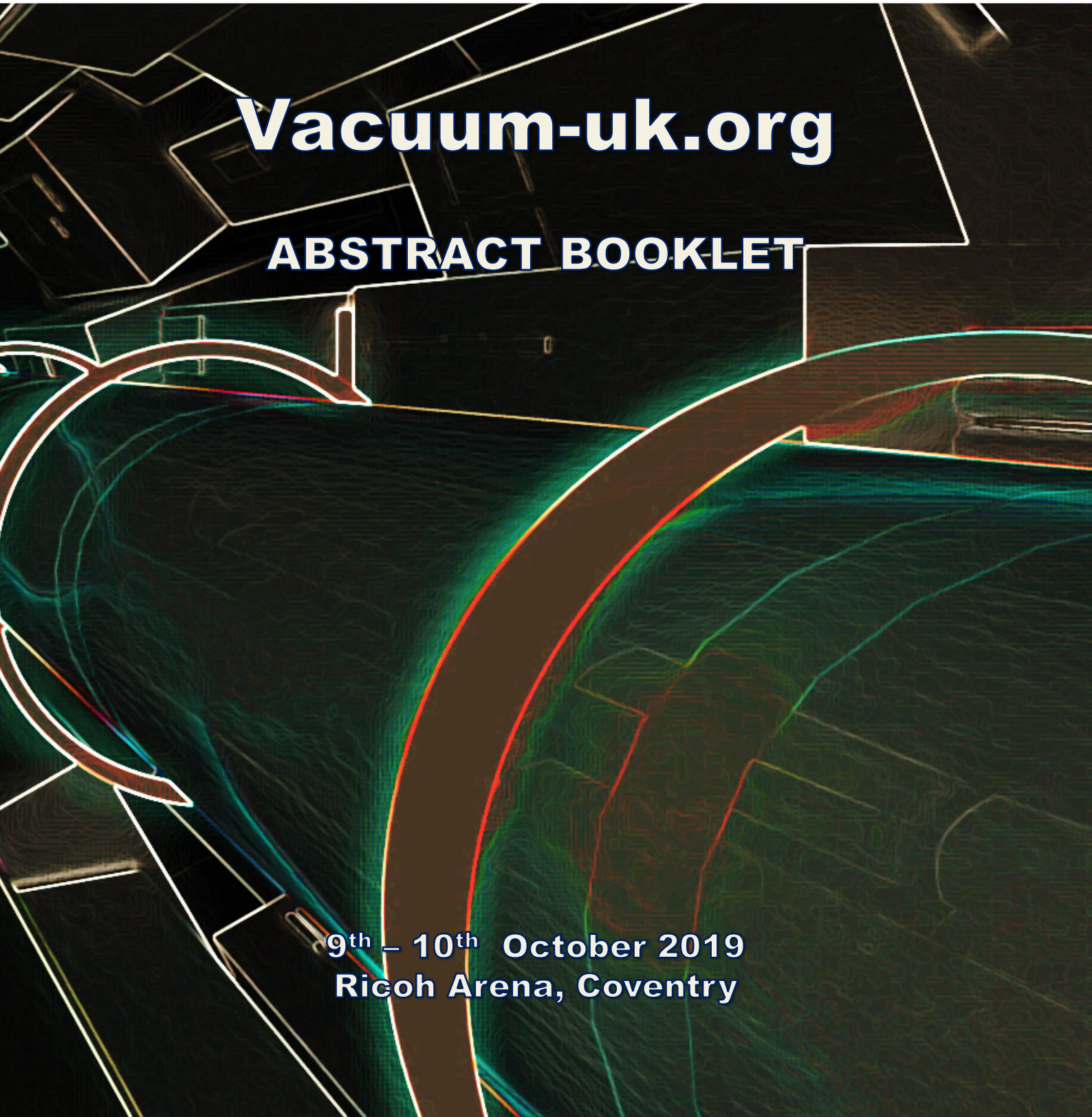
10TH VACUUM SYMPOSIUM UK

CELEBRATING 10 YEARS

# VACUUM SYMPOSIUM

a forum for scientists, academics, technicians and industrial users



# Vacuum-uk.org

## ABSTRACT BOOKLET

9th – 10th October 2019

Ricoh Arena, Coventry

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# Chairman's Report 2019

This is a special year for Vacuum Symposium as we hold VS10, our 10th anniversary.

Reflecting back over the last 10 years to where it all started, the RGA User Group I find it amazing to see what has been achieved today.

Over the last 10 years Vacuum Symposium has grown in size each year and has become a leading technical and training conference.

Vacuum Symposium UK has maintained its independence and we continue to welcome support from the IOP, BVC and our Industrial sponsors.

Special thanks also go to Xmark Media for provision of conference facilities and their ongoing efforts to share and support Vacuum Symposium meetings.

Over the last 10 years the aim of Vacuum Symposium UK has been exactly the same model as the RGA User Group Meetings, but embraces a wider cross-section of vacuum users: regular 'free to attend' meetings that allow interaction between academics, industrial users and manufacturers.

Vacuum Symposium provides a series of technical meetings, poster sessions and vacuum training.

We continue to grow our technical meetings through the support of Meeting Organisers who provide a full day of oral presentations that cover various topics/applications and are delivered by leading scientists, invited speakers and users with practical and extensive knowledge.

Our training courses are well attended; the courses are given by trainers chosen by the Vacuum Symposium Committee with attendees receiving a certificate of attendance and a copy of the training slides.

The poster session has grown alongside our technical meetings, and a Vacuum Poster Prize is awarded each day and is open to all attendees and exhibitors.

This year we are proud to be presenting the 5th Harry Leck Memorial Medal and I would like to congratulate Dr Alan Webb as this year's winner.

It gives me great pleasure to welcome you all to VS 10 and to encourage you to visit the exhibition hall. I would like to thank all our continued and new sponsors and supporters of Vacuum Symposium.

This year I have a special thank you to the members of the Vacuum Symposium Committee, their hard work and support over the last 10 years has resulted in the success of Vacuum Symposium. I take great pleasure in working with them and seeing our shared vision going from strength to strength.

Robin Hathaway

Vacuum Symposium Chairman

# Vacuum Through the Years

## Lounge South

Wednesday 9th October 2019

### Meeting Agenda

0900 – 1025 Registration opens in the atrium
1025 – 1030 Welcome
*Dr Sunil Patel, ISIS Vacuum Group, STFC Rutherford Laboratory*
1030 – 1100 History of dry pump applications in semiconductor processing
*Mike Thompson Edwards Vacuum, UK*
1100 – 1130 1957-2019, 60+ Years of Ion Pumps from invention to latest developments
*Mauro Audi, Agilent Technologies*
1130 – 1200 Non Evaporable Getter pumps: evolution and experience of more than 40 years
*Enrico Maccallini, SAES Getters S.p.A., Italy*
1200 – 1300 Lunch, Exhibition & Poster session
1300 – 1330 Break – delegates are encouraged to visit the exhibition
1330 – 1400 Poster session in the exhibition hall
1400 – 1430 Dry versus wet pumps – Different dry pump principles
*Paul Davies / Kris Haran , Pfeiffer Vacuum, UK*
1430 – 1500 A history of vacuum measurement and other curiosities
*Jonty Bray, MKS Instruments, UK*
1500 – 1630 Close of meeting and poster session in the exhibition hall
1630 – 1700 Poster prize will be awarded for the best poster
1700 Exhibition open until 1700

