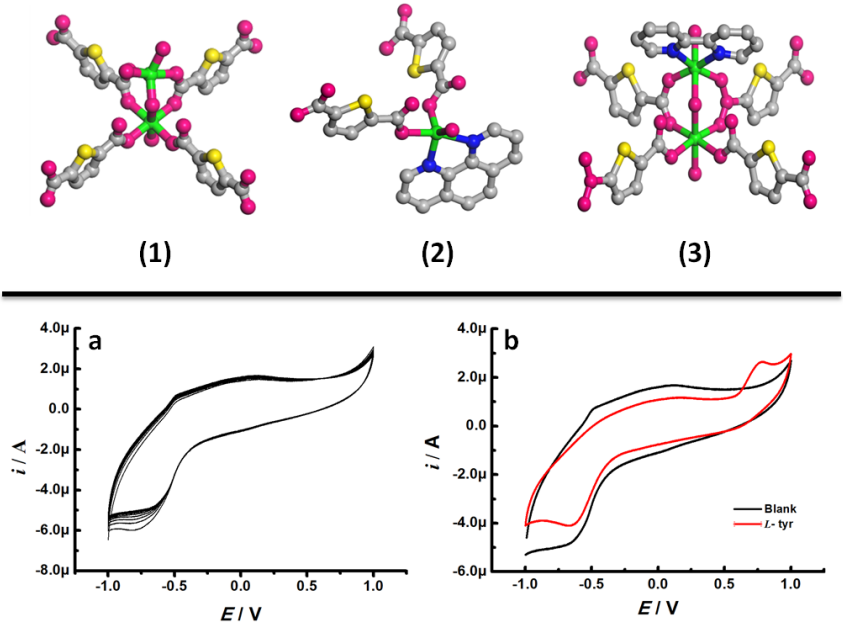

Figure 1 Top: Coordination environment of **1-3**, respectively the colors of red, gray, blue, green and yellow respect O, C, N, Zn and S atoms. Bottom: CVs of

3-GCE in phosphate buffer solution (pH 6.8) obtained (**a**) without amino acid for 30 circles (**b**) in the presence of addition concentration of *L*-tyr. Scan rate 0.1 $V \bullet s^{-1}$.

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Picomolar Reversible Hg(II) Solid-State Sensor Based on Carbon Dots in Double Heterostructure Colloidal Photonic Crystals

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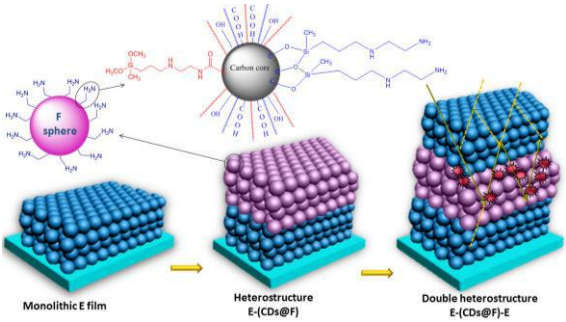
Mercury contamination in water is a persistent issue due to both natural geological and anthropogenic activities. Portable, facile and affordable sensors for detection and sensing different species of mercuries are highly desirable. We report a highly effective fluorescent, solid state sensor with high sensitivity, good selectivity and excellent reversibility for Hg(II) ion. Hg(II)-responsive carbon dots immobilised polystyrene spheres were fabricated as a middle layer in double heterostructure colloidal photonic crystal film. Significant fluorescence enhancement was achieved due to doubly resonant of the modes of photonic crystals and multi beam interface inside the double heterostructure film. The amplified fluorescence enhances the sensitivity of detection, achieving a detection limit of 91 pM for Hg(II) ion, even 17 times lower than that of carbon dots solution probe. The polystyrene-based film sensor is negligibly responsive to other metal ions and can easily be recovered by rinsing with cysteine.



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Single-material optical fiber high temperature sensors

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Optical fibers are useful tools for physical sensing, such as temperature, strain and pressure, due to benefits such as immunity to electromagnetic interference and ability to perform multiplexed measurements. We will present recent results on using a single-material optical fiber, known as a suspended-core microstructured optical fiber [SCF, Fig. 1(a)] for high temperature sensing, up to 1300°C. This has been achieved through both the multi-mode interference effect[1] [Fig. 1(b)] and femto-second laser written fiber Bragg gratings[2] [Fig. 1(c)]. These sensors are being tested at the Nyrstar metals processing facility in Port Pirie, South Australia.

