THIRD

AUSTRALIAN - EU

GRAPHENE WORKSHOP

30th – 31st March 2023

Melbourne, Australia

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Chairs' message

Welcome to THE THIRD AUSTRALIAN - EU GRAPHENE WORKSHOP (30-31 March 2023) in Melbourne Australia. The workshop is initiated by the European Graphene Flagship project and co-organized by the Australian Research Council (ARC) Research Hub for **Advanced Manufacturing with 2D Materials** (AM2D), and the ARC Research Hub for **Graphene Enabled Industry Transformation** (GEIT).

The aim of this workshop provides a platform for research leaders in the graphene field and graphene industry leading companies to discuss the common challenges in moving graphene from research laboratories to commercial products, and identifying the opportunities for future collaborations.

This book contains all abstracts for this workshop covering essential aspects of translation of graphene research with particular emphasis on graphene large-scale production, protective coating, polymer composites, CVD graphene and 2D materials, graphene membranes and graphene for energy and biomedical applications.

We hope that you enjoy the warm hospitality of Australian researchers, delicious food and the best wine, and more importantly, utilize this opportunity to foster new collaborations and friendships.

Chairs

Ken Teo
AIXTRON Ltd.

Dusan Losic
University of Adelaide

Mainak Majumder
Monash University

Michael Fuhrer
Monash University

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Ian Kinloch


Vladimir Falko


Johan Ek Weis


Ken Teo


Lucia Delogu


Alberto Bianco


Francesco Bonaccorso


Vincent Bouchiat


Vincenzo Palermo

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Francesca Iacopi


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Invited Industry Speakers


Meysam Sharifzadeh


Neil Armstrong


Abozar Akbari


Ashok Kumar Nanjundan


Manju Gunawardana

Organising Team and Chairs

EU (Chair)	Ken Teo (AIXTRON Ltd)
Australia (Chair)	Dusan Losic (University of Adelaide),
Australia (Co-Chair)	Mainak Majumder (Monash University)
Australia (Co-Chair)	Michael Fuhrer (Monash University)
Australia	Phillip Sheath (Monash University)

Eu Flagship Speakers

Name (alphabetical by surname)	**Organisation**
Alberto Bianco	CNRS Strasbourg
Francesco Bonaccorso	BeDimensional
Vincent Bouchiat	Grapheal SAS
Lucia Delogu	University of Padua
Vladimir Falko	University of Manchester
Andrea Ferrari	University of Cambridge
Jari Kinaret	Chalmers University
Ian Kinloch	University of Manchester
Vincenzo Palermo	CNR Bologna
Ken Teo	AIXTRON Ltd

Australian Speakers

Name (alphabetical by surname)	**Organisation**
Deepak Dubal	Queensland University of Technology
Michael Fuhrer	Monash University
Francesca Iacopi	University of Technology Sydney (UTS)
Baohua Jia	Royal Melbourne Institute of Technology (RMIT)
Dan Li	University of Melbourne
Qin Li	Griffith University
Dusan Losic	University of Adelaide
Mainak Majumder	Monash University
Hoe Tan	Australian National University (ANU)
Ajayan Vinu	Newcastle University
Sumeet Walia	Royal Melbourne Institute of Technology (RMIT)
Gordon Wallace	University of Wollongong

Invited Industry speakers

Name (alphabetical by surname)	**Organisation**
Abozar Akbari	NematiQ
Neil Armstrong	First Graphene
Manju Gunawardana	LOLC ATA/Ceylon Graphene Technologies (Sri Lanka)
Ashok Kumar Nanjundan	Graphene Manufacturing Group Ltd.
Meysam Sharifzadeh	Ionic Industries Ltd

Program

Day One Thursday 30 March 2023	
8.15 -8.45	Speaker transport from hotels (CBD) to Monash University
8.30 -8.45	Arrival delegates and registration
	Opening
9.00-9.10	Welcome and openings
9.10-11.15	**Opportunities, Fundamentals and Composites (Chair: K. Teo)**
9.10- 9.35	**Jari Kinaret**, Chalmers University Graphene Flagship: a look at its ten years' voyage and the way ahead
9.35- 9.55	**Dusan Losic,** University of Adelaide Graphene and 2D materials and their translation for emerging applications
9.55-10.15	**Vladimir Falko**, University of Manchester Electronic properties of marginally twisted bilayers of transition metal dichalcogenides
10.15-10.35	**Michael Fuhrer,** Monash University Passivating Graphene and Suppressing Interfacial Phonon Scattering with Mechanically Transferred Large-Area High-Dielectric-Constant Ga_2O_3
10.35-10.55	**Ian Kinloch,** University of Manchester Multifunctional Hybrid Composites
10.55- 11.15	**Gordon Wallace**, University of Wollongong Getting Graphene into useful Structures and onto End-Users
11.15-11.45	**Morning break (catered)**
11.45-13.10	**Energy Storage (Chair: D. Losic)**
11.45-12.05	**Mainak Majumder,** Monash University A holistic full-cell approach towards designing practical Lithium Sulfur batteries
12.05- 12.20	**Francesco Bonaccorso**, BeDimensional Industrially produced 2D materials for energy applications
12.20-12.35	**Meysam Sharifzadeh,** Ionic Industries Graphene in High Power Energy Storage Devices
12.35-12.50	**Ashok Kumar Nanjundan,** Graphene Manufacturing Group Graphene for energy applications
12.50-13.10	**Dan Li**, University of Melbourne Electrifying graphene-based ion nanochannels
13.10-14.40	**Lunch break (catered)**
14.40-16.00	**Sustainability and safety (Chair: I. Kinloch)**
14.40-15.00	**Ajayan Vinu,** Newcastle University Nanoporous Nitrides and their Hybrids: A Unique Solution for Clean Energy and Environment
15.00- 15.20	**Deepak Dubal,** QUT Low Carbon Emission Manufacturing of Carbons from Agricultural Waste
15.20 -15.40	**Alberto Bianco**, CNRS Strasbourg Toxicity of graphene-based materials
15.40-16.00	**Lucia Delogu,** University of Padua High-Dimensional Approaches for Immune Profiling of 2D Materials
16.00-17.30	**Lab tours**
Registration required	**Tour 1:** Visit Melbourne Centre for nanofabrication (MCN)
	Tour 2: Visit Monash labs (AM2D and FLEET)
18.00-21.30	**Speaker Dinner at Monash (invite only)**

<u>Day Two</u> Friday 31 March 2023	
8.15 -8.45	Speaker transport from hotels (CBD) to Monash University
8.30 -8.45	Arrival delegates and registration
9.00-10.40	**2D applications: photonics, optoelectronics and electronics (Chair: M. Fuhrer)**
9.00-9.20	**Andrea Ferrari**, University of Cambridge Graphene and layered materials for photonics and optoelectronics
9.20- 9.40	**Sumeet Walia**, RMIT Two-dimensional materials for next-generation electronics and optoelectronics technologies
9.40- 10.00	**Baohua Jia**, RMIT Graphene integrated devices
10.00-10.20	**Ken Teo,** AIXTRON Ltd Wafer scale deposition of Graphene and 2D materials and their integration into devices
10.20-10.40	**Hoe Tan**, ANU h-BN and III-V semiconductor nanostructures
10.40-11.10	**Morning break (catered)**
11.10-12.40	**Wearables and filtration (Chair: A. Bianco)**
11.10-11.30	**Vincent Bouchiat**, Grapheal SAS Biocompatible Graphene Sensors for the Detection and Remote Monitoring of Chronic Diseases
11.30- 11.50	**Francesca Iacopi,** UTS Epitaxial graphene sensors for EEG -based brain-machine interfaces
11.50-12.10	**Qin Li**, Griffith University Green Graphene Quantum Dots for Wearable Sensor Devices
12.10-12.25	**Abozar Akbari**, NematiQ Commercialisation of Graphene Oxide Membrane
12.25-12.40	**Vincenzo Palermo**, CNR Bologna 2-Dimensional nanosheets for water filters: an example of translational technology within the Graphene Flagship
12.40-14.00	**Lunch break (catered)**
14.00-14.45	**Standardisation and commercialisation (Chair: V. Palermo)**
14.00-14.15	**Johan Ek Weis,** Chalmers IndustriTecknik Standardisation and the Graphene Flagship
14.15-14.30	**Manju Gunawardana**, LOLC ATA/Ceylon Graphene Technologies How to Decide on the Best Graphene Material for your Specific Application
14.30-14.45	**Neil Armstrong,** First Graphene Exploring Key Commercial and Development Activities in Graphene Applications: An Update on First Graphene's Progress
14.45-16.00	**Forum: Graphene Commercialisation challenges and closing (Moderator: TBA)**
Panel	Panel comprised of academic and industry experts Topics: key challenges in translation of graphene research and commercialisation, quality control and standardisation, health and environmental impacts, EU-Australia collaboration.
16.00	**End**

FAQs - Directions and Maps

Contacts

	Contact	Email	Mobile
EU	Ken Teo	k.teo@aixtron.com	+44 7824 690202
Australia	Dusan Losic	dusan.losic@adelaide.edu.au	+61 423 926 275
Australia (logistics)	Phillip Sheath	phillip.sheath@monash.edu	+61 405 225 323

Accommodation

For delegates staying in Melbourne:
The main city (Melbourne) is approximately 30 - 45 min drive from Monash University, Clayton. Whilst the university is serviced by public transport, there are no direct routes to the university from the city. Please advise the contacts above if you are staying in Melbourne. Group transportation to and from Monash University can be arranged.