# Thin Films and Coating Technologies for Science & Industry

## Theatre 2 - Ericsson Exhibition Hall

Wednesday 9th October 2019

### Meeting Agenda

0900 – 1000 Registration opens in the atrium
1000 – 1010 Welcome and opening remarks
*Dr Mark Baker, Reader in Surface Science and Engineering, University of Surrey*
1010 – 1040 Keynote Speaker: Exploring the functional magnetic properties of high entropy alloy thin films via sputtering
*Professor Nicola Morley, University of Sheffield, UK*
1040 – 1105 The numerical simulation of a cathode spot motion and formation of ion flow parameters of an arc discharge
*Professor Ihar Ivanou, Belarusian National Technical University, Belarus*
1105 – 1115 Exhibitor Presentation
1115 – 1140 Refreshment Break
1140 – 1205 Advances in CdTe Thin Film Photovoltaics enabled by MOCVD
*Dr Giray Kartopu, University of Swansea, UK*
1205 – 1230 Advanced photocatalytic thin films for hydrogen production via water splitting
*Dr Glen West, Manchester Metropolitan University, UK*
1230 – 1300 Lunch, Exhibition and Poster Session
1300 – 1330 Break – Delegates are encourage to visit the exhibition
1330 – 1400 Poster Session in the exhibition hall
1400 – 1430 Keynote Speaker: In-line patterned vacuum R2R coated layers for flexible electronics
*Professor Hazel Assender, Oxford Materials, University of Oxford, UK*

1430 – 1455 Oblique angle deposition of AZO
*Beaujolais Bussell, University of Surrey, UK*
1455 – 1505 Exhibitor Presentation
1505 – 1530 Micro LED Thin Film Coatings and Where to Find Them
*John Whiteman, Plessey Semiconductors Ltd., UK*
1530 – 1555 Oxide thin-film devices for displays and low power electronics
*Professor Aimin Song, University of Manchester, UK*
1555 – 1600 Concluding comments Dr Mark Bake
1600 – 1630 Close of meeting and POSTER SESSION in the exhibition hall
*A poster prize will be awarded for the best poster*
1630 – 1700 The exhibition remains open until 1700

# 17th Technology Plasma Workshop

Lounge North

Wednesday 9th October 2019

## Meeting Agenda

Please refer to TPW Abstract Booklet for Agenda

# Structure and Dynamics of Surfaces and Interfaces

Lounge South

Thursday 10th October 2019

## Meeting Agenda

0900 – 0950 Registration opens in the atrium

0950 – 1000 Opening and Prize Presentation

1000 – 1025 BVC 60th anniversary presentation from 2019 IUVSTA Prize for Science winner
Determining Surface Structure: Why and How?
*Phil Woodruff, University of Warwick*

1025 – 1050 Electronic Structure and Charge Density-Wave States in Single-Layer Transition-Metal Dichalcogenides
*Phil King, University of St Andrews*

1050 – 1110 Tea/Coffee

1110 – 1135 Hot electrons: a new source of light on the nanoscale
*Kristina Rusimova, University of Bath*

1135 – 1200 Chiral nanoplasmonic systems
*Malcolm Kadodwala, Univeristy of Glasgow*

1200 – 1400 Lunch Break | Poster Session | Exhibition Session
*A poster prize will be awarded at 13:30 for the best poster*

1400 – 1425 X-ray Photoelectron Spectroscopy: Beyond the Surface
*Anna Regoutz, University College London*

1425 – 1450 On-surface covalent-coupling reactions: molecular, sub-molecular, and atomic scale characterisation
*Alex Saywell, University of Nottingham*

1450 – 1500 Close of meeting

1500 – 1600 Exhibition open until 1600

# Surface Analysis – The Changing Composition at the Surface

Theatre 1, Main Hall

Thursday 10th October 2019

## Meeting Agenda

1055 – 1100 Welcome and Introduction: Mark Baker

1100 – 1120 SIMS isn't just for silicon
*Dr David Sykes, Loughborough Surface Analysis Ltd, UK*

1120 – 1140 Hard X-ray Photoelectron Spectroscopy: depth profiling from the surface into the bulk
*Dr Ben Spencer, University of Manchester, UK*

1140 – 1200 Unravel the structure of buried soft interfaces
*Dr Wuge Briscoe, University of Bristol, UK*

1200 – 1220 Application of hard X-ray photoelectron spectroscopy in semiconductor materials characterisation
*Professor Greg Hughes, Dublin City University, Ireland*

1220 – 1400 Poster Session, Exhibition and Lunch Break
*A poster prize will be awarded at 13:30 for the best poster.*

1400 – 1430 KEYNOTE: Chemical reactions, corrosion and electrochemistry at solid-liquid interfaces – routine operando studies with Near Ambient Pressure XPS
*Dr Andreas Thissen, SPECS Surface Nano Analysis GmbH, Germany*

1430 – 1450 Advanced Surface and Interface Analysis to enable Next Generation Additive Manufacturing
*Dr Gustavo Trindade, University of Nottingham, UK*

1450 – 1510 Surface phase analysis using XPS
*Dr Robert Palgrave, University College London, UK*

1510 – 1530 Applications of photoemission – from catalysis to biomaterials
*Dr David Payne, Imperial College London, UK*

1530 Close of Meeting

1600 The exhibition remains open until 1600

# 17th Technology Plasma Workshop

Lounge North

Thursday 10th October 2019

**Meeting Agenda**

Please refer to TPW Abstract Booklet for Agenda

# Harry Leck Memorial Medal

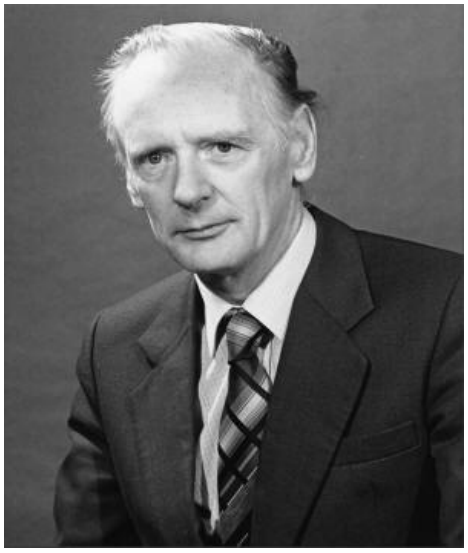
Each year the organising committee of Vacuum Symposium UK seeks nominations for the Harry Leck Memorial Medal. The Medal is awarded for distinguished contributions to British scientific research and/or related scientific/technical communities, in the field of Vacuum Science and Technology.

The medal has been established to honour the memory of **Professor John Henry Leck**, known to his friends as 'Harry'.

The medal will be awarded in the Exhibition Hall at 4:30pm on Wednesday 9th October 2019 at VS10.

Harry epitomised the ideals of Vacuum Symposium. His warm, friendly personality made vacuum accessible for everyone he met. We all gained knowledge and understanding from Harry at just the right level with him instinctively knowing the individual or audience he was addressing.

This great, understated person reveals his background in an interesting interview (recorded 1991) that can be found on the AVS Science and Technology website providing a wonderful insight into the humour and knowledge of the man.

# Dr Alan Webb Announced as 2019 Winner of Harry Leck Memorial Medal

The winner of the 2019 Harry Leck Memorial Medal is Dr Alan Webb, Consultant. Presentation of the Medal will be made in the Exhibition Hall at 4:30pm on Wednesday 9th October 2019.

Having started, and ended, his career in academia, in between Alan spent nearly 30 years in industry at Caswell involved in high technology process improvement under vacuum conditions. Alan developed a wealth of knowledge, and built a reputation as the "goto" person for resolution of the challenges faced in the area of plasmas. This significant contribution and understanding of business in plasma chemistry, plasma physics and thin films, cuts across the boundaries and marks out Dr Alan Webb as a worthy winner of the Harry Leck Memorial Medal.