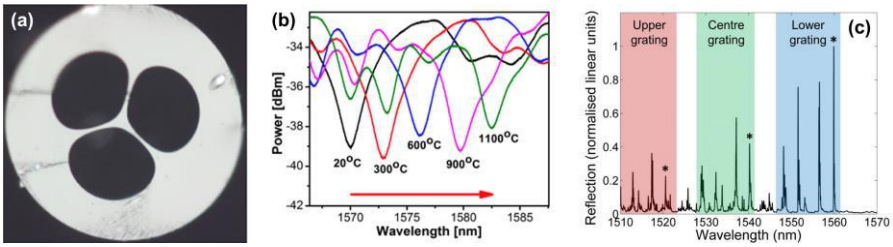

Fig. 1. (a) Scanning electron microscope image of the single material suspended-core microstructured optical fiber used for high temperature sensing. (b) Typical interference spectrum obtained from the SCF, in this case 24 mm long, and the response to increasing temperature. (c) Reflection spectra from three gratings inscribed into a SCF.

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Concurrent session 11: Sensor networks

The SKA radio telescope as a massive sensor system

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The international astronomical community, with significant inter-Governmental support, is collaborating to realize a huge distributed radio telescope. Its key science goals are to (i) trace the evolution of galaxies and (ii) provide extreme tests of the predictions of General Relativity.

The International Square Kilometre Array project (SKA)[1] is now in its preconstruction phase to finalise the design for SKA Phase 1 comprising two arrays – SKA_Low and SKA_ Mid – to be built in Australia (WA) and South Africa (Karoo) respectively. Phase 1 SKA will be built from ~2018 onwards and will be followed by the full SKA (Phase 2) where both the SKA_Low and SKA_Mid arrays are to be incremented in capability by massive factors to support an operational lifetime of ~50 years.

There are a number of "precursor" telescopes already operating or in advanced development. Both SKA and its precursors adopt dish (SKA_Mid) and dipole (SKA_ Low) antennas to observe across the 50 MHz to 20 GHz frequency range, and allow the study of everything from near earth phenomenon to searching for the earliest signals of primordial galaxy formation.

My presentation will review some key technology developments and discoveries that have been made within the SKA project and how Curtin University is playing a central role to deliver the SKA_Low in Australia. Curtin both owns and directs the Murchison Widefield Array[2] (MWA), a SKA_Low precursor sited at the Murchison Radio astronomy Observatory (MRO) in Western Australia, and is a major partner in the Low frequency aperture array Design Consortium to design and validate SKA_Low.

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Subhash Challa

UHF partial discharge sensing technology for overhead distribution line monitoring and early detection of fire on power lines

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Electricity distribution networks form the backbone of electricity delivery system between the transmission system and power consumers in urban, suburban and rural areas. Power distribution network in general delivers electricity at a rated voltage of 12.7kV, 22kV and 33kV using either overhead bare or insulated conductors or insulated underground cables. In the case of network constructed using wooden poles and cross--arms, aging of the equipment can lead to arcing and fire between the equipment and the wooden support structure. Vegetation that are in close proximity or in contact with overhead bare conductor can also initiate burning of the vegetation. According the report from Powerline Bushfire Safety Taskforce [1], burning of vegetation such as tree branch and grass only requires less than ten amperes. This type of defects in the system is difficult to detect using conventional protection system due to the small amount of energy being produced by the event. In our work, UHF partial discharge sensing technology is being used to detect the partial discharge, which is also known as partial breakdown of insulation, occurred between the overhead conductor and tree branches. The UHF detector can detect signals of broad bandwidth from few kilohertz to several hundred megahertz, which allows the sensor to detect a variety of discharges travel along the overhead conductor. The UHF feature of the detector eliminates the need for attaching the detector onto the conductor and thus reduces the time and cost in installation. In a pilot project carried in 2015, the proposed UHF partial discharge sensing system successfully detected unique patterns of discharge which led to fires on power pole. The UHF sensing technique detected partial discharge activities several times higher than the normal level several days before a pole top fire took place. Results of the partial discharge pattern will be presented in this paper.

