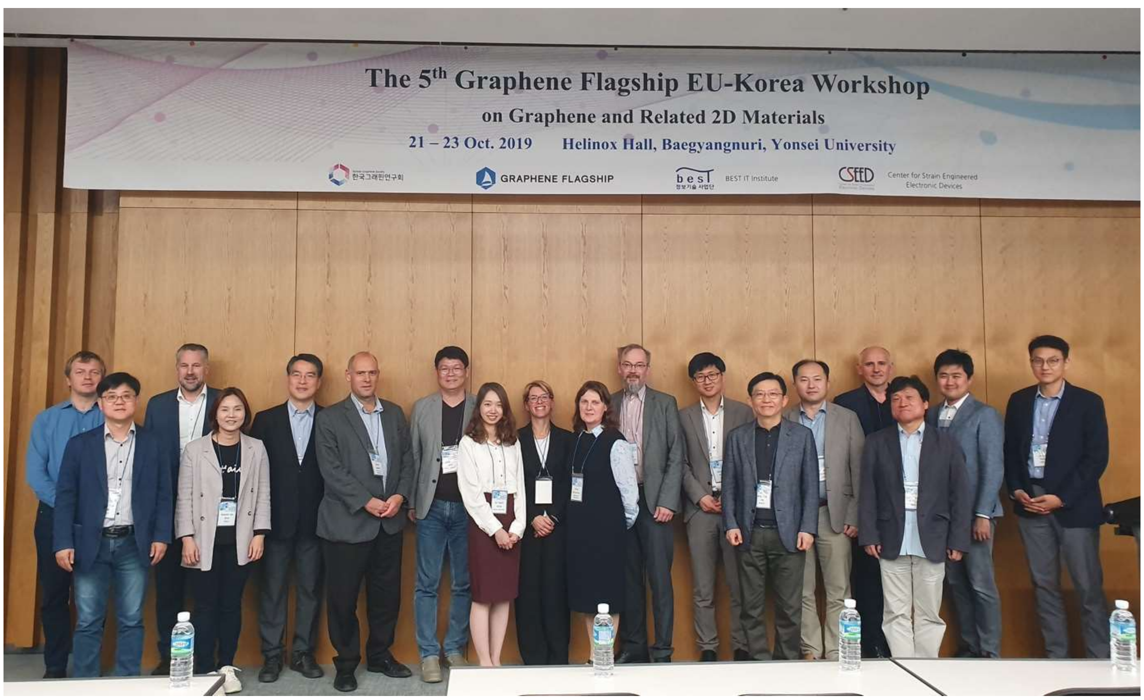
Graphene Flagship EU-Korea Workshop 2019
Graphene and related 2D materials

Yonsei University, Seoul (Korea), 21-23 October 2019



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Overview

The 5th EU-Korea Workshop on Graphene and Related Materials was held on 21-22 October 2019 in Seoul, Korea. The goal of this workshop is to offer a forum for the exchange of experiences, practices and ideas related to the current and emerging topics associated with the basic chemical approaches, materials synthesis, integration, application (in the field of energy storage and generation, opto-electronics, spintronics and sensing) development and commercialization for graphene and related 2D materials. Importantly, the aim was to explore further possibilities for collaborative research opportunities between researchers in Europe and Korea. This was a follow up of four most successful workshops already organised, the first workshop was held in Busan (Republic of Korea) in 2015, the second in Copenhagen (Denmark) in 2016, the third in Jeju Island (Republic of Korea) in 2017, the fourth in San Sebastian (Spain) in 2018. The meeting was jointly prepared and co-chaired by Korean and European researchers.

Workshop chairs: Prof. Jari Kinaret (Sweden) and Prof. Prof. Jong-Hyun Ahn (Republic of Korea)

Program chairs: Prof. Paolo Samori (France), Prof. Xinliang Feng (Germany), Hyeon Suk Shin (Republic of Korea) and Prof. Hyesung Park (Republic of Korea).

The workshop gathered 24 participants (14 from Korea and 10 from Europe), coming mainly from academic institutions. Speakers gave 19 talks that have shown the breadth of activities and topics covered by their respective research groups. The selection of the scientific speakers and participants was done by the two groups of organizers. All presentations stimulated questions and discussions.
The workshop was opened by Professors Samori and Shin who set the scene and introduced the overall goals for the meeting. Prof. Kinaret presented the status of the Graphene Flagship and the plans for the Core 3 project. He indicated that opportunities and threats have been identified and the Graphene Flagship is now moving toward addressing them.