In 1971, Alan was awarded a B.Sc. in physics from the University of East Anglia. He then went on to gain a D.Phil from the University of Sussex studying refractive index changes produced in silica by ion implantation. Research positions followed at the Universities of Zurich, Strathclyde and Glasgow before being appointed as a Senior Principal Scientist at Plessey Research, Caswell in 1984.

Throughout the many changes of ownership at the Allen Clark Research Centre, Caswell – Plessey, GEC Marconi, GEC Marconi Materials Technology, Marconi Optical Components, Bookham, Oclaro – Alan was promoted to Optoelectronics Process Manager, reporting to the Production Manager.

After retiring from Oclaro in 2011 Alan joined the Open University for 2 x 2 years tenure. Nowadays he is a Consultant and still finds time for active involvement with the Institute of Physics and British Vacuum Council.

Elected as a Fellow of the Institute of Physics in 1995, Alan is currently a member of both IPSI and Vacuum Groups. In the same year he was a pivotal member of the initial organising group that initiated the 1st Plasma Ion and Surface Engineering (PISE-UK) Committee in the UK. It transformed from the PISE international workshops into the national Technological Plasma Workshop (TPW) that now meet at Vacuum Symposium. Alan was Chairman of the British Vacuum Council from 2008 to 2010, and continues to be co-opted on the committee where his continuity and experience are a valuable asset.

# POSTER SESSION

Wednesday 9th & Thursday 10th October 2019

Poster sessions will take place on both days of VS10. Everyone attending this year's event is invited to present a poster which may be on work related to any of this year's meeting topics or any aspect of vacuum in general.

This year the Vacuum Symposium Poster Prizes (£100 and certificate on both days) will be sponsored by the IOP Vacuum Group and the VS Platinum Sponsor, Leybold Ltd.

Posters will be judged on the basis of scientific content, effectiveness of communication and overall appearance.

Poster prizes will be awarded in the main exhibition area at the following times:

Day 1 – 4.30pm

Day 2 – 1.30pm

# Training Courses

Wednesday 9th & Thursday 10th October 2019

*VTC 1,2,3 & 6 - Jimmy Hill Coventry (time on tickets)*

*VTC 4, 5 & 7 – Jimmy Hill City (time on tickets)*

The purpose of these courses is to present this basic knowledge in a straightforward and accessible way. The principles and practice that are involved in creating and measuring a vacuum will be dealt with and illustrated by worked examples from various applications. Ultra-high vacuum, important in many applications, will be discussed only briefly in courses VTC1 and VTC2, however they will serve as a good introduction to the course "Ultra High Vacuum" VTC3 which addresses the matter of UHV in more detail. These courses are aimed at newcomers to the field, those who wish to refresh their knowledge, and those who wish to go further into UHV practicalities. They will be appropriate for new graduate students in physics, chemistry and engineering for whom vacuum techniques will be a working tool. After attending any of these courses, participants should be able to analyse the behavior of their own vacuum systems with increased understanding, and have the basis for evaluating the effectiveness of proposed designs. There are four specialist application courses: VTC4 on "Leak Detection", VTC5 on "The Design and Fabrication of Vacuum Chambers", VTC6 on Introduction to Residual Gas Analysis (RGA) and VTC7 on "Vacuum Pump Training for Reliable Application Operation, and Maintenance". Places on each course are very limited, so you are encouraged to register early.

The material is presented in an informal/tutorial style with an effort to address participants' needs. A copy of the training slides and a Certificate of Attendance will be provided.

# Vacuum Through the Years

Lounge South
Wednesday 9th October 2019

**Meeting Agenda**

0900 – 1025 Registration opens in the atrium
1025 – 1030 Welcome
1030 – 1200 Session 1
1200 – 1400 Lunch Break | Poster Session | Exhibition Session
1400 – 1500 Session 2
1500 – 1630 Close of meeting & poster prize awarded
1630 – 1700 Exhibition hall remains open until 1700

This meeting will encompass all aspects of vacuum progress over the years with a focus on major milestones.

Leading scientists and industry experts will plot the path to modern realisation of ideas into products and techniques, and look to future developments.

# History of dry pump applications in semiconductor processing

Mike Thompson
*Edwards Vacuum, UK*

Over 30 years ago semiconductor manufacturers first began the transition from oil-sealed rotary vane pumps to dry pumps, and within a short space of time the dry pump had become the technology of choice for such applications. Since that period, waves of dry pump development have taken place in order to meet the relentless increases in applications challenges driven by the pace of development in the semiconductor industry. This talk explores the history of dry pump developments needed to meet those challenges and the challenges to come.

# 1957–2019, 60+ Years of Ion Pumps from invention to latest developments

Mauro Audi
*Agilent Technologies*

Since their invention in 1957 at Varian Associates as a pumping device for electron tubes at relatively high pressures, Ion Pumps have continuously moved towards lower pressures, and nowadays they are the pumps of choice for most UHV applications in both research and industrial field

This includes a large variety of High and Ultra High Vacuum systems, from Particle Accelerators to Synchrotron Light Sources and Gravitational Wave Detectors, as well as Scanning Electron Microscopes, Surface Analysis and Medical Equipment

Application requirements have changed dramatically in these 60+ years in terms of starting and operating pressures, pumping performances, precision in reading pressure, cleanliness, particle emission, safety, resistance to radiation.

The latest developments on Ion Pump Technology are presented, including:
- a new combination of magnetic field and cell dimensions to realize the first ion pump with a maximum pumping speed in the low pressure range
- a new vacuum firing process to minimize the outgassing and reduce particles
- an anode design that minimizes the field emission and leakage current, with an additional shields that minimize charged particle emissions
-new controller design that allows starting Ion Pumps with very limited power and with the ability to adjust the voltage supplied to the ion pump in order to optimize both the pumping performances and the pressure reading
- a combination of ion pumps with NEG pumps in order to reach the lowest ultimate pressure

# Non Evaporable Getter pumps: evolution and experience of more than 40 years

Enrico Maccallini, Dario Nicolosi, Andrea Cadoppi, Paolo Manini, Marco Urbano, Michele Mura, Tommaso Porcelli, Alessandro Ferrara, Fabrizio Siviero
*SAES GETTERS S.p.A., Viale Italia 77, 20020, Lainate (Mi)-Italy*

Non Evaporable Getter (NEG) pumps have been developed in the 70's and since then they have been adopted by the industry, R&D labs, research centres and in large physics projects like accelerators, synchrotrons or fusion reactors. NEG pumps are very compact and vibration-free, able to deliver very high pumping with minimal power requirement. Their capability to pump very effectively hydrogen, the main residual gas in UHV-XHV systems, makes them the ideal choice to achieve and maintain low pressure conditions in a variety of experimental chambers or industrial devices. In the last years, the new ZAO® alloy has been developed, thanks to which the benefits of NEG pumping can now be extended to the high vacuum pressure range, i.e. up to 1e-8 Torr. The basic chemical and physical principle of operation of getter pumps, as well as their main practical features, will be reported with a special focus on their typical applications in accelerators, surface science, portable systems and other laboratory equipment. An overview of the NEG technology evolution from compressed to sintered materials will be also given.

Distributed NEG pumping solutions will be also presented.

# Dry verses wet pumps – Different dry pump principles

Paul Davies / Kris Haran
*Pfeiffer Vacuum, UK*

An overview of Dry pump principles, reviewing the advantages & disadvantages of Dry pump verses Wet pump technology.

# A History of Vacuum Measurement (And Other Curiosities)

Jonty Bray
*MKS Instruments, UK*

A brief walk through the interesting development of vacuum gauges from past to present.

This non-technical talk will examine the technologies, characters and industrial drivers that have led to the instrumentation we commonly use today.