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Concurrent session 12: Wearable sensors

Enabling frontier textile materials for sport and medical sensing applications.

Olga Troynikov

RMIT University, Ausralia

‘Smart textiles’ with their added functionalities are growing in importance in a range of new wearable products. The application market for wearable technologies is segmented into major verticals such as consumer applications, medical, wellness, sport, occupational health and safety, healthcare and enterprise/industrial. However, according to a number of reports, up to 75% of wearable “gadgets” are abandoned both in personal and healthcare use after only one month of purchase/introduction, due to addition of burden to everyday busy lives and working/professional environments. Therefore it is critical to develop integrated wearable platforms and devices which would be able to “disappear” into the garments and textiles already worn on our bodies. Development of tactile, comfortable garments and textile materials where sensors are integrated into a garment or another article of textile/footwear and become “unnoticeable” to the wearer present both a significant opportunity as well as a great challenge.
The current presentation will address a number of aspects of new enabling technologies and textile materials for sport and medical applications. A case study of monitoring of interface pressure generated by sports gloves to the underlying hand tissue, which explores the interface pressure at the dorsal hand side during typical dynamic postures, will be considered.

Mehmet Rasit Yuce

Microfluidic Paper□based Sensors for Environmental Analysis

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Paper-based microfluidic sensors have gained considerable popularity in recent years as a new type of disposable analytical sensing devices which meet the increasing needs of rapid, accurate and low-cost monitoring and analysis for environmental protection and healthcare. They utilize the capabilities of cellulose fibres in paper, which form a hydrophilic porous matrix, to transport liquids by capillary force only.

The present paper describes the development and application of paper-based microfluidic sensors for environmental monitoring of nutrients such as nitrite and nitrate [1], phosphate [2] and ammonia [3]. The hydrophilic liquid penetration channels and detection zones in these sensors were ink-jet printed using a paper-sizing agent. Colour analytical reactions were utilized for analyte detection with the colour intensity being measured by a conventional flatbed scanner. Complex on-line sample pre-treatment steps such as reduction of nitrate to nitrite and membrane-based gas- diffusion separation of ammonia have been successfully implemented for the first time in the proposed paper-based sensors thus further expanding their analytical capabilities. The paper-based sensors, mentioned above, were successfully applied to natural samples and very good agreement with the corresponding reference methods was observed.

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POSTER SESSIONS

Performance analysis of a high gain microstrip array antenna for 5G mobile communication

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In this paper, the design and performance analysis of a cross shaped 4x4 microstrip array antennas for 28 GHz millimetre wave frequency is presented. The proposed array is designed specifically to achieve a high gain, high radiation efficiency and a good matching at the said frequency. The design employs 16 of the total micro-strip patches to obtain the desired cross shaped arrangement. The values for gain and return loss upon simulation were obtained to be as -21 dB and 12.4 dB respectively. The said array has been designed keeping in mind the frequency requirement for 5G mobile communication. The patches are connected to each other by the micro-strip lines, providing the array with the necessary spacing. A co-axial feed is connected to the array to provide the excitation.

Keywords: Millimetre wave; 5G mobile communication; micro-strip antenna; co-axial feed.

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Analyzing the Relationship between Multi Spectral Indices from a Landsat 8 Image in a LiDAR-Derived River Network