For delegates staying in Clayton:
The following accommodations are within walking distance (10 mins) of Monash University and the conference venue. Discounted (corporate) rates are available by contacting the accommodation directly (details below) and stating that you are a visitor to Monash University. Please mention that you were advised of corporate rates by Dr Phillip Sheath

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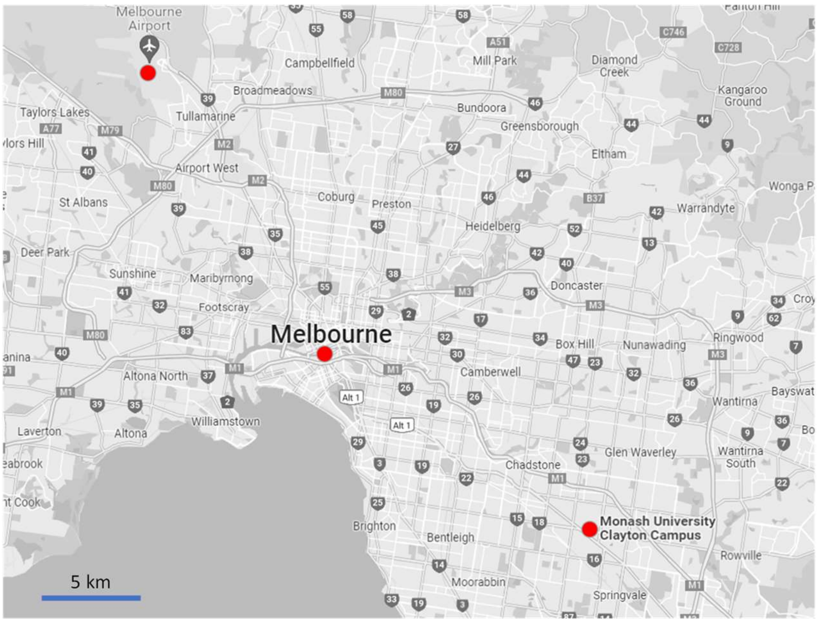
https://www.questapartments.com.au/ properties/vic/notting-hill/quest-notting-hill/overview 5 Acacia Place Ferntree Business Park Notting Hill VIC 3168 Australia Tel: +61 3 9069 2888 questnottinghill@questapartments.com.au (continental breakfast on-site, or adjacent café for more options)	(https://www.gatewayonmonash.com.au/) 630 Blackburn Rd Notting Hill VIC 3168 Australia Tel: +61 3 9561 4455 stay@gatewayonmonash.com.au (buffet breakfast on-site)

Tips and tricks travelling through Melbourne

- There is no train station at Melbourne Airport. The airport is well serviced by domestic taxi providers including Uber.
- Generally, the weather in Melbourne and at Monash University will be pleasant with moderate temperatures and typically very little rain.
- To plan for your taxi to the airport from Monash University (Clayton), please be aware of the following:
- It can take up to 1.5 hours in peak hour (3PM to 7PM) to get to the airport. Outside of peak hour the travel time is approx. 45 mins.
- Make sure to book a taxi in advance. Finding a taxi between 4PM and-5PM can be very difficult as this is the driver shift change period. (inform the organisers that you require a taxi and it can be arranged for you)

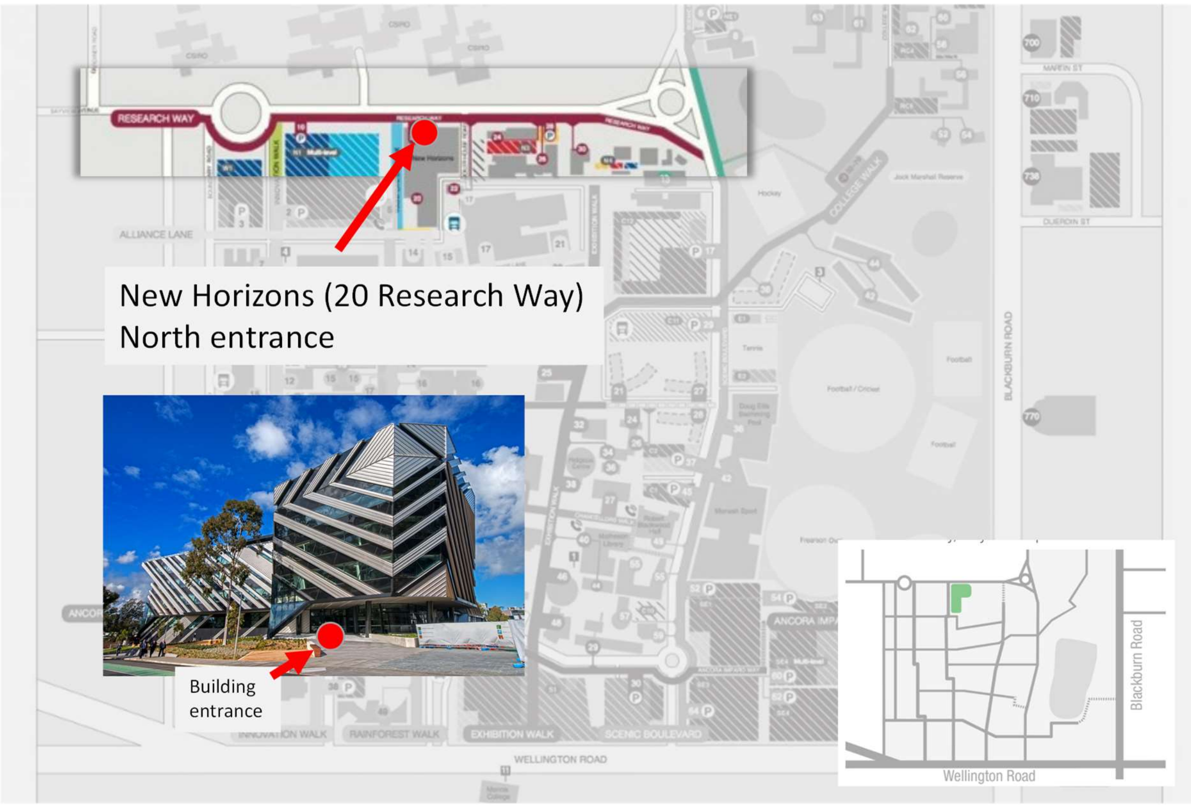
Directions

For reference, the location of the airport, Melbourne city, and Monash University Clayton are shown below.



Monash University, New Horizons Building 20 Research Way, Clayton, VIC 3800 (search this on Google maps)

Enter the building via the north entrance on Research Way.



Dinner on Day 1 will be held at Monash University. Directions to the locations for tours will be provided at the time of the tour.

Abstracts

Graphene Flagship: a look at its ten years' voyage and the way ahead

Jari Kinaret

jari.kinaret@chalmers.se

Chalmers University of Technology, Gothenburg, Sweden

Abstract

In this talk I will describe the Graphene Flagship project, the progress we have made in the last ten years and what to expect in the future.

Biography

Jari Kinaret was born in Kokkola, Finland, and obtained his M.Sc. degrees in Theoretical Physics and Electrical Engineering from the University of Oulu in 1986 and 1987, respectively. He graduated with a Ph.D. in Physics from the Massachusetts Institute of Technology in 1992, and has since worked in various capacities at research institutes and universities in Copenhagen, Denmark, and Gothenburg, Sweden, currently as a Professor of Physics at the Chalmers University of Technology. He initiated the process that led to the Graphene Flagship being selected by the European Commission as one of the two first flagships of future and emerging technologies and has acted as the Director of the flagship since its launch in 2013. Kinaret is a member of the Royal Swedish Academy of Engineering Sciences.

Graphene and 2D materials and their translation for emerging applications

Professor Dusan Losic

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The University of Adelaide, School of Chemical Engineering, SA 5000 Adelaide, Australia

Abstract

Graphene and 2D materials having many outstanding properties are rapidly moving from academia to industry with development of hundreds of new products on market and emerging new industries. Having versatile and tailorable properties these materials are nicely positioned to solving many global problems in energy (storage), environmental (remediation), health and agricultural sectors. In this talk, some of the latest advancements from my group supported by ARC Research Hub for Enabled Industry Transformation will be presented. That will include examples on development scalable graphene manufacturing technology, progress on advancing graphene and 2D materials by their functionalization and tailored properties (adsorption, sensing, barrier, strength, electrical/thermal conductivity, compatibility) which are used for specific value add materials, products and device developments in collaboration with industry partners. Key translation cases of these developments such as protective functional coatings (anticorrosion, fire protection), energy storage (hybrid supercapacitors), radiation shielding, chemo-resistive sensors (biomedical diagnostics), water purification and environmental remediation (PFAS, heavy metals, CO_2), construction industry (concrete) agriculture (nutrients delivery, pest control) etc, will be highlighted. Contribution toward the development of simple and low-cost methods for characterization and quality controls of graphene related materials in bulk forms will be emphasized.