# Thin Films and Coating Technologies

Theatre 2 - Ericsson Exhibition Hall

Wednesday 9th October 2019

**Meeting Agenda**

| | |
|---|---|
| 1000 – 1010 | Welcome and Introduction |
| 1010 - 1230 | Session 1 |
| 1230 – 1330 | Lunch |
| 1330 – 1400 | Poster session in exhibition hall |
| 1400 – 1600 | Session 2 |
| 1600 – 1630 | Close of meeting & Poster session |
| 1630 – 1700 | Poster prize will be awarded |
| 1700 | Exhibition hall closes |

Thin films are used in just about every aspect of our lives, from the optical anti--scratch/anti-reflection lens on our spectacles to those out of sight coating applications in electronics, optical, photovoltaic and other high technology industries.

This one-day meeting will bring together scientists and technologists with expertise in the design, development, characterisation and production of thin film materials and integrated devices for a broad spectrum of scientific and industrial applications. The aim being to share knowledge, ideas and experiences.

The meeting comprises a programme of invited speakers and a poster session (which will be combined with other meetings for added interest). The programme will allow time for delegates to network with others and to visit the exhibition.

# Exploring the functional magnetic properties of high entropy alloy thin films via sputtering

*Prof Nicola Morley*

Soft magnetic thin films are used in a wide range of applications including microelectronic mechanical system (MEMS) devices, microinductors and sensors. The main research focus is to fabricate films, which have the optimum properties for their application. This is achieved by understanding how the growth parameters influence the films' morphology and hence the magnetic and electrical properties. The search for new soft magnetic thin films has led to the exploration into multi-component alloys (MCAs), which contain four or more elements with percentages between 12.5% and 33%. These alloys when in equimolar ratios are known as high entropy alloys (HEAs), and can be fabricated to have a single phase. The resulting alloys often have interesting functional properties, which are linked to their structure. Exploring the different structures and how they change the functional properties, allows for a greater understanding of the mechanism of these alloys, along with the discovery of new functional magnetic materials. This talks presents our research on the $CoFeNi_{0.5}Cr_{0.5}Al$ composition in thin films. It investigates how the fabrication parameters (growth power and time) changes the morphology and composition of the films, along with the functional magnetic properties.

# The numerical simulation of a cathode spot motion and formation of ion flow parameters of an arc discharge

Ihar A. IVANOU
*Belarusian National Technical University, Minsk, Republic of Belarus*

Vacuum arc discharge is widely used for deposition of metallurgical coatings, such as TiN, Ti(C, N), TiSi, $Ti_xSi_yN(C)$. For this process it's very important to control cathode spot trajectory and energy of ion flow. In this report the results of applying of stochastic approach (Monte Carlo method) for numerical simulation of PVD-processes are discussed. For this purpose the algorithm for calculation of a trajectory of a single cathode spot of a vacuum arc is described. This algorithm allows to take into account the discrete nature of the cathode spot movement. Also the program for modeling the motion of plasma flow ions taking into account pair elastic collisions with atoms of a technological gas was developed. The numerical simulation was done for titanium plasma for different technological regimes (outer tangential magnetic field, gas pressure, distance between deposition surface and vacuum plasma evaporator).

# Advances in CdTe Thin Film Photovoltaics enabled by MOCVD

Giray KARTOPU
*Centre for Solar Energy Research, College of Engineering, Swansea University, OpTIC Centre, St. Asaph Business Park, LL17 0JD, UK.*

The CdTe thin film photovoltaic (PV) technology reached 22.1% efficiency for solar cells and 18.6% for modules. The CdTe solar absorber is typically vacuum-deposited by physical vapor methods at high temperatures (~600°C). Metalorganic chemical vapor deposition (MOCVD) could be a low temperature and non-vacuum alternative as it offers non-vacuum, low-temperature growth with *in-situ* alloying and doping flexibility. The best solar cell performance we achieved for all-MOCVD-grown CdTe devices is about 15%. Scaling-up potential of MOCVD CdTe devices has been explored via an in-line tool, developed in-house at the Center for Solar Energy Research. This innovative system uses a vertical injector and a chamber-less configuration to coat substrates up to 15 cm width. We also demonstrated mini-module devices of 5×5 cm size, reaching 12.9% efficiency.

- S.L. Rugen-Hankey et al, *Improvement to thin film CdTe solar cells with controlled back surface oxidation*, Solar Energy Materials and Solar Cells (2015).
- G. Kartopu et al, *CdTe thin film solar cells produced using a chamberless inline process via metalorganic chemical vapour deposition*, Thin Solid Films (2015).
- G. Kartopu et al, *Progression of metalorganic chemical vapour-deposited CdTe thin-film PV devices towards modules*, Progress in Photovoltaics (2016).

* Email: giray.kartopu@swansea.ac.uk; Tel: +44 1745 53 5213.

# Advanced photocatalytic thin films for hydrogen production via water splitting

Dr Glen West
*Manchester Metropolitan University*

Titanium dioxide-based photocatalyst powders were obtained by deposition of copper and/or platinum clusters by means of pulsed direct current magnetron sputtering with different deposition time and plasma composition during Cu sputtering. A top-down configuration was employed with the sputtering source facing the powder holder mounted on a shaker mechanism, which continuously mixed the powders during the sputtering process. HRTEM analyses revealed the presence of well dispersed, subnanometric sized metal clusters, even for long deposition times, while XRD analysis showed no modification of the $TiO_2$ crystal structure upon metal deposition. The so obtained powders were tested as photocatalysts in methanol photo-steam reforming for hydrogen production. The presence of Pt clusters increased the photoactivity with respect to that of bare $TiO_2$. The plasma composition during Cu sputtering was found to strongly affect the photoactivity of the obtained materials, Cu alone deposited as co-catalyst in an Ar-only atmosphere imparting better photoactivity than Cu sputtered in $Ar/O_2$. When the deposition of Cu clusters was coupled with the deposition of Pt clusters, an additive effect of the two metals in increasing $TiO_2$ photoactivity was observed only if Cu clusters were sputtered in the absence of oxygen

# In-line patterned vacuum R2R-coated layers for flexible electronics

Hazel Assender
*Thomas Cosnahan, Bryan Stuart, Xudong Tao, Kai Zhang*
*Department of Materials, University of Oxford*

The breakthrough of flexible electronics depends upon suitable large-scale high-throughput manufacturing routes. Many functional materials exhibit best performance when manufactured by in-vacuum deposition, but the routes to in-line patterning of layers, such that device structures and circuits can be built, are less well developed than for in-ambient counterparts. Large area, continuous deposition of patterned metallization in the aesthetic printing industry has the potential for application to electrode interconnects for devices on flexible substrates, and this patterning could be extended to a wider range of materials. The in-line patterning process relies on adaptation of flexography ink printing which typically transfers ink to a rubber patterned plate for printing images onto polymer webs. Evaporation has been used to deposit aluminium onto a flexography applied pattern by replacing ink with a low vapour pressure oil (e.g. Perfluropolyether, Krytox®) to act as a temporary 'liquid shadow mask'. The radiative heating of metallization causes simultaneous evaporation of the oil pattern, thereby rapidly forming the desired metal pattern onto the non-oiled regions. We have extended this idea to a range of metals, and also to sputter-deposited layers, and made first assessments of materials properties (composition, conductivity, work function etc.) that would be required for use of this method in flexible electronics. Such patterned layers are being employed within various device structures including thermoelectric devices, gas sensors, and OTFT-based amplifier circuits for medical sensors.

# Oblique angle deposition of AZO

Beaujolais Bussell - PhD Student
*University of Surrey*

Abstracts not available at time of printing.

# Micro LED Thin Film Coatings and Where to Find Them

John Whiteman
*Plessey Semiconductors Ltd., UK*

Presenting new thin film materials and deposition techniques that are being incorporating in process development activities to solve the size reduction and integration challenges when developing micro LEDs and micro LED displays.