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Multi spectral indices like normalized difference vegetation index (NDVI), normalized difference water index (NDWI), and normalized difference turbidity index (NDTI) say a lot about a river especially with regards to vegetation, wetness, and turbidity. Understanding the relationship between these indices as well as their relationship to elevation is very important especially as it can characterize the water and other resources found near the river. This study aims to analyze the multi spectral indices and elevation in a river to see if there is a significant correlation between them. The main line of a river network derived from a LiDAR DEM was first characterized by calculating multi spectral indices from a Landsat 8 image. The NDVI, NDWI, and NDTI were calculated from a Landsat 8 image of the area of the river network. Points were created at 30 meter intervals along the main line of the river including the start and end point. A total of 1,535 points were created and the NDVI, NDWI, and NDTI were calculated at each point. From the start point (mouth of the river) to the end point (upland area near head waters), a profile for each multi spectral index as well as the DEM for all points was created. Pearson's r and r-squared for the relationships between the multi spectral indices (NDVI-NDWI, NDVI-NDTI, and NDWI-NDTI) as well as the relationship between each index and the DEM were computed to quantify the relationship. After the computation of Pearson's r, it was found that for the main line of the river, the weakest relationship was between NDTI and DEM as it had a low to moderate positive correlation ($r = 0.4129$) while the strongest relationship was between NDVI and NDWI which had a strong negative correlation ($r = -0.9762$). A t-test was also done to check the significance of all correlations. For 1,535 data points, it was found that all correlations were significant at $p < 0.01$. This implies that regression analysis and a model for prediction of the NDVI, NDWI, and NDTI can be done. Further testing can be done to see if the same significant correlations exist in other streams or rivers.

Android voltammetry: a simple but powerful smartphone-based biosensing platform

Conor Hogan, Darrell Elton, Seng Loke

Chemistry and Physics School of Molecular Sciences

The development of simple, inexpensive (yet quantitative) sensors for food/beverage, environmental, wellbeing and medical sensing applications is an extremely important emerging area because it has the potential make chemical and biochemical analysis, usually confined to the lab, widely available. We believe that allowing people to easily and frequently measure levels of molecules in themselves or their environment could be transformational, particularly in remote areas or in the developing world where levels of health expenditure are minute compared with developed countries.

Technology Description

Voltammetry is among the most important approaches to electrochemical biosensing, with many thousands of methods available for countless different analytes. Voltammetry requires an instrument called a potentiostat, which modulates the applied voltage whilst simultaneously measuring the resultant current, the magnitude of which is an indicator of concentration. In essence, we have devised a means of utilising the audio features of a mobile phone (the audio output and the microphone) to carry out voltammetry; no potentiostat required; in fact no other hardware at all. Thus, using only a cheap disposable sensor strip and a phone we can replicate what is usually done using expensive laboratory equipment, and perform “instrument free” analysis.

We have developed a simple mobile phone based biosensing platform (initially using Android phones) which brings the cost of sensing close to $0. This is achieved in two ways: 1.) By developing sensors based on cheap readily available materials (such as paper), which can be mass produced without recourse to expensive fabrication facilities and 2.) By removing the requirement for an “instrument” and using the built-in capabilities of modern mobile phones to facilitate detection.

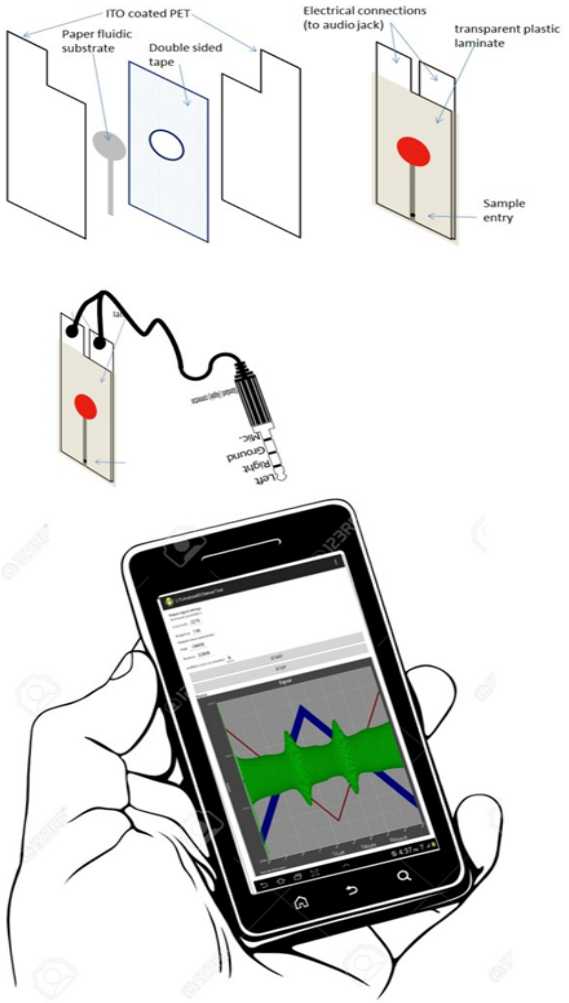

Figure 1. Paper micro-fluidic sensor strips + mobile phone detection = very low cost sensing.