Biography

Prof Dusan Losic, is a professor at the University of Adelaide, the School of Chemical Engineering, Adelaide, former Director of Australian Research Council (ARC) Research Hub for Enabled Industry Transformation, currently Deputy Director of ARC Research Hub for Advanced Manufacturing with 2 materials (AM2D). His multidisciplinary research in Nanoscience and Nanotechnology including graphene and 2D materials is focused on engineering of new graphene related 2D materials (GR2Ms), exploring their properties and developing their products and devices in collaboration with industry partners for their translation for addressing real problems in industry, environment, energy, health, agriculture etc.

Electronic properties of marginally twisted bilayers of transition metal dichalcogenides

Vladimir Falko

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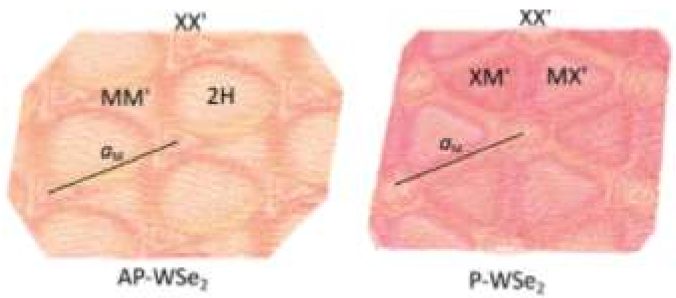
National Graphene Institute, the University of Manchester, M13 9PL, Manchester, UK

Abstract

We discuss lattice structure and physical properties of twisted bilayers of transition-metal dichalcogenide. We show that for ‘marginally’ (small-angle) lattice recbnstruction results in the neworks of domains with the energertically preferential stacking and domain walls, which are similar to dislocations in bulk crystals. In some cases, such domains feature weak interfacial ferroelectric polarisation, which gives rise to the tunability of domain wall networks by an out-of-plane electric field.



Also, inhomogeneous strain near domain walls gives rise to substantial pieelectric charges, producing -- together with stacking-dependent interlayer hybridization of band-edge states – arrays of dot-like features for electrons and holes in thetwisted bilayers. All these effects are fully quantified for twistronic TMD bilayers.

Biography

Vladimir Falko MAE is the leader of WP Enabling Science of Graphene Flagship. As a condensed matter theorist, he has been responsible for several advances in the theory of electronic and optical properties of atomically thin two-dimensional crystals and their heterostructures (graphene, transition metal dichalcogenides, post-transition metal chalcogenides), and he worked on various general aspects of quantum transport and fundamentals of nanoelectronics. His current interest is focused on twistronic structures of 2D materials. He is the Professor of Condensed Matter Theory and Director of National Graphene Institute and at the University of Manchester.

Passivating Graphene and Suppressing Interfacial Phonon Scattering with Mechanically Transferred Large-Area High-Dielectric-Constant Ga_2O_3

Michael S. Fuhrer

michael.fuhrer@monash.edu

School of Physics and Astronomy, Monash University, Melbourne, Victoria 3800, Australia

ARC Centre of Excellence in Future Low-Energy Electronics Technologies, Monash University, Melbourne, Victoria 3800, Australia

Abstract

Insulating layers are essential components for passivating electronics and enabling electrostatic gating. Hexagonal boron nitride (h-BN) has been widely used as a high-quality dielectric layer in van der Waals heterostructures, enabling a plethora of devices. However, production of high-quality large-area h-BN has remained challenging.

We have demonstrated ultrathin amorphous Ga_2O_3 synthesized on liquid Ga metal[1] as an alternative large-area passivation layer for graphene which is amenable to mechanical transfer and van der Waals heterostructure fabrication[2]. A comparison of temperature-dependent electrical measurements of millimeter-scale passivated and bare graphene on SiO_2/Si indicates that Ga_2O_3 passivated graphene maintains its high field effect mobility desirable for applications. Surprisingly, the temperature-dependent resistivity is reduced in passivated graphene over a range of temperatures below 220 K, due to the interplay of screening of the surface optical phonon modes of the SiO_2 by high-dielectric-constant Ga_2O_3 and the relatively high characteristic phonon frequencies of Ga_2O_3. Raman spectroscopy and electrical measurements indicate that Ga_2O_3 passivation also protects graphene from further processing such as plasma-enhanced atomic layer deposition of Al_2O_3.

[1] Ali Zavabeti, Jian Zhen Ou, Benjamin J. Carey, Nitu Syed, Rebecca Orrell-Trigg, Edwin L. H. Mayes, Chenglong Xu, Omid Kavehei, Anthony P. O'Mullane, Richard B. Kaner, Kourosh Kalantar-zadeh, Torben Daeneke. A liquid metal reaction environment for the room-temperature synthesis of atomically thin metal oxides. *Science* **358**, 332 (2017).

[2] Matthew Gebert, Semonti Bhattacharyya, Christopher C Bounds, Nitu Syed, Torben Daeneke, and Michael S. Fuhrer, *Nano Letters* **23**, 363 (2023).

Biography

Michael S. Fuhrer received his B.S. in Physics from the University of Texas at Austin in 1990, and Ph.D. in Physics from the University of California at Berkeley in 1998. After a postdoctoral appointment at Lawrence Berkeley National Laboratory, Fuhrer joined the University of Maryland as an Assistant Professor in 2000, and from 2009-2012 was Professor, and Director of the Center for Nanophysics and Advanced Materials. In 2012 Fuhrer was awarded an ARC Laureate Fellowship, and moved to Monash University as Professor of Physics in 2013. Fuhrer founded the Monash Centre for Atomically Thin Materials, and currently directs the ARC Centre of Excellence in Future Low-Energy Electronics Technologies. Fuhrer's current research interests lie in understanding the electronic properties of atomically-thin materials such as graphene, as well as topological insulators, newly discovered materials which are insulating in their interior but conduct along their boundaries.

Multifunctional Hybrid Composites

Ian Kinloch

Email: Ian.Kinloch@manchester.ac.uk

Dept. of Materials, National Graphene Institute and Henry Royce Institute, University of Manchester, UK

Abstract

The tuneability of composite materials leads to the promise of multifunctionality where a material can simultaneously provide good mechanical, electrical, thermal, barrier and fire retardancy properties. These individual properties, though, often have conflicting demands in their optimal microstructure, leading to compromises being made when designing the material. Hybrid composites in which 2D materials are combined with other traditional fillers is one potential route to address this challenge.

This talk will highlight the developments we have made across elastomer, thermoplastic and thermoset composites. In particular, we will show using FKMs how 2D materials give unique benefits to elastomers as the flakes behave as macroscale reinforcements despite their nanosize. These mechanism means that graphene nanoplatelets impart higher barrier, toughness and stiffness than tradition carbon blacks which reinforce through polymer bound on their surfaces. The electrical percolation of nanotube-carbon black-graphene filled polycarbonate composites will be studied through a combined electrical and modelling approach. It is found that the aspect ratio of the primary particles and the clusters they form determine the percolation threshold. In the case of hybrid systems the weighted average aspect ratio of the two filler types determines behaviour, with no synergy predicted or observed. Conductive AFM allowed mapping of the conductive pathways within the composite, allowing comparison between monte-carlo simulations and experiment. Finally an enclosed parameter window for values of the percolation threshold and the power exponent is found through tuning the ratio between the three fillers studied.

Biography

Ian is the Deputy Workpackage Leader of the Composites Workpackage within the Graphene Flagship. He holds the Royal Academy of Engineering/Morgan Advanced Materials Chair in Carbon Materials at the University of Manchester. His group sits across the Department of Materials, National Graphene Institute and Henry Royce Institute. His research covers the production, processing and use of nanomaterials with a focus on the energy transition (power materials and energy storage) and composite applications. He has previously held R.A.Eng/EPSRC Research and EPSRC Challenging Engineering Fellowships.