# Oxide thin-film devices for displays and low power electronics

Prof Aimin Song
*University of Manchester*

Abstracts not available at time of printing.

# 17th Technology Plasma Workshop

Lounge South

Wednesday 9th October 2019

**Meeting Agenda**

| | |
|---|---|
| 1000 – 1200 | Welcome and Registration |
| 1200 – 1340 | Session 1 |
| 1340 – 1430 | Refreshment break |
| 1430– 1600 | Session 2 |
| 1600 – 1700 | Session 3 |
| 1830 | Conference Dinner |

The Technological Plasma Workshop (TPW) is principally a UK-based international forum on the science and technology of plasmas and gas discharges.

Since the EPSRC Technological Plasma Initiative in 1997, technological plasmas have found applications in diverse fields ranging from nano-science energy, through biomedicine and environment, to space exploration. They offer major collaboration opportunities for academic and industrial communities and exciting career prospects for younger scientists and engineers.

To support a full realisation of these opportunities, TPW aims to foster academic-industry collaboration and to engage young plasma scientists with a scientific programme anchored by leading plasma scientists.

In 2011, TPW became a conference of the Institute of Physics (IOP) Plasma Physics Group and since 2014 TPW has been held in conjunction with the Vacuum Expo and the Vacuum Symposium. The conference is currently co-sponsored by the IOP Plasma Physics Group and the IOP Dielectrics & Electrostatics Group

TPW
Abstracts
Refer to TPW
Abstracts
Booklet

# Structure and Dynamics of Surfaces and Interfaces

Lounge South

Thursday 10th October 2019

**Meeting Agenda**

0900 – 0950 Registration opens in the atrium

0950 – 1000 Opening and Prize presentation

1000 – 1050 Session 1

1050 – 1110 Tea/Coffee

1110 – 1200 Session 2

1200 – 1400 Lunch Break | Poster Session | Exhibition Session

1400 – 1450 Session 3

1450 – 1500 Close of meeting

1500 – 1600 Exhibition hall remains open until 1600

This meeting is organised as a celebration of the 60th anniversary of the British Vacuum Council, and a celebration of the award of the 2019 IUVSTA Prize for Science to Prof. Phil Woodruff of Warwick University. The Prize was awarded for "outstanding contributions to deepening our understanding of the structure of surface through the development and application of broadly applicable tools now widely available to the surface science community".

To complement the presentation from Prof. Woodruff, we have chosen five internationally-leading surface scientists who will present their work covering structure, electronic structure, reactivity, and the physics of dynamic processes at surfaces and interfaces.

# Determining surface structure: why and how.

Phil Woodruff
*University of Warwick, Coventry CV4 7AL,UK*

The axiom that *structure determines function* applies not only to bulk materials including biological material, but also to solid surfaces. The structural influence of the chemical reactivity of surfaces, the crucial ingredient of heterogeneous catalysis, is implicit in common references to 'the active site' in catalysis literature, while the functionality of essentially all electronic devices is strongly influenced by the structure of the hetero-interfaces that make up the device, such as those between a metal conductor and a semiconductor. The key conclusion is thus that it is important to determine the atomic-scale structure of surfaces with chemically and electronically significant precision, specifically less than ~ 0.1 Å.

During the 50 years or so of development of 'modern' ultra-high-vacuum surface science, a large number of different experimental methods have been developed that are not only *sensitive* to the presence of the outermost few atomic layers of a surface, but also provide information that is *specific* to this region, despite the presence of the vastly larger number of atoms in the underlying bulk. Amongst these are a number of techniques capable of obtaining quantitative structural data, although in general analysis of data from these experiments can be quite demanding. Somewhat more recently two other techniques have become widely used, namely scanning probe microscopy (especially scanning tunnelling microscopy - STM) experiments and density functional theory (DFT) calculations. Both STM and DFT have had a hugely positive impact on surface science studies in general, and as I will show, when used in combination with quantitative experimental structural data they can significantly aid structural studies. However, I will also show how structural investigations based *only* on these two techniques, as has become common in recent years, are far from ideal.

# Electronic Structure and Charge Density-Wave States in Single-Layer Transition-Metal Dichalcogenides

Phil King
*SUPA, University of St Andrews, KY16 9SS, UK*

Control over materials thickness down to the single-atom scale has emerged as a powerful tuning parameter for manipulating not only the single-particle band structures of solids, but increasingly also their interacting electronic states and phases. A particularly attractive materials system in which to explore this is the transition-metal dichalcogenides (TMDs), both because of their naturally-layered van der Waals structures as well as the wide variety of materials properties which they are known to host. I will describe our recent work on single-layer TMD metals grown by molecular-beam epitaxy, and will show how their ubiquitous charge density-wave states not only persist, but can be strengthened, in the single-layer systems as compared to the bulk parent compounds. I will argue how a combination of surface spectroscopies can provide key insight on the evolution of the quantum many-body states in these systems, in particular using in situ angle-resolved photoemission (ARPES) as an ideal probe of the electronic structure of such epitaxial monolayers, and showing how low-energy electron diffraction provides a powerful measure of the order parameter of the charge-density wave. I will further discuss the delicate balance between competing interacting states and phases that the two-dimensional environment of such monolayer TMDs naturally provides, opening potential for the future targeted engineering of the collective properties in such systems.

This work was performed in close collaboration with M.D. Watson, A. Rajan, J. Feng, D. Biswas, and colleagues from the Universities of St Andrews, Oxford, Keil, Diamond, Elettra, and SOLEIL.

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# Chrial nanoplasmonic systems

Malcolm Kadodwala

*School of Chemistry Univeristy of Glasgow, Joseph Black Building, Glasgow< G12 8QQ, UK*

Keywords: Chirality, biosensing, plasmonics

For over 100 years the characterization of chiral media has been performed using techniques based on the differential interaction of circularly polarised light. In this talk I will discuss a new paradigm for the ultrasensitive characterization of chiral materials. Specifically, how near fields with chiral asymmetries, generated by light scattering from chiral nanostructures, can uniquely probe chiral structure over a range of length scales. Introducing inherently chiral biomaterials into the nearfield region induces an asymmetric change in the optical properties of left and right handed plasmonic structures. The level of asymmetry observed is correlated to biomacromolecular structure over a range of lengthscales [1-7]. The reported phenomena are replicated using numerical EM simulations, which provides a basis for fundamental understanding.

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# X-ray Photoelectron Spectroscopy: Beyond the Surface

Dr Anna Regoutz
*Department of Chemistry, University College London, 20 Gordon Street, London WC1H 0AJ, UK.*

Hard X-ray excitation sources extend the probing capabilities of X-ray photoelectron spectroscopy (XPS), which traditionally uses soft X-ray sources up to around 1.5 keV, beyond the outermost surface of materials. Hard X-ray photoelectron spectroscopy (HAXPES) delivers much greater probing depths of tens of nanometres enabling the characterisation of buried layers and interfaces in structured materials as well as bulk characteristics of homogeneous samples. Like XPS, HAXPES enables the study of both chemical states and electronic structure. Over the last decade the development of advanced beamlines at synchrotrons in parallel with the advent of laboratory-based spectrometers has opened up HAXPES for a much wider range of materials and applications. This talk will present the challenges and opportunities that HAXPES presents and will cover recent developments and results.