Key benefits

- As the data and associated metadata can be readily shared, this opens up a range of exciting possibilities for eHealth, telemedicine and “crowd sourced sensing”

- Mobile phone companies are showing high interest in having and implementing capabilities to detect chemicals in people or the environment

- Ability to make chemical measurements with a mobile device that 90% of the people on the planet already have in their pocket

Applications

- Determination of food / water contaminants such as toxic metals (lead cadmium, zinc, copper), pesticides (e.g. methylparathion) and other chemical residue screening.

- Detection of chemical in humans; quantification of metals (e.g. lead in blood), proteins (immuno-detection of disease biomarkers) and DNA.

Having clearly established the viability of this technology by demonstrating the sensitive detection of simple electrochemical probes, we are now poised to develop the capability of this technology further and extend it to the detection of a wide variety of compounds.

La Trobe University is seeking a commercial partner to accelerate and further develop this technology into a consumer ready product that will positively impact the eHealth, environmental and food industries.

Nanoscale imaging of solid state bio-markers for sensing applications

Denitza Denkova [1,2*], Martin Ploschner [1,2], Lindsay Parker [1,2], Alfonso Garcia-Bennett [1,2], Yiqing Lu [1,2], Nicolle Packer [1,2] and James A. Piper [1,2]

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[2]ARC Centre of Excellence for Nanoscale BioPhotonics (CNBP).
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Novel classes of solid state biological markers, such as upconversion nanoparticles (UCNPs)[1], nanoruby, nanodiamond, have been extensively explored last years for various bio-labelling and bio-sensing applications[2], including single particle and molecule sensing, local temperature sensing, local magnetic field sensing, etc. These particles offer the immense advantage of being photo-stable over long time periods. Thus, they have the potential to allow targeting, quantifying, tracking and visualizing individual nanostructures in cells over a long time period.

Therefore, it is crucial to develop and apply techniques able to visualize and analyze individual nanoparticles in biological environment. This is a challenging task, as the long-lifetime nanoparticles typically have low emission efficiency and are difficult to image on an individual level. We suggest different approaches to access this information with resolution and sensitivity down to single nanoparticles. We are exploring the possibility to optically observe nanoparticles with sub-diffraction resolution. A co-localized optical and atomic force microscopy platform provides access to additional structural and chemical information. Initial experiments suggest that both techniques allow accessing single nanoparticles and obtaining information about their bio-conjugation and behavior in biological environment with resolution down to 100 nm. The successful implementation of these methods is a crucial step towards future applications of solid state nanoparticles as sensing bio-markers.

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CASE WESTERN RESERVE UNIVERSITY EST. 1826

Opportunity Summary

Novel Cystic Fibrosis Sweat Tester for Definitive Diagnosis in Newborns

Rapid, low-cost, easy-to-use, mobile point-of-care device for diagnosing Cystic Fibrosis that requires only two microliters of sweat which can be obtained from two-week-old infants.

In Brief:

Novel, low-cost, handheld POCD that requires only 2 microliters of sweat for definitive diagnosis of cystic fibrosis. Provides rapid, low-cost, easy-to-use, portable and absolute diagnosis that requires no special training or expertise to operate.

Commercial Readiness:

Working prototype successfully tested

Intellectual Property:

International patent application PCT/US2016/056219 filed on October 10, 2015.

Commercialization Path:

Available for licensing and/or start-up development.

Inventors:

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Background

Sweat chloride is the gold standard biomarker for cystic fibrosis (CF). We invented and developed a technology that can translate the clinical laboratory sweat test to a point-of-care test with a handheld, easy-to-use sweat chloride diagnostic device that requires only 2 µL of sweat. Besides diagnosing CF our technology can also be used for monitoring the status of the disease in patients when they undergo treatments that partially restore the function of CFTR channels.

First Market Application

Rapid, low-cost, point-of-care CF diagnosis in low-resource settings.