Getting Graphene into useful Structures and onto End-Users

Gordon Wallace

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Intelligent Polymer Research Institute, AIIM Facility, Innovation Campus, University of Wollongong, Wollongong, NSW 2500

Abstract

The excitement aroused by the discovery of the phenomenal physical properties of graphene has been tempered by our inability to translate these into practical devices and structures. Pristine graphene displays the physical properties we crave but is difficult to process. Addition of oxygen containing functional groups renders the material more processable but compromises properties. A number of innovative strategies to tackle this dichotomy have been investigated. Process as graphene oxide (GO): chemical exfoliation of graphene results in formation of graphene oxide (GO) with oxygen contents that render the material dispersible in water. If the GO sheets produced are sufficiently large, liquid crystalline phases are formed (1) and these can be used to produce GO fibres via wet spinning (2). After chemical reduction these fibres have found application as sensors and energy storage devices. Processable reduced graphene oxide (RGO): chemical reduction of GO while controlling the pH of the media results in formation of a conducting graphene with sufficient oxygen content to improve processability e.g. forming films/membranes by LBL deposition, by air brush spraying or filtration (3). These RGO electrode membranes exhibited some fascinating properties when used as electrodes for energy storage or for biomedical applications (4). In other work, this form of graphene has been used to coat cellulose - structures that have proven useful in studies aimed at developing implants that support bone regeneration (5). Edge functionalised graphene (EFG): our more recent discovery of EFG (6) has enabled us to capture the physical attributes of graphene while retaining processability. This unusual combination of properties enables high dispersability in aqueous or organic media enabling a diverse array of processing options. Of particular interest is the ability to create composites with a wide range of engineering and biomaterials (7).

References

1. R. Jalili et al., ACS Nano, **7** (5), 3981-3990 (2013). 2. R. Jalili et al., Adv. Funct. Mater., **23**, 5345-5454 (2013). 3. D. Li et al., Nat. Nanotechnol., **3** (2), 101-105 (2008). 4. H. Chen et al., Adv. Mater., **20** (18), 3557-3561 (2008). 5. J. Li et al., Mater. Sci. Eng. C, **107**, 110312 (2020). 6. G.G. Wallace et al., WO-2020073081-A1, Publication Date: 16/04/2020. 7. A. Naseri et al., 3D Printing and Additive Manufacturing (2022) https://doi.org/10.1089/3dp.2022.0169

Biography

Professor Gordon Wallace's specialty is design and discovery of advanced materials for application in energy and health. In health - new materials to improve human performance. In energy - new materials to transform and store energy, including novel wearable and implantable energy systems for medical technologies. He is committed to fundamental research and translation of discoveries into practical applications. He has published more than 1,100 refereed publications with in excess of 64,000 citations. He has been named as a co-inventor on more than 60 patents. In 2017 he was listed as the second most influential inventor in Australia. Professor Wallace is currently the Director of the Intelligent Polymer Research Institute, ANFF Materials node and TRICEP. In 2017 he was appointed an Officer of the Order of Australia. He is a fellow of the Australian Academy of Science and the Academy of Technological Science and Engineering.

A holistic full-cell approach towards designing practical Lithium Sulfur batteries

Mainak Majumder

E: mainak.majumder@monash.edu

Monash University

Abstract

The mature and reliable Lithium-ion battery (LiB) technology (<265 Wh kg^{-1}) is unlikely to be entirely replaced and yet is set to see a few competing battery chemistries that can outperform in more than one index of performance. Lithium-Sulfur (Li-S) battery is one such chemistry that promises a safer, more energy-dense, less expensive, and more sustainable storage technology.

I will describe the principal components of a LiS battery, the role and function of each component and the ideal characteristics that are required to overcome the principal challenges for designing practical batteries including issues such as increasing the areal Sulfur loading (> 4-5 mg_s/cm^2), decreasing the electrolyte requirements E/S ratio, increasing the coulombic efficiency and the cycle life, and finally, the design and manufacturing of LiS pouch cells.

To address these challenges, we have developed novel microstructures within the cathode capable of handling stress associated with lithiation and de-lithiation steps termed ‘expansion tolerant architectures’ [1]; introduced polysulfide regulating functional properties into cathodes by including molecules with redox properties [2]; and sulfur cathodes containing self-organized cellulose nanofibers [3] with low electrolyte to capacity ratio (<5 μL mAh^{-1}) and high ion and electron conductivity. These innovations have resulted in our team being able to produce >300Wh/Kg LiS Ah-level pouch cells which have shown to extend the cruising range of drones. One key component of the Li–S battery is the separator, because it holds tremendous promise for improving cycle-life by mitigating the well-known polysulfide shuttle, enabling lean electrolyte configurations, and restricting solid electrolyte interphase growth at the Li-metal anode. [4] We have demonstrated various new concepts such as self-assembled polyelectrolyte nanoparticles deposited on Celgard as functional separators. [5] Role of additives such as porous aromatic framework (PAF) decorated with sulfonated groups show polysulfide retention properties in conjunction with high Li^+ -ion diffusion properties [6]. More recently we have mimicked cell plasma membranes by integrating the abilities to provide rapid and permselective Li^+ channels alongside catalytic electrochemical reactions, we demonstrate a paradigm shift in the role of interlayers for achieving high-performance and practical Li-S batteries. [7]

*[1] Shaibani et al., **Sci. Adv**. 2020, **6**, eaay2757; [2] Huang et al., **Nat. Commun**. 2021, **12**, 5375; [3] Huang et al., **Adv.Energy Mater**, 2022, 2202474; [4] Jovanovic et al., **Advanced Materials Technologies** 6 (10), 2001136, 2021; [5] Jovanovic et al., ACS Appl. Energy Mater. 2020, 3, 8, 7908–7919; [6] Ghasemiestahbanati et al., J. Mater. Chem. A, 2022,10, 902-911; [7] Jovanovic et al., **Cell Reports Physical Science**, 2022*

Biography

Mainak Majumder is a professor in the Department of Mechanical and Aerospace Engineering of Monash University. He joined Monash as a lecturer in 2010 after his postdoctoral stint at Rice University, USA (2008-2010). He is the Director of the Australian Research Council’s Research Hub on Advanced Manufacturing with 2D Materials (AM2D), and an Associate Director of the Monash Energy Institute. He and his team have taken fundamental scientific breakthroughs in Graphene materials from the laboratory to market, including products such as energy-efficient water filtration systems and energy storage systems that can enable dissemination of IoT technologies.

Industrially produced 2D materials for energy applications

***Francesco Bonaccorso*[1,2]**

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Abstract

In this presentation we will provide an overview of the strategy of BeDimensional in the development of industrial-scale, reliable, inexpensive production processes of graphene and related two-dimensional materials (GRMs).[1-3] This is a key requirement for their widespread use in several application areas,[1-8] providing a balance between ease of fabrication and final product quality. In this context, we will show the effectiveness of the production of GRMs by wet-jet milling[3] and the route towards future Industrial scale up, maintaining the high-quality production ruled by the ISO standard.

Afterward, we will provide a brief overview on some key applications of the as-produced GRMs, with particular focus on the energy sector. In this context, the production of GRMs in liquid phase by wet-jet milling[3] represents a simple and cost-effective pathway towards the development of GRMs-based energy devices, presenting huge integration flexibility compared to other production methods. We will provide an insight into some application areas such as anticorrosion coatings and energy conversion and storage devices.[4-10]

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Biography

Francesco Bonaccorso is the Deputy of the workpackage Innovation of the Graphene Flagship, and He was responsible in defining the S&T roadmap for the project. He is the Scientific Director of BeDimensional SpA and visiting Scientist at the Istituto Italiano di Tecnologia. He gained the PhD from the University of Messina. In 2009 he was awarded a Royal Society Newton International Fellowship at Cambridge University, and elected to a Research Fellowship at Hughes Hall, Cambridge, where he also obtained a MA. He is author of 14 patents and more than 190 publications that have been cited more than 35000 times. He was featured as 2016 Emerging Investigator by J. Mater. Chem. A and in 2019 by ChemPlusChem. In 2018 he was recognized as Highly cited Scientist by Clarivate Analytics. In 2019 he received the Magister Peloritanus by Accademia Peloritana dei Pericolanti and ExAllievi Eccellenti by the University of Messina. He co-founded Cambridge Graphene Ltd and BeDimensional SpA.

Graphene in High Power Energy Storage Devices

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Abstract

High power energy storage devices, such as double-layer supercapacitors, have become one of the essential components of the electrification era. Traditionally, activated carbons have been used in manufacturing of industrial supercapacitors and their main material composition has not changed since the early 2000s. As a result, there has been little improvement in their performance metrics, such as energy density, and that has limited their pickup by the emerging applications which have higher energy and power requirements. Academia, on the other hand, has been promising significant improvement in certain performance metrics by using Graphene as an alternative to activated carbon, including power and energy density. However, adoption of the findings of the academic publications by the industry has been very slow, mainly due to the mismatch between the real-life requirements and the approach taken by most of the academics in developing and characterising electrodes produced by Graphene. This talk tries to address the gap between the academic literature and expectations of the industrial stakeholders as well as give insight to some of Ionic Industries developments in the field.