# On-surface covalent-coupling reactions: molecular, sub-molecular, and atomic scale characterisation

Alex Saywell
*University of Nottingham, Nottingham, U.K.*

The on-surface synthesis of covalently bonded molecular frameworks offers a promising route towards customisable 1D and 2D materials.[1] Such on-surface reactions, in which the substrate itself may be employed as a catalyst, potentially provide alternative reaction pathways to those available in solution-phase synthesis. In order to gain control over the efficiency and selectivity of these reactions an appreciation of the underlying mechanism is required: specifically with regards to the role of substrate chemistry and topology. These molecule-surface systems are readily studied by scanning probe microscopy (SPM) techniques, allowing real-space identification of the covalently bonded products and intermediate reaction states. Additional chemical analysis can be provided by photoelectron spectroscopy measurements and, in combination with x-ray standing wave (XSW) analysis, information on molecular conformations and adsorption sites may be obtained.

Here I will present details from our recent studies, illustrating aspects of on-surface synthesis, including; (i) the influence of surface topology on the reaction pathway,[2] (ii) the effect of templating a catalytic surface with porous molecular structures,[3,4] and (iii) details of surface adatoms participating in the formation of metal-organic intermediate structures. The reactions studied are based upon Ullmann-type on-surface coupling performed on metallic substrates held under ultra-high vacuum (UHV) conditions, and are characterised via scanning tunnelling microscopy (STM) and synchrotron based XSW measurements.

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# Surface Analysis: The Changing Composition at the Surface

Theatre 1, Main Hall

Thursday 10th October 2019

**Meeting Agenda**

| | |
|---|---|
| 1055 - 1100 | Welcome and Introduction |
| 1100 – 1220 | Session 1 |
| 1220 – 1400 | Poster Session, Exhibition and Lunch break |
| 1400 – 1530 | Session 2 |
| 1530 | Close of meeting |
| 1600 | Exhibition hall closes |

This meeting is arranged with the intention of improving the knowledge of surface analysis, characterisation and compound identification techniques.

Surface analysis is used not only for the development of new high functionality ‘smart’ surfaces and products utilising them, but also for helping high performance materials to properly exhibit their functionality.

Surface analysis is of particular importance for examining adhesion, biocompatibility of a material, chemical activity, composition, corrosion resistance, coatings, contaminants, electrical properties, friction, optical properties, product flow, semiconductors, structures, tomography and surface wetness.

# SIMS isn't just for silicon

Dr David Sykes
*Loughborough Surface Analysis Ltd, UK*

Dynamic SIMS or DSIMS became established as an important tool for semiconductor characterisation some decades ago. The casual observer might be led to believe that it is only useful for the characterisation of silicon as the only certified reference materials that exist are boron, arsenic and phosphorus in silicon (NIST SRM 2137, 2134 and 2133 respectively). Similarly, with documentary standards, there is ISO12406, Surface chemical analysis -- Secondary-ion mass spectrometry -- Method for depth profiling of arsenic in silicon, ISO17560 - Method for depth profiling of boron in silicon and ISO14237 - Determination of boron atomic concentration in silicon using uniformly doped materials. Again, the focus is on silicon but nothing could be further from the truth.

This talk will illustrate areas of application of DSIMS other than the analysis of silicon. In particular it will focus on the use of 18O as the primary bombarding species rather than the more common 16O and demonstrate the advantages of this unorthodox approach.

# Surface phase analysis using XPS

Dr Robert Palgrave
*University College London, UK*

X-ray photoelectron spectroscopy is a technique commonly used to quantify surface elemental composition and measure the surface chemical environments present. Both of these applications make use of photoemission from the core atomic orbitals. The valence electrons are the outermost electrons in an atom, and interact strongly with those of neighbouring atoms, forming chemical bonds. Valence band photoemission spectra thus contain information on the bonding and spatial arrangement of atoms. It is well known that different polymorphs, such as diamond and graphite, or anatase and rutile titania, can be qualitatively distinguished by measuring the valence band spectra. In this talk I will describe how valence band XPS and UPS can be used to quantitatively measure the crystallographic phase fraction of a range of inorganic and organic materials. The phase fractions determined by XPS are shown to be surface phase fractions, and in the TiO2 system, correlate strongly with surface photocatalytic activity.

# Unravel the structure of buried soft interfaces

Dr Wuge Briscoe
*University of Bristol, UK*

Many biologically and industrially relevant interfaces are decorated with polymers and surfactants. Understanding the structure of such soft interfaces is thus critically important. Using synchrotron X-ray reflectivity (XRR), we have studied self-assembled surfactant/lipid layers at the mica-water interface using a “bending mica” method, and observed layer structural characteristics which differ from those widely reported using AFM imaging. We have also used the XRR technique to study the collapse of thermoresponsive polymer brushes, critically examining the validity of two competing structural models for such a brush collapse process.

# Applications of synchrotron radiation based hard x-ray photoelectron spectroscopy (HAXPES) in semiconductor materials characterisation.

Prof Greg Hughes
*School of Physical Sciences, Dublin City University, Ireland*

Hard x-ray photoelectron spectroscopy (HAXPES) is emerging as a technique which has the capability to provide chemical and electronic information on much larger depth scales than conventional XPS. This has potential applications in the study of oxide/semiconductor and metal/semiconductor buried interfaces found in device structures, particularly after annealing cycles. In this first example, results of combined hard x-ray photoelectron spectroscopy (HAXPES) and electrical characterisation measurements (Capacitance-Voltage) on identical Si based metal-oxide-semiconductor (MOS) structures will be presented. The experimental findings obtained indicate that surface potential changes at the semiconductor/dielectric interface due to the presence of a thin metal gate layer can be detected by HAXPES core level measurements. Changes in the semiconductor band bending at zero gate voltage and the flat band voltage for the case of metal gate layers derived from the semiconductor core level shifts observed in the HAXPES spectra are in agreement with values derived from C-V measurements. In this second example, work of a HAXPES study of the creation of metallic copper layers by means of metal-salt infiltration into poly(2vinyl pyridine) (P2VP) films, and subsequent removal of the polymer host using UV/Ozone treatment is presented. HAXPES measurements were used to study the polymer film before and after metal salt infiltration, along with analysis of the copper oxide created after UV/Ozone treatment. The results show successful infiltration of the metal salt to the polymer film, as well as complete conversion to copper oxide following UV/Ozone treatment and reduction to metallic copper with a subsequent in situ anneal.

# Chemical reactions, corrosion and electrochemistry at solid-liquid interfaces – routine operando studies with Near Ambient Pressure XPS

Andreas Thissen, Paul Dietrich
[1]*SPECS Surface Nano Analysis GmbH, Berlin, Germany*

Over the last decades XPS under Near Ambient Pressure (NAP) conditions has demonstrated its promising potential in a wide variety of applications. Starting from operando studies of surface reactions in catalysis, the applications soon have been enhanced towards studies of processes at liquid surfaces, mainly using freezing/melting cycles, liquid jets or liquid films on rotation disks or wheels. Since more than 15 years, the need for basic studies of the fundamental chemistry at solid-liquid interfaces has attracted growing interest. Dip-and-pull experiments at synchrotrons finally also demonstrated, that in-situ and operando XPS in electrochemical experiments can be realized, mainly using synchrotron beams, significantly contributing to the basic understanding of modern energy converting or storing devices, like batteries, fuel cells, etc.
The development of pure laboratory NAP-XPS systems with optimized sample environments, like special sample holders, Peltier coolers and operando liquid cells combined with full automation and process control provides possibilities for the preparation and analysis of a multitude of liquid samples or solid-liquid interfaces on a reliable daily base.
Interfaces of semiconductors with organic solvents are important for production processes and device operation. The first example presented shows the simplicity of obtaining relevant results on Silicon in different organic solvents without the need of highly sophisticated setups or special excitation sources beyond Al K□.
The next level of complexity is to follow the effects of corrosion in organic or inorganic acids. As an example an operando study of metal corrosion in acetic acid is shown.
Most sophisticated experiments so far have been operando electrochemistry in a classical three-electrode setup. A versatile setup

is presented, allowing for studies of solid-electrolyte interfaces for example in Lithium ion batteries as a simple laboratory experiment. Finally an outlook is given on the future perspective of applications and scientific contributions of routine operando XPS.