Overview

Our POC diagnostic device is extremely accurate because the measurement is absolute. There is no need for unit calibration prior to any test and there is no special training or expertise required to operate it. The importance of early diagnosis and treatment cannot be overly stressed; numerous studies have shown that if treatment begins after the presentation of symptoms (typically 3 months), irreversible damage to the infant has already occurred. This leads to increased morbidity and a negative impact on the quality of future life. Specifically, early diagnosis enables treatment to reduce the frequency and severity of pulmonary, gastrointestinal, and improve life expectancy. The high prevalence of CF has led to the adoption/mandate of newborn screening across the US, however definitive diagnosis using sweat chloride as the biomarker is still problematic. With our device, presence of CF can be diagnosed as early as two weeks after birth as well as used for on-going monitoring once diagnosed. Initial diagnosis can be obtained 3-4 days after birth and if any abnormalities occur, the newborns can be additionally tested with our device a week after the first test.

Key Features

- Handheld main unit
- Disposable sampler – analyzer unit
- Absolute and therefore calibration free measurement
- Minimal required training
- Results available in a few minutes
- Automatic from sampling to display and web upload of result
- Two microliters of sweat sufficient
- Accuracy in the order of +/-2 mM over the entire concentration range

Patient	Clinical value	Measured value	difference
A	27mM	25.7mM	1.3mM
B	21mM	20.6mM	0.4mM
C	12mM	13.9mM	1.9mM
D	10mM	9.4mM	0.6mM

MODIS-based atmospheric method for nearshore shallow water bathymetry

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The use of multispectral remote sensing has been established for many shallow water applications where information about water optical properties and bottom features are needed. With the advent of new sensors, applications that require bathymetry information can also now benefit from improved depth and accuracy made possible from the introduction of additional sensor bands. Despite this advantage, obtaining accurate information about water depths still relies heavily on a well proven atmospheric correction algorithm as water-leaving radiance is very difficult to determine accurately from the top of atmosphere signal. We develop a MODIS-based correction procedure and apply it to a WorldView-2 image. We then use a semi analytical approach to obtain water depth and compare depth estimates with actual depth data from the field. Our result show that bathymetry estimates can be improved substantially with radiative transfer-based atmospheric correction methods.

Enhanced Wastewater Treatment and Higher Biomass Production using Liquid Cattle Waste by Native Isolate KMC-2 Microalga Strain

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Considering the sustainability of global energy needs there is lot of attention being directed towards the development and utilization of alternative energy resources. Among several, microalgae biofuel production has received global recognition [1,2]. But requirement of high volume water and nutrients has been the key challenge towards commercialization of this process. Recently several studies have been attempted towards utilization of various wastewater sources towards microalgae biofuel feedstock production. Present study is focused on campus Sewage Treatment Plant Wastewater (STPW) with Liquid Cattle Waste (LCW) using native isolate KMC-2 microalga strain. This KMC-2 strain was found to be one of promising strain for wastewater treatment process which was isolated from Indian Institute of Technology Guwahati (IITG) sewage treatment plant. To study the nutrient removal efficiency, initially KMC-2 has been grown in STPW and has removed 70% nitrogen and 74 % phosphate along with biomass yield of 1.23 g/L. Further to enhance nutrient removal efficiency different concentrations of LCW were added and optimized. Result suggest only 5% LCW concentration was enough to achieve 88% nitrogen and 92% phosphate removal. This also led to high biomass yield of 1.8 g/L. To conduct biofuel feasibility study extracted lipid were transesterified to fatty acid methyl ester (FAME). Gas chromatography report of FAME suggests presence C:16 and C:18 at higher fractions which justify the oil are feasible towards biofuel production [1,2].

Keywords: Wastewater treatment, Microalgae, Biomass, Biofuel

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Two-dimensional SnS2 nanoflakes for highly sensitive and selective gas-sensing

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Owing to large surface to volume ratios and high surface affinities, two dimensional (2D) materials are particularly conducive to gas-sensing applications. Typically, the gas-sensing mechanism of layered 2D materials is by the charge transfer process [1], [2].

One such 2D material is tin disulfide (SnS2). The favourable temperature - dependent electronic band structure and high polarizability provides a prospect to optimize the sensing response. Thus, desirable enhanced recovery kinetics at moderate temperatures ideal for gas-sensing applications may be achieved [3].