Biography

Dr. Meysam Sharifzadeh received his Ph.D. in Materials Science and Engineering from Nanyang Technological University, Singapore, in 2013. He has spent 5 years at the Institute of Materials Research and Engineering, A*STAR as a Research Scientist, working on different technologies including materials for energy harvesting, electromechanical energy conversion, and energy storage. In March 2018, he joined Monash university as a Research Fellow focusing on design and fabrication of electrode materials for different energy storage devices, especially supercapacitors. Today, he leads Ionic's R&D activities in developing graphene and graphene-enabled materials for different applications such as energy storage and smart sensors.

Graphene for energy applications

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Graphene Manufacturing Group Ltd.

Abstract

Graphene Manufacturing Group Ltd (GMG) is a leading manufacturer of graphene products and is developing technologies for the Energy Savings and Energy Storage markets. In the frame of this talk, I will introduce GMG and its role in the clean energy market. The focus of the talk will be on the Graphene Aluminium-ion battery technology co-developed by the University of Queensland and GMG. The potential applications of this technology range from consumer electronics to electric vehicles and renewable energy storage systems. The talk will also highlight the efforts being made by GMG in the Energy Savings market with graphene-based products.

Biography

Ashok Kumar Nanjundan received his Doctor of Engineering degree in Materials Chemistry in 2010. He is a recipient of several prestigious fellowships, namely, the Marie Curie Fellowship, the Japanese Society for the Promotion of Science (JSPS) Fellowship, and the UQ Fellowship. He is currently the Chief Scientific Officer at Graphene Manufacturing Group Ltd., Australia, where he leads the company's research efforts in advanced materials for energy applications. He holds Adjunct Associate Professor positions at the School of Chemical Engineering at The University of Queensland and the Queensland University of Technology. With over 20 years of combined academic and industrial experience, his expertise lies in synthesising carbon-based nano-structured materials for emerging energy storage applications, particularly lithium- and post lithium-based batteries.

Electrifying graphene-based ion nanochannels

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Abstract

Ion transport in nanopores or nanochannels is involved in a variety of biological and chemical processes related to energy, water and biomedicine. If the nanochannels are made of electroconductive materials, the nanochannels can be directly charged or electrified with an external electrical potential through the formation of electric double layer on the nanochannel surfaces. As manifested by tremendous research related to supercapacitors in the past decades, the direct electrification of nanoporous electrodes can lead to strong surface polarisation and a substantial variation of the local ion population inside the nanochannels, enabling the emergence of new nanoconfined ion transport phenomena. In this talk, I will first give a brief overview about our group's research on graphene-based soft materials and then discuss how multilayered reduced graphene oxide membranes with interlayer distance tuneable in the sub-10 nm range can serve as a versatile experimental platform to probe and manipulate nanoconfined ion transport under electrification. I will also discuss the challenges and future opportunities in this emerging field.

Biography

Professor Dan Li is an Australian Laureate Fellow at the Department of Chemical Engineering, the University of Melbourne, Australia. He was a co-director of Monash Centre for Atomically Thin Materials (2015-2017). He received the ARC Queen Elizabeth II Fellowship in 2006, the Scopus Young Researcher of the Year Award (Engineering and Technology) in 2010, ARC Future Fellowship in 2011, Australian Laureate Fellowship in 2018. His research interests include graphene-based soft materials, nanoionics, electro-ionic systems and their application for energy storage and conversion, resource extraction, water purification and healthcare.

Nanoporous Nitrides and their Hybrids: A Unique Solution for Clean Energy and Environment

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Abstract

Innovative approaches to translate basic nanomaterials research into real-world products are critical for our future. Nanotechnologies can deliver successful energy, environment and health solutions - such as converting carbon dioxide into clean fuel with only sunlight and water and developing innovative devices for energy storage and conversion. In this talk, I will present the development, capabilities, and current and future applications of multifunctional nanoporous materials. Especially, much focus will be given to the fabrication of new family of semiconducting nanostructures composed of carbon and nitrogen (carbon nitrides) with different pore diameters, nitrogen contents, and structures.[1-7] I will demonstrate how the chemical composition, structure, porosity and the functionalization of these unique materials can be tuned, as well as the fabrication of CN with single molecular precursors with C, N, S elements and with 2D nanostructures including graphene and metal sulphides. These two-dimensional nanostructures offer high electronic conductivity which are useful for energy storage applications. In the last part of the talk, I will present on the energy storage and photocatalytic performance of these unique nanoporous carbon nitrides and their hybrids. Much focus will be given on the photocatalytic conversion of seawater, its mechanism, and the stability of these nanoporous carbon nitride materials.

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Biography

Prof. Vinu is currently working as a Global Innovation Chair Professor and Director of Global Innovative Center for Advanced Nanomaterials at the University of Newcastle and made a significant contribution in the field of nanoporous materials and their application in energy storage, fuel cells, carbon capture and conversion, hydrogen technologies, catalysis and drug delivery. His contribution has led to ca. 500+ papers with 28,700 citations and a H-index of 86, and more than 32 patents. He has been ranked number 1 (last 20 years) and number 7th (last 50 years) in Australia among the Top 2% scientists in the field of "Materials" as per the database created by the Stanford University in 2020, reflecting his high-quality research and research impact that he made in this field. The quality of his research has been recognised with several international awards including Medal, Chemical Research Society of India 2018, SPARC award 2019, CNR Rao Lectureship award 2019. Medal and KY NIEM CHUONG Award 2018, Scopus Young Researcher Award 2014, Friedrich Wilhelm Bessel award by the Humboldt Society (2010), JSPS Senior Invitational Fellow 2014, Australian Future Fellowship 2010, Indian Society for Chemists and Biologists award for excellence 2010, Catalysis Society of India Young Scientist award 2010, Chemical Society of Japan Award for the Young Scientist 2008, and Laureate of Khwarizmi International Award 2008. Prof. Vinu is honoured with the Fellow of Royal Society of Chemistry, RACI, World Academy of Ceramics, World Academy of Art and Science, Indian Chemical Society, and Asia-pacific Academy of Materials.

Low Carbon Emission Manufacturing of Carbons from Agricultural Waste

Prof. Deepak Dubal

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Abstract

Carbon materials are often produced via carbonization, ranging from carbon black, activated carbon, graphene, carbon nanotubes (CNTs), and carbon dots to carbon fibers. The traditional heating methods used for carbonization and graphitization include using conventional furnaces, spray pyrolysis, or solvothermal reactors. The thermal energy is transferred from the heating element of a heating instrument to carbon precursors via thermal radiation, convection, or conduction through various mediums. Extensive studies have shown that carbon materials 'structure and texture strongly depend on their heat treatment temperature, heating/cooling rates, duration, and environment. We proposed new rapid heating method to prepare carbon products including graphene-like carbons using agricultural waste feedstock. Unlike conventional pyrolysis process where the heating rate is limited to 5 degree/min (takes longer time to reach desired temperature) and resident time is in hours (5 to 10 hr), the new method provides rapid heating (ultra-fast heating rate >50 degree/min) and resident time is in minutes (10 to 30 min).

Biography

Dr. Deepak P. Dubal is currently working as Professor at the Queensland University of Technology (QUT), Australia. He is a prolific, well-cited, and multiple-fellowship-winning scientist. His achievements are honoured by several prestigious fellowships such as Brain Korea-21 (GIST, South Korea- 2011), Alexander von Humboldt Fellow (TUC, Germany-2012), Marie Curie Fellow (ICN2, Spain-2014) and Vice chancellor Fellow (UoA, Australia-2017). In 2018, he won an exceptionally competitive ARC - Future Fellowship and moved to QUT. Prof. Dubal has published over 250 peer reviewed journal articles, which has attracted more than 17,000 citations with 'h'-index of 70 and i10 index of 180. He receives regular international recognition for his work including being listed among the World's Top 2% of Scientists for his lifetime achievements in last three years (2019-2021) in the field of 'Energy' (Stanford University rankings), and as one of Australia's top-100 Materials Scientists, appointments as Visiting Guest Professor at Mid Sweden University (MSU), Sweden, and Foreign Young Associate Fellow of Maharashtra Academy of Sciences (FFMAS), India. His research expertise is in the design and development of functional materials for clean energy conversion and storage technologies. In addition, his team is extending research area in radiant heaters, biomass valorisation and battery recycling, aiding towards the circular economy and sustainable practices.

Toxicity of graphene-based materials

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Abstract

In the last ten years, the work package Health and Environment of the Graphene Flagship has focused on the investigations of the physicochemical properties and the biological interactions of graphene-related materials (GRMs) following their introduction into biological systems, taking into account the potential routes of exposure. The assessment of the potential impact of graphene, graphene oxide and other 2D materials on health and the environment is a key step on the development of current and future technologies based on these materials. In this talk I will highlight the potential risks of using GRMs and the solutions to overcome them, in view of their REACH registration as new and "safe" chemicals.