# Advanced Surface and Interface Analysis to enable Next Generation Additive Manufacturing

Dr Gustavo F Trindade
*University of Nottingham*

Additive Manufacturing (AM), also referred to as 3D printing, is nowadays employed in a wide range of fields utilising various materials alongside constant developments in terms of geometrical complexity. However, in addition to exploiting geometry, a multi institutional and multi industry project [1] seeks to augment these products three-dimensional functionality through the co-deposition of both functional and structural materials contemporaneously. These functions can be, for example, electronic, biological and pharmaceutical and can be incorporated through a variety of novel processes such as piezo ink-jetting and UV-sintering/curing of metal nanoparticles/polymers [2], novel drop-on-demand jetting of high-temperature metals and multi-photon nanolithography of nano-composite materials [3]. A primary concern with regards to enabling this next generation AM is the difficulty of inter and intra layer coalescence/bonding for functional-structural or functional-functional materials due to differences in physical state, chemistry and temperature at deposition or conversion. To overcome these problems one of the requirements is the development of a suite of ex-situ interface analysis methodologies capable of delivering a complete 3D characterisation of samples at the micro/nano scale with chemical specificity and high spatial resolution. This work will present recent developments and current challenges on materials interface characterisation in the context of multi-material AM [4]. These involve specific methodologies for analytical techniques such as focused ion beam for scanning/transmission electron microscopy (FIB-SEM), time-of-flight secondary ion mass spectrometry (ToF-SIMS), Raman microscopy and X-ray photoelectron spectroscopy (XPS). Moreover, the University of Nottingham has recently acquired a state-of-the-art 3D orbiSIMS instrument [5] that expands even more the analysis of complex materials.

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# Hard X-ray Photoelectron Spectroscopy: depth profiling from the surface into the bulk

Ben F. Spencer
*Department of Materials, The University of Manchester*

The surface of a material is often very different from the bulk, and a range of advanced materials utilise buried interfaces and layered structures. There is a need to non-destructively probe the chemical state of these layers. Higher energy X-ray sources now allow us to apply the important technique of XPS, gaining quantified elemental and chemical information about a material non-destructively, over much deeper sampling depths. Whereas XPS is limited to around the top 3-5 nanometres of the surface, HAXPES can enable probing through hundreds of nm. Angular-resolved spectroscopy then enables a depth profile to be extracted from the surface into the bulk of a material. The technique is demonstrated using the world's first lab-based HAXPES system from Scienta Omicron, in the Sir Henry Royce Institute, which uses a 9.25 keV gallium metal jet X-ray source (Excillum). Initial measurements include some high quality layer structures and calibration samples, with an outlook on the potential for HAXPES in advanced materials characterisation.

# Applications of photoemission - from catalysis to biomaterials

David J. Payne
*Department of Materials, Imperial College London, UK*

Photoelectron spectroscopy (PES) is perhaps the most direct probe of electronic structure available to the experimental scientist, as well as an invaluable tool for elucidating bulk and surface chemical composition. This talk will aim to discuss the variety of different photoemission techniques used today. This will range from standard X-ray photoelectron spectroscopy (XPS) to hard X-ray photoelectron spectroscopy (HAXPES) and high-pressure photoelectron spectroscopy (HPXPS), with some work on angle-resolved PES (ARPES) as well highlighted. For example, HPXPS is rapidly developing as a tool to understand how surfaces behave “at pressure” as the majority of photoemission performed over the last 40 years uses ultra-high vacuum conditions ($10^{-10}$ mbar). I will use recent examples of how combination of different PES techniques can fundamentally change our understanding of the physics and chemistry of well-known systems, from catalysts to biomaterials.

# 17th Technology Plasma Workshop

Lounge North

Thursday 10th October 2019

**Meeting Agenda**

| | |
|---|---|
| 0930 – 1030 | Session 4 |
| 1030 – 1100 | Refreshment break |
| 1230 – 1330 | Session 5 |
| 1330 – 1400 | Session 6 |
| 1400 – 1530 | Session 7 |
| 1530 | Close |

The Technological Plasma Workshop (TPW) is principally a UK-based international forum on the science and technology of plasmas and gas discharges.

Since the EPSRC Technological Plasma Initiative in 1997, technological plasmas have found applications in diverse fields ranging from nano-science energy, through biomedicine and environment, to space exploration. They offer major collaboration opportunities for academic and industrial communities and exciting career prospects for younger scientists and engineers.

To support a full realisation of these opportunities, TPW aims to foster academic-industry collaboration and to engage young plasma scientists with a scientific programme anchored by leading plasma scientists.

In 2011, TPW became a conference of the Institute of Physics (IOP) Plasma Physics Group and since 2014 TPW has been held in conjunction with the Vacuum Expo and the Vacuum Symposium. The conference is currently co-sponsored by the IOP Plasma Physics Group and the IOP Dielectrics & Electrostatics Group

TPW
Abstracts
Refer to TPW
Abstract
Booklet

# VS10 Posters

| *Number* | *Title* | *Author(s)* | *Day(s) Presenting* |
|---|---|---|---|
| 1 | Thin-film coatings for electro-optics in a Quantum Engineering perspective. | Roberto Alfano, Peter Smith | 9th Oct. |
| | | | |
| 2 | Mars within 39 days: The VASIMR | Louis Kang, Yao Lu, Siyu Yang, Haojian Zhang | 9th Oct. |
| | | | |
| 3 | Adaptive nanocomposite coatings on the base of carbon-dopped titanium nitride | V. Kazachenko, I. Razanau, A. Dvorak | 9th Oct. |
| | | | |
| 4 | Surface hardening of sealing elements made of elastomers using coatings on the base of diamond-like carbon | V. Kazachenko, I. Razanau, A. Dvorak, M. Popova | 9th Oct. |
| | | | |
| 5 | Electron induced chemistry and complex dynamic simulations of FEBID precursors | Maria Pintea, Nigel Mason, Maria Tudorovskaya, Pablo de Vera | 9th and 10th Oct. |
| | | | |
| 6 | Ar plasma | Ichiro Takano | 9th and 10th Oct. |
| | | | |
| 7 | Discover the 2D World of Elements with XPS | S. Guan, P. Davies, D. Morgan D. Willock, R. Palgrave, D. Lennon, M. Isaacs | 10th Oct |

# Notes

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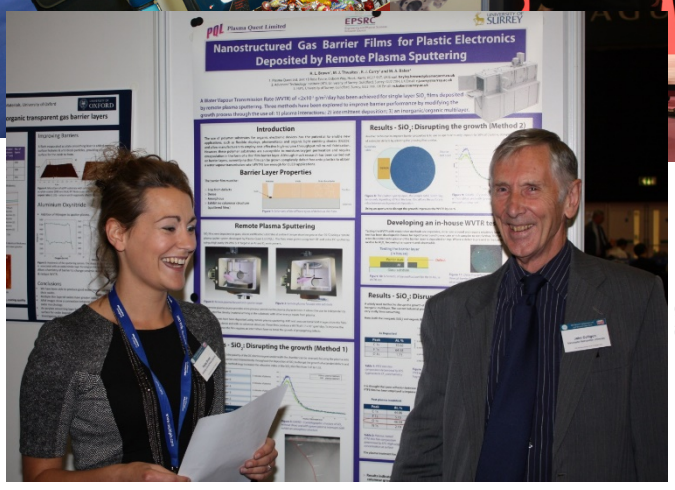
# VS1 was kicked off at Cockcroft Institute, Daresbury Laboratory in 2010