In this work, we show the high selectivity and sensitivity of SnS2 to the paramagnetic nitrogen dioxide (NO2) gas at slightly elevated temperatures. The response at 120^{o}C showed optimal sensitivity with great response and recovery dynamics. Other gases tested for cross sensitivity were oxygen (O2), hydrogen sulphide (H2S), ammonia (NH3) and carbon dioxide (CO2).

The SnS2 is incorporated onto a resonant antenna circuit substrate manufactured using a low temperature co-fired ceramic (LTCC) technique [4]. This results in a passive wireless inductor-capacitor (LC) gas sensor. Physical adsorption of gas molecules onto the SnS2 surface result in a consequent change in capacitance and resistance of the sensor. These response trends were observed in this work.

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Nitric oxide micro concentrations detection with ZnO thick films

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The nitric oxide is one of the most important biological mediators. One of express and reliable noninvasive diagnostics methods can be based on defining of NO in the exhaled air. This fact enables to perform quick diagnostics and monitor development of bronchial asthma [1]. The comparative sensitivity of sensors, developed on the basis of ZnO, WO_3 and doped SnO_2 have been investigated to detect NO microconcentrations. The dimensions of sensitive element were 2 x 0.5 x 0.2 mm. The sensitive films were deposited by thick-film technology. The investigations were carried out under the sensor thermal stabilization conditions in the range 50 - 450 ^{o}C. Developed sensors showed the best sensitivity to NO at temperature equal 150 ^{o}C. A temperature impulse mode effect on a sensitive layer was used for the model gas mixtures and breath analysis. Sensors based on ZnO had high repeatability of gas sensitivity and resistance's stability. Sensors showed high sensitivity to NO at 10 ppb level in air, response time of sensors does not exceed 10 seconds. The influence of other gases present in exhaled air at 150 ^{o}C is minimal and can be estimated when the signals of sensors are mathematically processed.

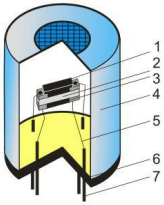

Fig. 1. The construction of a sensor:1-gas sensitive film; 2 – substrate; 3 – heater;4 - metal porous casing; 5 - platinum wire;6 - glass frame; 7 – leads.

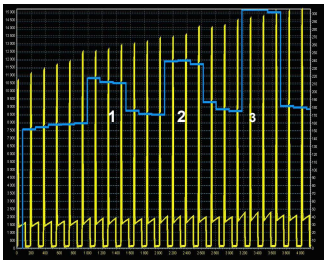

Fig. 2. An example of the measurements - window of the program (ZnO; working temperature – 150 ^{0}C): 1-10 ppb NO, 2 – 25 ppb NO, 3 – 50 ppb NO. Yellow line – measured resistance;blue line – calculated results

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Nanostructured modified thin films for microhumidity measurements

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Nanostructured silica films, activated with different additives at appropriate conditions can get specified sensor properties [1]. The method of hydrolytic polycondensation of tetraethyl orthosilicate solutions was used for forming films. It allows obtaining films activated by different hygroscopic salts, which can used as sensitive layers for microhumidity sensors. The active area of the sensor with interdigital structure of metal electrodes was 4 x 4 mm. The conductivity changes and adsorption properties were tested. The films had thickness of 0,2 - 0,3 μm and micro globular structure with dimension of 2-4 nm. Solution composition and technological conditions were chosen to reach highest possible micro pores content. A calculated specific surface area was 400 - 450 m^2/g for different specimens. Content of LiCl, P_2O_5 and $CaCl_2$ in SiO_x films results in increase adsorption ability for investigated films. And vice versa films with content of NaCl and KCl have lower adsorption activity than undoped SiO_x films. It is important to control or stabilize the environment temperature of the sensor's surface at measurements. The microhumidity sensor may be realized as "sandwich type" sensor with active area of 200 x 200 μm or as crystal with sensors great number.

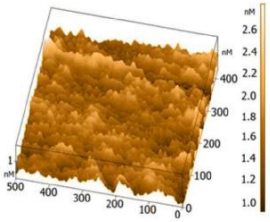

Fig. 1. SEM image of hybrid film's surface morphology.