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https://euon.echa.europa.eu/documents/2435000/3268573/echa_2021_286_graphene_study.pdf

Biography

Alberto Bianco received his PhD in 1996 from the University of Padova. As a visiting scientist, he worked at the University of Lausanne, the University of Tübingen (as an Alexander von Humboldt fellow), the University of Padova and Kyoto University. He is currently First Class Director at the CNRS in Strasbourg. His research interests focus on the design of multifunctional carbon and 2D nanomaterials for therapy, diagnostics and imaging. He is also interested on their health impact, particularly on the immune system. He has published more than 330 articles (h-index: 90, > 47500 citations). In 2017 he has been elected Fellow of the European Academy of Science and in 2020 of the Academia Europaea, and in 2019 he has obtained the CNRS Silver Medal. Since 2011 he is Editor of the journal CARBON.

High-Dimensional Approaches for Immune Profiling of 2D Materials

Lucia Delogu

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Abstract

We recently depicted the "Nano-immunity-by-design" where the characterization of 2D materials is not solely based on their physical-chemical parameters but also on their immuneprofiling. [1] The immune-profiling can be revealed on its complexity by unique, informative ways: high dimensional approaches. [2,3] We exploited high-dimensional approaches, such as single-cell mass cytometry and imaging mass cytometry on graphene and other novel two dimensional materials, such as transition metal carbides/carbonitrides (MXenes). [4-6] We revealed that the amino-functionalization of graphene oxide increased its immunocompatibility. [4] Moreover, we combined graphene with AgInS2 nanocrystals, enabling its detection by single-cell mass cytometry on a large variety of primary immune cells. [5] Recently, we reported the immune modulation of specific MXenes, and their label-free detection by single-cell mass cytometry and other high dimensional approaches. [6-7] Together with our published works, I will present unpublished results on a wider variety of novel 2D materials, Mxenes, MoS2, WS2, and bismuthene. Our results conceptualize that chemical and immnological designs of 2D materials offer new strategies for their safe exploitation in biomedicine.

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Biography DL Move photos int Biography text

Lucia Gemma Delogu is head of the ImmuneNano-Lab at the Department of Biomedical Sciences of the University of Padua (UNIPD, Padua, Italy) and visiting professor at New York University Abu Dhabi. She acquired her experience in Material Science, Immunology, and Nanotechnology at the University of Southern California (Los Angeles, USA) and Sanford-Burnham Institute (San Diego, USA), and at Technische Universität Dresden (TUD; Dresden, Germany). Prof. Delogu has been the Scientific Coordinator of four interdisciplinary European projects under HORIZON2020 (G.-IMMUNOMICS, CARBO-IMMAP, and SEE) and she currently coordinates the project MX-Map on developing 2D materials MXenes for biomedical applications involving 14 Institutions, 11 countries, and two companies. Prof. Delogu has received several awards, including the "Marie S. Curie Individual Fellow", the "200 Young Best Talents of Italy 2011" from the Italian Ministry of Youth, and the "Bedside to Bench & Back Award" from the National Institutes of Health, USA. Since 2020, Prof. Delogu is in charge of the Italian chapter and a member of the road map working group of the Advanced Material Global Pandemic & Future Preparedness Taskforce (AMPT) www.amptnetwork.com/. She introduced the "NanoImmunity-by-design" concept and pioneered the use of high-dimensional single-cell approaches in the context of 2D materials. Her works appeared in major journals, including Advanced Materials, Nature Communications, Nano Today, and ACS Nano.

Graphene and layered materials for photonics and optoelectronics

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Abstract

Graphene and layered materials have great potential in photonics and optoelectronics, where the combination of their optical and electronic properties can be fully exploited, and the absence of a bandgap in graphene can be beneficial. The linear dispersion of the Dirac electrons in graphene enables ultra-wide-band tunability as well as gate controllable third-harmonic enhancement over an ultra-broad bandwidth, paving the way for electrically tuneable broadband frequency converters for optical communications and signal processing. Saturable absorption is observed as a consequence of Pauli blocking and can be exploited for mode-locking of a variety of ultrafast and broadband lasers. Graphene integrated photonics is a platform for wafer scale manufacturing of modulators, detectors and switches for next generation datacom and telecom. These functions can be achieved with graphene layers placed on top of optical waveguides, acting as passive light-guides, thus simplifying the current technology. Heterostructures based on layers of atomic crystals have properties different from those of their individual constituents and of their three dimensional counterparts. The combinations of such crystals in stacks can be used to design the functionalities of such heterostructures, that can be exploited in novel light emitting devices, such as single photon emitters, and tuneable light emitting diodes.

Biography

Andrea Ferrari is Professor of nanotechnology at the University of Cambridge and a Fellow of Pembroke College. He founded and directs the Cambridge Graphene Centre and the EPSRC Centre for Doctoral Training in Graphene Technology. He chairs the management panel and is the Science and Technology Officer of the European Graphene Flagship. He is a Fellow of the Royal Academy of Engineering, the American Physical Society, the Materials Research Society, the Institute of Physics, the Optical Society, the Royal Society of Chemistry, The European Academy of Sciences, the Academia Europaea, and he received numerous awards, such as the Royal Society Brian Mercer Award for Innovation, the Royal Society Wolfson Research Merit Award, the Marie Curie Excellence Award, the Philip Leverhulme Prize, The EU-40 Materials Prize.

Two-dimensional materials for next-generation electronics and optoelectronics technologies

Sumeet Walia[a]

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Abstract

Atomically-thin materials possess unique intrinsic properties and are amenable to a range of tuning techniques. We harness these properties underpinned by application demand and work with industry to translate into end-user products.

Firstly, we synthesise a variety of atomically-thin metal oxides, mono/dichalcogenides and elemental 2D materials using solid, liquid and vapour phase techniques guided by application.

Our fundamental advances have been uncovering the origins of oxidative degradation in few-layer black phosphorus (BP) and subsequently proposing an ionic liquid-based approach to prevent ambient degradation of BP. Using defect engineering, we have demonstrated light operated artificial- synaptic and logic devices and neural networks that can recognise numbers and patterns. We have explored the use of hybrids of dissimilar materials to enhance electronic and optical performance. Ultra-thin layers have been used to develop one of the world's thinnest photodetectors that can sense all shades of light from UV-infrared. We further study strain-tunability in low-dimensional structures via integrating them onto elastomeric platforms.

Using a cross-disciplinary approach, we deploy multifunctionality of these new material systems into solving technological challenges for a range of industry partners.

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Biography

Sumeet Walia is a Professor of electronics and materials engineering at RMIT University in Melbourne, Australia. His interdisciplinary research explores fundamentals of low-dimensional materials to underpin applications in miniaturized smart electronics, optoelectronics, functional coatings, neuromorphic sensors, and antimicrobial technologies. He is passionate about solving industry challenges using fundamental innovation for the benefit of the end user.

Graphene integrated devices

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Abstract

Metamaterials comprising alternating graphene and dielectric layers are artificially structured materials designed to attain extremely high optical responses. Graphene-based metamaterials with layered artificial structure can enhance optical modulation leading to diverse applications. However, the fabrication of graphene-based metamaterials remains significantly challenging due to the inaccurate control and sophisticated transfer process of conventional mechanical exfoliation and deposition methods, restricting experimental demonstrations to only a few examples. In this talk, I will present a low-cost solution-phase method that generates a multilayered metamaterial consisting of alternating monolayer graphene oxide (GO)/graphene and dielectric layers without a transfer step. The single-step method produces metamaterial on diverse substrates with arbitrary surfaces, shapes, and sizes. Such graphene metamaterials pave the way to multifunctional integrated devices due to their exceptional mechanical, thermal, optical, and electrical properties not available in conventional materials. This talk explores the optoelectronic applications of graphene metamaterials by using the direct laser printing (DLP) method.[2] Our results demonstrate the great potentials of graphene metamaterial films as an emerging integratable platform for ultrathin, light-weight and flexible photonic devices towards all-optical communications, microscopic imaging and energy storage applications.

Biography

Baohua Jia joined RMIT in 2022 as a full professor and Australian Research Council Future Fellow in School of Science. Before joining RMIT Baohua was the Founding Director of Centre for Translational Atomaterials at Swinburne University of Technology. Prof. Jia's research focuses on the fundamental light and nano-and atomaterial interactions. In particular her work on laser manipulation of two-dimensional materials has led to the design and fabrication of functional nanostructures and nanomaterials for effective harnessing and storage of clean energy from sunlight, purifying water and air for clean environment and imaging, spectroscopy and nanofabrication using ultrafast laser towards fast-speed all-optical communications and intelligent manufacturing. Prof. Jia has co-authored more than 230 scientific publications in highly ranked journals and prestigious international conferences. She has delivered more than 60 keynote/invited talks at prestigious international conferences and serves multiples professional committees. She has received numerous prizes and awards, including the ARC Future Fellow, DECRA and APD, Finalist for the Prime Minister's Science Awards, Young Tall Poppy Science Award, and L'Oréal Australia and New Zealand for Women in Science Fellowship et al.