# Can you spot yourself?

# VS through the years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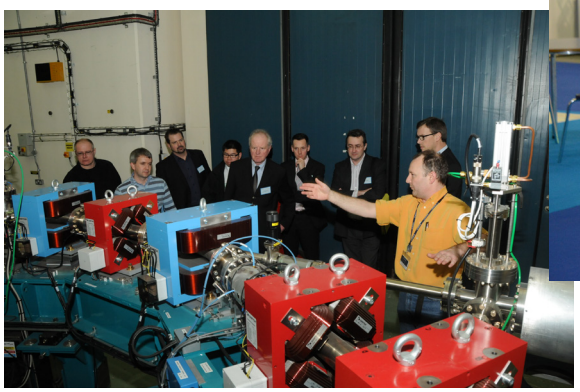
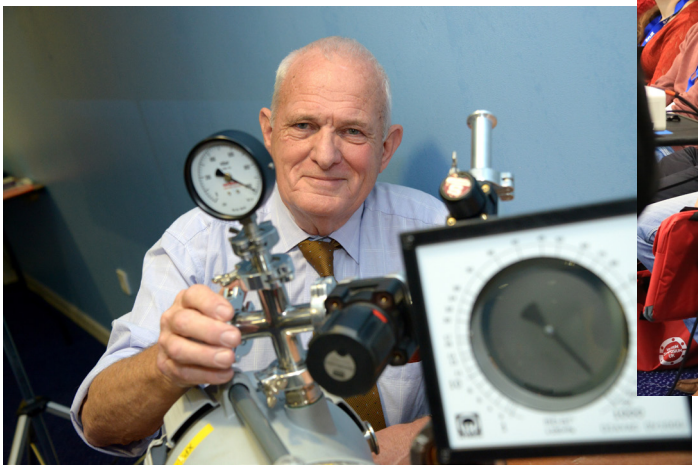
16 & 17 October 2013, Coventry

# VS through the years





6TH VACUUM SYMPOSIUM UK
14 & 15 October 2015, Coventry



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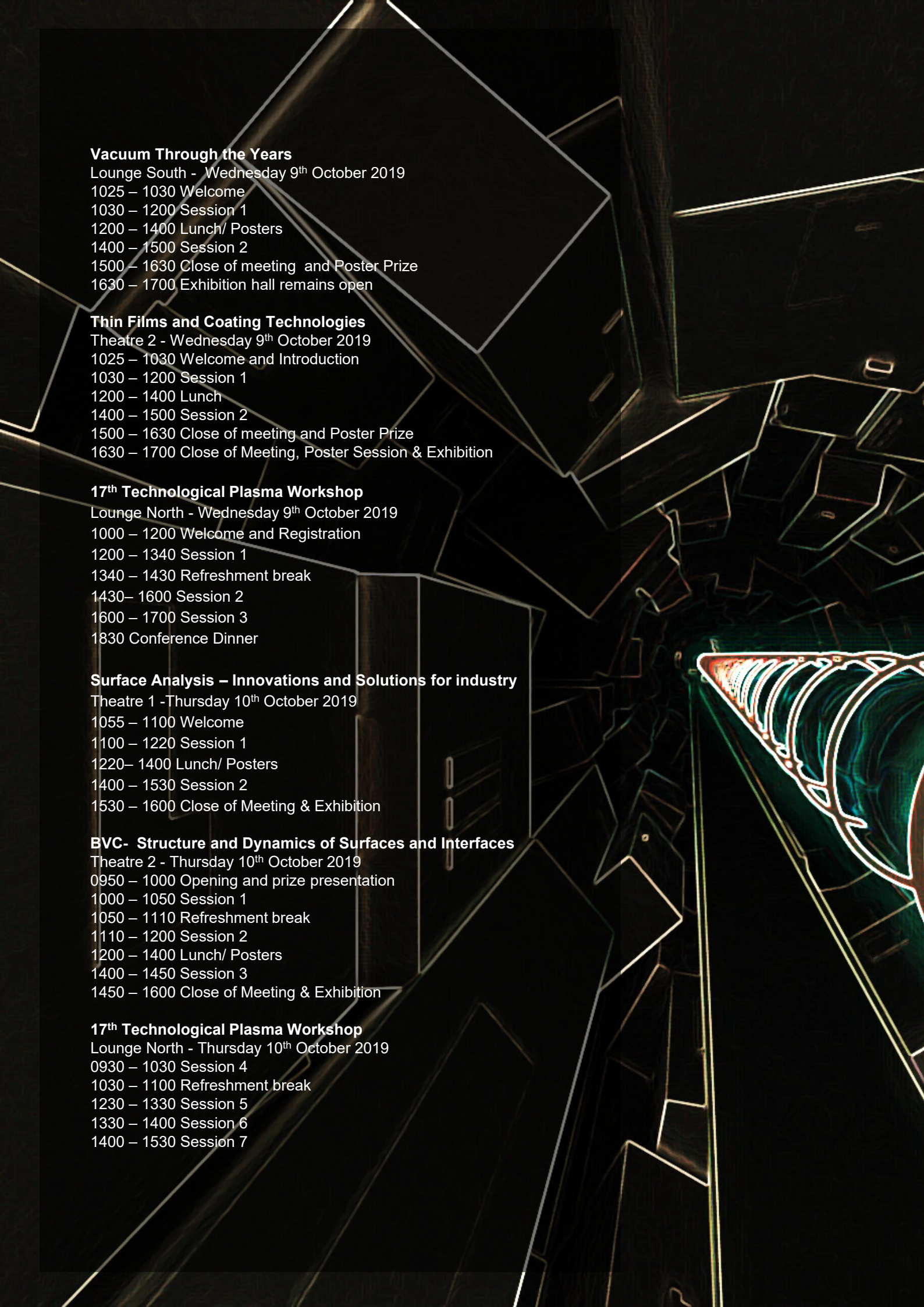

**Vacuum Through the Years**
Lounge South - Wednesday 9th October 2019
1025 – 1030 Welcome
1030 – 1200 Session 1
1200 – 1400 Lunch/ Posters
1400 – 1500 Session 2
1500 – 1630 Close of meeting and Poster Prize
1630 – 1700 Exhibition hall remains open

**Thin Films and Coating Technologies**
Theatre 2 - Wednesday 9th October 2019
1025 – 1030 Welcome and Introduction
1030 – 1200 Session 1
1200 – 1400 Lunch
1400 – 1500 Session 2
1500 – 1630 Close of meeting and Poster Prize
1630 – 1700 Close of Meeting, Poster Session & Exhibition

**17th Technological Plasma Workshop**
Lounge North - Wednesday 9th October 2019
1000 – 1200 Welcome and Registration
1200 – 1340 Session 1
1340 – 1430 Refreshment break
1430– 1600 Session 2
1600 – 1700 Session 3
1830 Conference Dinner

**Surface Analysis – Innovations and Solutions for industry**
Theatre 1 -Thursday 10th October 2019
1055 – 1100 Welcome
1100 – 1220 Session 1
1220– 1400 Lunch/ Posters
1400 – 1530 Session 2
1530 – 1600 Close of Meeting & Exhibition

**BVC- Structure and Dynamics of Surfaces and Interfaces**
Theatre 2 - Thursday 10th October 2019
0950 – 1000 Opening and prize presentation
1000 – 1050 Session 1
1050 – 1110 Refreshment break
1110 – 1200 Session 2
1200 – 1400 Lunch/ Posters
1400 – 1450 Session 3
1450 – 1600 Close of Meeting & Exhibition

**17th Technological Plasma Workshop**
Lounge North - Thursday 10th October 2019
0930 – 1030 Session 4
1030 – 1100 Refreshment break
1230 – 1330 Session 5
1330 – 1400 Session 6
1400 – 1530 Session 7