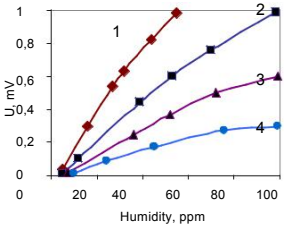

Fig. 2. The sensitivity dependence on humidity content in toluene for activated SiO_x films:
1- P_2O_5 (10% mass.); 2 - P_2O_5 (5% mass.);
3 - Li_2O (5% mass.); 4 - P_2O_5 (1% mass).

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Two-Electron, Two-Proton Oxidation of Catechol: Kinetics and Apparent Catalysis Sensing

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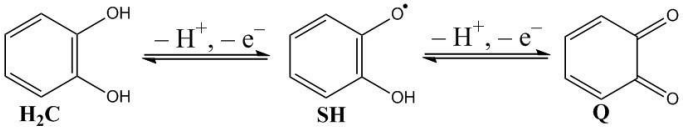
The study of proton-coupled electron transfer reactions is of great current interest.[1] In this work,[2] a pH sensor is developed based on the catechol redox process, which was studied voltammetrically in the pH range from 1.0 to 14.0 using a glassy carbon electrode. Analysis of the peak potentials and currents together with Tafel analysis allowed the inference of the likely transition states and electrode reaction mechanism within the 'scheme of square'.[3] Modification of the glassy carbon electrode surface with sparse coverages of alumina particles[4-5] was shown to lead to strong apparent catalysis of the catechol redox process at low pH. A possible mechanism for this is proposed.



Scheme 1. Two one-electron transfers of catechol (H_2C) along with the oxidation products, *o*-benzoquinone (Q) and the semiquinone species (SH).

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Magnetic particle tracking with diamond

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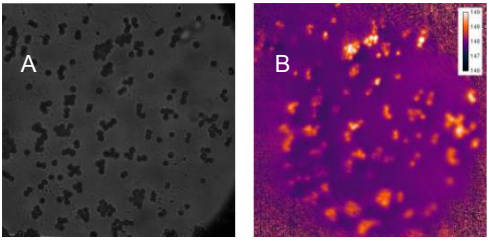
Magnetic particles are currently seeing applications in a wide range of biological environments. The ability to non-invasively image the location and field strength of these particles within cells would be highly desirable. We have developed a quantum diamond-based magnetic imaging device to track these particles by their magnetic field, opening up the possibilities of imaging cell dynamics without the limitations of fluorescence-based techniques.

The diamond-based sensing chip exploits the quantum properties of nitrogen-vacancy (NV) centres. NV centres fluoresce red, and the rate of fluorescence indicates the NV centre spin state. By manipulating the NV centres with microwave pulses, then detecting the change in the spin state, properties such as magnetic field strength and local temperature can be extracted. In order to map such effects in 2D, we engineered a layer of near-surface NV centres into a single-crystal diamond and imaged the diamond's fluorescence with a wide-field microscope coupled to an sCMOS imaging detector.



Bright field image (A) and magnetic field image (B) of commercially-available magnetic particles, scale in Gauss

Our imaging capabilities comprise a magnetic field spatial resolution of 440 nm and a magnetic sensitivity of ~1.5 μT/√(Hz). Micron-sized magnetic signals are detectable up to a few tens of microns above the diamond sensor.

Magnetic particle imaging affords the opportunity of cell tracking without exposing the sample to phototoxicity damage, as well as other cell techniques such as tractometry.

Comparison of Different SVM Classification Techniques: An Application of Agricultural Resources Extraction in Victorias City, Negros Occidental

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With the large dataset that researchers encounter to solve various real world problems, machine learning methods (e.g., SVM) will really have a difficulty in dealing with the corresponding large number of input features for use in image classification. Not all features or attributes can be very helpful in image classification for all data. Inclusion of features that are irrelevant and redundant in the classification process may cripple the predictive accuracy of the model and may slow down the processing time. This paper aims to show that feature selection improves the training time, application time and accuracy of the project, compare the classification results of SVM with and without the use of feature selection in terms of training time and application time, as well as compare the different feature selection methods in Weka. By performing the experiments, it was found that the selection of attributes is critically important because through this process, the problem is meaningfully and successfully modeled. Moreover, with the help of feature selection, training time and processing time are lessened, and accuracy is improved thus, getting the most out of the data that is available.

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