Wafer scale deposition of Graphene and 2D materials and their integration into devices

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Abstract

Growth and device results are presented from small scale up to 200mm/300mm wafer scale. Catalytic growth of graphene on metal catalysts (in particular Cu, Ni), graphene growth directly onto sapphire as well as 2D material deposition will be discussed.

For graphene growth onto metal catalysts, integration schemes such as transfer or in-situ removal of the metal catalyst will be shown. Devices made in the framework of the Graphene Flagship will also be featured as part of this presentation.

Recently, using MOCVD (metal organic chemical vapour deposition), the full "tool kit" of 2D materials can directly be grown into sapphire. The tool kit of materials covers graphene (semi-metallic), hBN (insulator/enpcapsulation), WS_2 (n-type), MoS_2 (n-type) and WSe_2 (p-type). The ability to deposit these materials in a single reactor enables the direct formation of heterostructures, opening up the possibilities for manufacturing future devices with unique electronic, optoelectronic and photonic applications.

Biography of Presenter

Ken Teo is the Chair of the Executive Board, Graphene Flagship. He is the Managing Director at AIXTRON Ltd (UK) and Group Innovation Officer at AIXTRON Group. He holds a BE (Elec) from the University of Canterbury, MBA and PhD from the University of Cambridge. In 2005, Dr. Teo founded and ran Nanoinstruments Ltd (UK) which manufactures innovative Graphene and Carbon Nanotube growth equipment for research and industry; in 2007, Nanoinstruments was acquired by AIXTRON. His previous roles include Director of Nanoinstruments at AIXTRON, Lecturer in Electrical Engineering at University of Cambridge, Fellow/Director of Studies at Christ's College Cambridge, Royal Academy of Engineering Research Fellow, Fellow of the Institute of Nanotechnology, Project Engineer at Defence Material Organisation (Singapore) and Product Engineer at PDL Holdings (NZ). Dr Teo has extensive experience in the area of carbon nanomaterials and is the author/co-author of ~200 papers and 35 patents/applications.

h-BN and III-V semiconductor nanostructures

Hoe Tan

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Abstract

Hexagonal boron nitride (h-BN) is a unique 2D layered, wide bandgap semiconductor that is used as a dielectric layer in many field effect devices based on 2D materials. Point defects in h-BN can be used as single photon sources for quantum computing and bio-diagnostics. h-BN can be also used as template to grow III–V compound semiconductor materials through van der Waals epitaxy that facilitate the development of flexible electronic devices. However, currently available h-BN is limited to a few mm in size. In this presentation, I will give an overview of our effort to grow wafer-scale h-BN by metal organic chemical vapour deposition technique.

In the second part of my talk, I will also discuss selective area growth of III-V nanostructures, showing the possibility of obtaining functional nanostructures such as nanowires, nanomembranes, micro-rings etc. These shape-engineered nanostructures open up possibilities of new applications based on devices with novel geometries.

Biography

Prof. Tan's research focusses on the epitaxial growth of low dimensional III-V semiconductors and devices. He has published/co-published over 550 journal papers and 6 book chapters, with over 20,000 citations and a h-index of 65. He is also a co-inventor in 6 US and 2 Australian patents related to laser diodes, infrared photodetectors and catalysis. Prof. Tan is a Fellow of the IEEE and was the Distinguished Lecturer for IEEE Nanotechnology Council (2016 & 2017) and IEEE Photonics Society (2016-2017). He was named "Australia's leading researcher in nanotechnology" by The Australian's research magazine in 2020. Prof. Tan is the director of the $25M Australian Nanofabrication Facility - ACT Node, which provides micro/nano-fabrication facilities for the R&D communities.

Biocompatible Graphene Sensors for the Detection and Remote Monitoring of Chronic Diseases

Vincent Bouchiat

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Abstract

Graphene appears as a very promising material for bioelectronics for both in- vitro and in-vivo sensing applications. Indeed, it combines in the same film biocompatibility [1,2], mechanical flexibility, optical transparency and high mobility Field effect [3]. The mass production of Single layer film by CVD on Copper foil has enabled the production of disposable biosensing devices with competitive pricing.

At Grapheal, we have explored the use of graphene-on-polymer for enabling at the same time biosensing and tissue engineering [4] with integration to RFID component to enable direct smartphone connectivity. I will show the application of graphene surface functionalization to implement sensitive and selective biosensors. Finally, I will show prospects for consumer applications that unlock new use cases [5] for wearable and in-vitro diagnostics.

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[4] Le Gall et al. doi: 10.1101/2021.05.16.444337 (2021)
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Biography

Vincent Bouchiat is the Founder and CEO of Grapheal, a company spin-off from Neel Institute focusing on bioelectronics and healthcare applications of monolayer graphene. He is on leave from the French National Research Center (CNRS) at Grenoble, where he has a permanent position since 1997. He received an engineer degree from ESPCI in 1993 and has completed his Ph.D. on quantum devices at CEA-Saclay & Paris University in 1997 under supervision of Michel Devoret.

He co-authored more than 110 publications in electron transport in nanodevices with over 5500 citations and hold 9 international patents. He received the Visiting Miller Professorship Award from University of California, Berkeley in 2007, and the Lee Hsun Research Award from the Chinese Academy of Sciences (2017).

Epitaxial graphene sensors for EEG -based brain-machine interfaces

Prof. Francesca Iacopi

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Centre of Excellence in Transformative Meta-Optical Systems (TMOS)

Centre of Excellence in Low-Energy Electronics Technologies (FLEET)

Abstract

Electroencephalography (EEG) is an efficient non-invasive approach for early detection and monitoring of neurodegenerative diseases, as well as of sleep patterns, cognitive stress loads, and more recently, it is finding applications as means for wearable brain-machine interfaces [1].

However, for a mainstream uptake of EEG outside of a clinical setting, the main bottleneck for achieving portable EEG is the availability of suitable dry sensors [2]. Dry sensors tend to show a high contact impedance with the skin, impeding an accurate read-out of the strongly attenuated ~μV amplitude biopotentials to be collected on the scalp [3].

We demonstrate the use of epitaxial graphene on silicon carbide on silicon as a low- contact impedance EEG sensorreliable upon long-term usage [4]. The graphene sensors are wafer- thin, biocompatible, and show a lower contact impedance than commercial sensors. We observe that their contact impedance improves once in contact with the skin, thanks to a gradual wetting of the graphene's surface [5]. The epi graphene sensors are also remarkably resilient to corrosion. We will discuss the latest progress in the use of epitaxial graphene sensors for the hands-free control of a remote robotic platform in collaboration with the Australian Army.

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Biography

Professor Francesca Iacopi has over 20 years' industrial and academic research expertise in semiconductor technologies, with 160 peer-reviewed publications and 10 granted US patents, spanning interconnects, CMOS devices and packaging. Her research focuses on the translation of basic scientific advances in nanomaterials and novel device concepts into implementable integrated technologies. She is known for her seminal work on the integration of porous dielectrics in on-chip interconnects, and for the invention of the alloy -mediated epitaxial graphene platform on SiC/Si pseudo-substrates.

She was recipient of an MRS Gold Graduate Student Award (2003), an Australian Research Council Future Fellowship (2012), and a Global Innovation Award in Washington DC (2014) and was listed among the most innovative engineers by Engineers Australia (2018). Francesca is a Fellow of the Institution of Engineers Australia, an IEEE EDS Distinguished Lecturer and serves regularly in technical and strategic committees for IEEE and MRS. She is an Elected Member to the IEEE EDS Board of Governors and serves in the Editorial Advisory Board for ACS Applied Nanomaterials, and the IEEE The Institute magazine. She leads the Integrated Nanosystems Lab, in the Faculty of Engineering and IT, University of Technology Sydney.

Green Graphene Quantum Dots for Wearable Sensor Devices

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Abstract

Graphene quantum dots (GQDs) are fragments or nanodiscs of graphene with lateral sizes typically less than 20 nm [1–6]. GQDs' unique optical, electrical, and magnetic properties arising from the quantum confinement effect and semiconductor nature have received significant research interest. They offer profound prospects in various applications including bioimaging [7], single-electron transistors [8,9], spintronics [10,11], quantum memory [12], amongst others. Moreover, since they are comprised of no more than one hundred or so carbon atoms, GQDs are largely assessed as a low to no toxicity material. While their optical properties can be employed for chemical/biochemical sensing, our recent study has found that electron tunnelling can occur among GQDs embedded in a polymer film, which adds a powerful new mode for GQDs to operate as a key component of wearable sensors. [13] In this talk, I will first introduce a couple of green methods for fabricating GQDs [14], followed by an example of utilising the electron tunnelling effect to devise GQDs into a wearable strain sensor.

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Biography

Dr. Qin Li is a Professor at Queensland Micro- and Nanotechnology Centre, and School of Engineering and Built Environment, Griffith University. She is the co-founder and co-chair of the Green and Sustainable Chemistry & Engineering National Group at Royal Australian Chemical Institute. She obtained her Bachelor and Master degrees from Zhejiang University, and a PhD in Chemical Engineering from the University of Queensland (2002). Her research interests span from nanocarbons, colloids and interfacial engineering, to functional materials and sustainable technologies, addressing wide application fields in water, energy and healthcare. Qin was a Marie Curie Fellow hosted by the Max Planck Institute for Polymer Research (2006 – 2008), and a finalist of Women in Technology in 2015 and 2020, respectively. She has edited 2 books, and co-authored 6 book chapters, 120 + journal papers and 4 international patents with an h-index of 48.

Commercialisation of Graphene Oxide Membrane

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Abstract

Graphene has made quite an impact on the way we think about 2D materials and their use. Graphene Membranes have been made in the laboratory across many research groups displaying ultrafast water transport, precise molecular sieving of gas and solvated molecules and offer great promise in novel separation platforms.

Here, we report on the findings from practical demonstration of our industrial scale manufactured spiral wound Graphene Membranes. Applications that have been investigated include drinking water organic removal, treated effluent treatment, horticulture water recycling and grey water recycling.

Biography

Abozar Akbari is the R&D Manager at NematiQ Ltd Pty. NematiQ is a 100%-owned subsidiary of Clean TeQ Water, an ASX-listed company. Abozar started his journey in graphene technology back in 2011 and has spent the past decade developing graphene-based raw materials and membranes. Abozar undertook his PhD at Monash University, where he invented the technology to fabricate graphene membranes using a process that has the potential to operate at commercial scale. Abozar is now the R&D Manager at NematiQ in charge of new product development and product applications research.

2-Dimensional nanosheets for water filters: an example of translational technology within the Graphene Flagship

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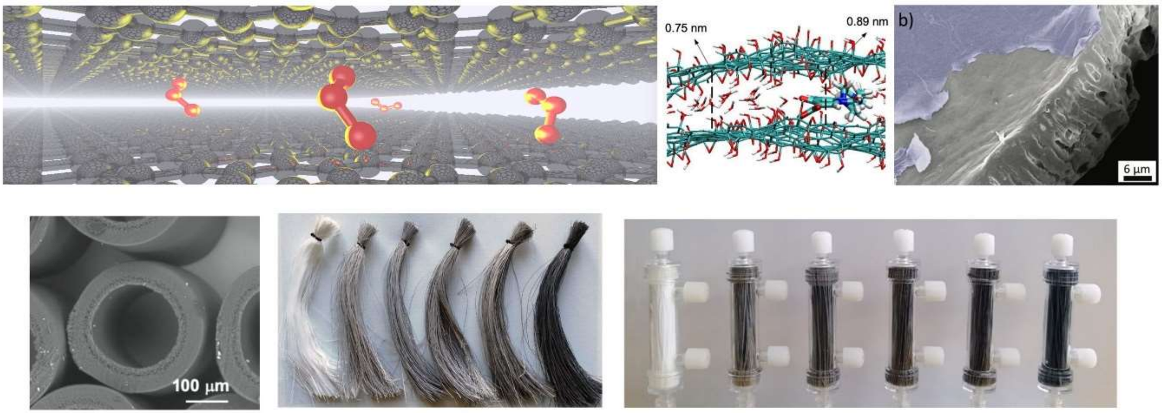
Abstract

The industrial exfoliation of 2-dimensional nanosheets allows to produce novel, layered nano-composites which would be impossible to make with conventional 3D materials or 1D polymers. In such composites, the gap between stacked nanosheets forms a unique, highly anisotropic environment where water, small molecules or ions can diffuse following physical and chemical processes as exotic as the better-known charge transport of electrons in graphene.

In the Graphene Flagship, we produced and tested novel composites where 2D materials, and in particular Graphene Oxide (GO), are combined with commercial filters to remove water contaminants like pesticides, drugs, perfluoroalkyl substances (PFAS) and metal ions. The tunable surface chemistry of GO allows to process these composites by extrusion, coating or filtration, to stabilize them using temperature or microwaves, to enhance their ability to capture contaminants thanks to selective intercalation, electrostatic interactions or π-π stacking. We characterized such composites from atomic scale to complete filter devices using a combination of computational and experimental techniques, in collaboration with different industrial partners of the Graphene Flagship; we also compared their performance with state-of-the-art technology (activated carbon), showing more efficient and faster removal of some of the most challenging contaminants.



Biography

Vincenzo Palermo is the director of the Institute for Organic Synthesis and Photoreactivity (ISOF) of the National Research Council of Italy, and associated professor of Chalmers University of Technology (Sweden). He uses nanotechnology and supramolecular chemistry to create new materials for aerospace, environmental and biomedical applications. He published >190 scientific articles on international journals in chemistry, nanotechnology and materials science (>8000 citations, h-index >52), collaborating with key industrial partners in Europe (Airbus, FIAT, Leonardo, BASF, Nokia, STMicroelectronics etc.).

He had been vice-director, leader of WP on Dissemination and leader of WP on Composites of the Graphene Flagship, one of the largest research projects ever launched in Europe. He won the Lecturer Award for Excellence of the Federation of European Materials Societies (FEMS), the Research Award of the Italian Society of Chemistry (SCI) and the Science dissemination awards of the Italian Book Association.

Standardisation and the Graphene Flagship

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Abstract

Standards play an important role in taking new technologies or materials from university labs to factories and into new products.

This presentation will describe the current status of standardisation of graphene and other 2D materials. What is in place? What is the role of the Graphene Flagship and what has been done?

The need to develop new standards remains high and participation in the standardisation process is becoming increasingly important for companies in order to be competitive. That is, competitive also to other materials and technologies than the two-dimensional ones our community is focused on.

Biography

Johan Ek Weis is the task leader for standardisation within the Graphene Flagship. He is also the Chair of SIS TK 516 Nanotechnologies, which is the Swedish mirror committee of ISO 229. After several years as an academic researcher (MSc, PhD and postdocs) in five different countries studying graphene and carbon nanotubes, he started focusing on taking graphene from the lab to the industry in 2015. He has helped numerous companies using graphene and is part of the program office of SIO Grafen. SIO Grafen is a Swedish strategic innovation programme which has involved 200 organisations in innovations with graphene. He holds a MSc from Chalmers University of Technology and a PhD from the University of Edinburgh.

How to Decide on the Best Graphene Material for your Specific Application

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Abstract

Graphene has increasingly been considered in many areas of applications. A major barrier from consideration to actual adoption of Graphene is understanding the quality of Graphene required for the specific application at hand. This is evident through the setbacks experienced by the early adopters of the wonder material, who were left underdelivered on the expected performance aspects. As the overall volume from new production methods and the quality of the resulting graphene have both increased over time, we are starting to finally see graphene's true benefits. With it, a better understanding of the way in which Graphene behaves in different applications. Even within an industry, there are countless variables between manufacturers which dictates the exact quality and quantity of Graphene required to achieve the expected benefits. Collaboration with a research institute, or a Graphene manufacturer who have similar capabilities and resources to understand your exact requirements is the most prudent way forward. Through research and development, you will be able to identify the exact quality of Graphene and how much is required for your application.

Biography

Manju counts over 20 years in Research and Innovation in various subject areas including Nano technology, Agriculture, Pharmaceutical, Advanced material & Engineering. He started his career as an Electronics Engineer and specialized in military electronics. Manju has worked in some of Sri Lanka's leading engineering companies such as TOS Lanka Co Pvt Ltd, Orange Electric as a Director Engineering and Head of research responsible for product development and research management. Currently he is a Director of Ceylon Graphene technologies, Sri Lanka Institute of Nano Technology (SLINTEC), LOLC Advanced Technologies and Fortigrains. Manju has secured multiple international awards including 3 Geneva Innovation Congress Gold Medals and one Silver Medal.

Exploring Key Commercial and Development Activities in Graphene Applications: An Update on First Graphene's Progress

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Abstract

First Graphene is a leading graphene supplier and developer of innovative graphene applications. In this presentation, we will provide an update on the company's recent commercial activities and developments in the field of graphene applications.

Our discussion will focus on three key topics: graphene in cement applications, graphene in thermally conductive polymers, and graphene in supercapacitors. We will examine the latest research and developments in each of these areas and highlight the benefits that graphene brings to these applications.

Biography

Neil Armstrong is currently serving as the Commercial Manager at First Graphene, a leading graphene supplier and developer of innovative graphene applications. He is an effective and hands-on problem solver, driven by innovation, sustainability, and the future.

Neil has played a critical role in the design and commissioning of First Graphene's world-leading production facility in Henderson, Western Australia. He has been instrumental in developing new equipment and processes focused on the commercial-scale production of graphene and its industrial applications.

With over a decade of experience in the manufacturing and technology industries, Neil has demonstrated expertise in project management, research and development, and commercialization. He is passionate about driving innovation and sustainability in the industry and has worked towards the goal of making graphene a commercially viable material for various applications. Neil's dedication and expertise have contributed significantly to First Graphene's success in the field of graphene applications.