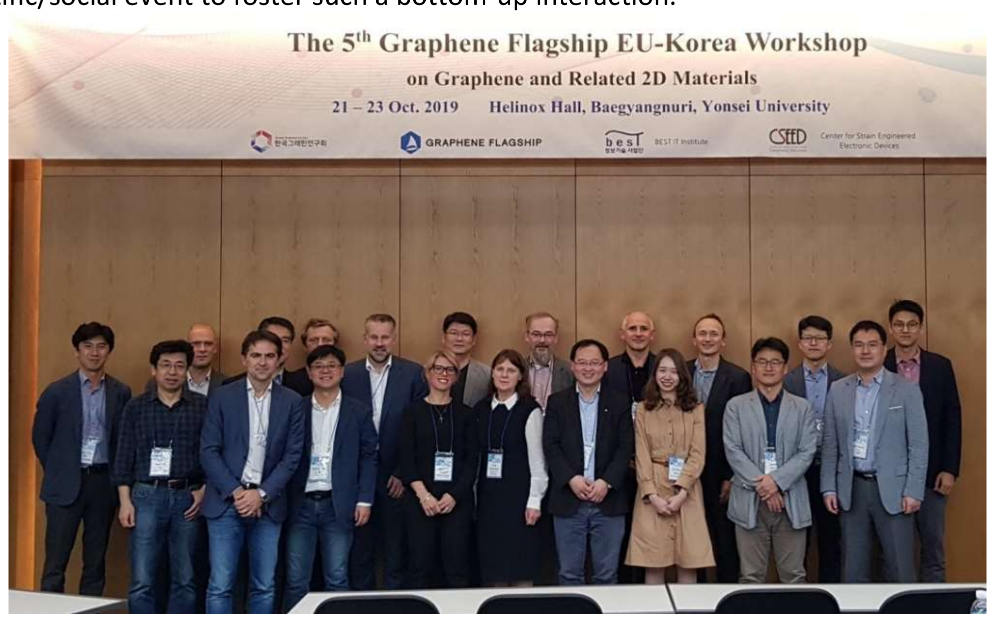
Prof. Ahn, the workshop chair from Korea introduced the 13 Korean delegates attending the event, and the Korean Graphene Society. He also highlighted the major endeavors on this field of science both from the academic and industrial perspectives, highlighting the strong industrial activity carried out at LG and Samsung, for example.
Several Graphene Flagship work-packages and leading Korean institutions active in GRM research were represented at the meeting which offered a unique opportunity for direct exchanges and development of new collaborations.

Common challenges and opportunities for collaborations

In the final discussion session, participants identified areas of common interest that comprises fundament science on graphene and related materials (GRM) on chemical approaches (production and functionalization), processing and device engineering. A special interest has been also identified on the topic of standardization of GRMs and on sensing.

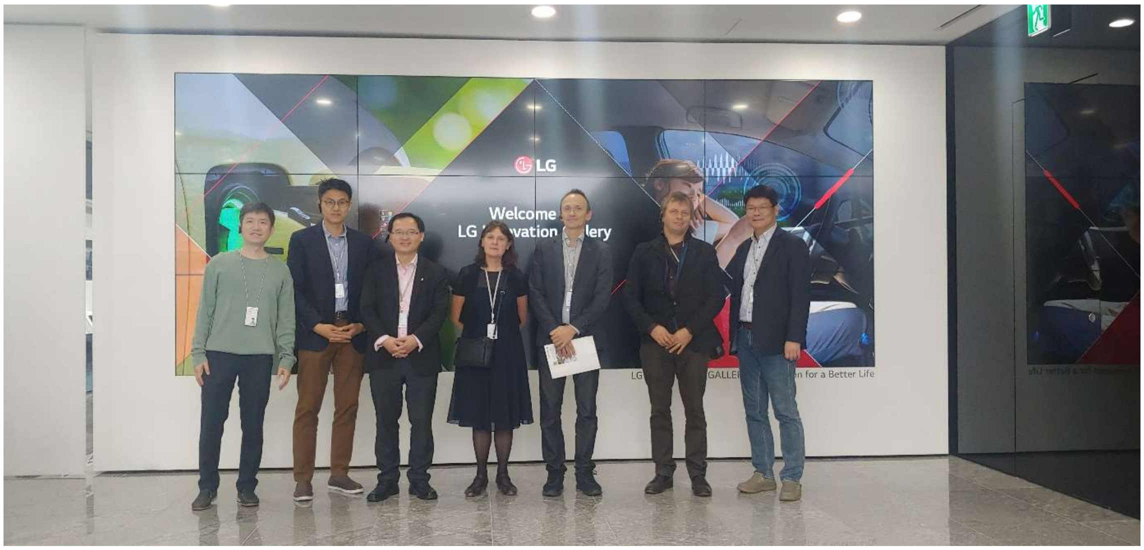
Mobility grants under the Graphene Flagship Core 2 have been identified as a tool to further strengthen the collaborations between EU and Korea to enable young researchers from Europe to perform research stays in laboratories in Korea. Such tools are unsubscribed. This opportunity should be further explored, and Korean participants mentioned that support for travel grants for Korean scientists is available on Korea side as well. Discussions between the co-chairs will continue on this issue in order to explore the possibilities for exchanges.

At the end of the meeting, there was clear interest to continue the series of workshops by organising the next workshop in Strasbourg in 2020 at the end of the Graphene Week 2020. This would be an optimal opportunity also for Korean scientists working on GRMs to disclose their latest science and technology at the Graphene Week 2020.
During the next Workshop a slightly different format could be put in place. Beside the normal sessions on general topics and approaches to GRMs, the idea is having also some of the programme dedicated to special topics such as (bio)chemical sensing and standardization, via special topical sessions lasting 2 hours or so. It was also proposed to organize initiatives to promote more interaction between younger researchers via the organization of special scientific/social event to foster such a bottom-up interaction.



Special Tour at LG Science Park & LG Electronics – 23 October 2019

The workshop participants had the unique opportunity to perform a Tour at LG Science Park & LG Electronics on 23 October 2019. Such visit made it possible to observe the impressive R&D on graphene at LG, including their high performance CVD developed via R2R.
LG Science Park tour offered unique experiences introducing the cutting-edge innovated technologies in the key areas of electronics, chemicals, biotechnology, software, and services to discover future growth engines that create customer value and contribute to business.



Programme

October 21, 2019		
Chair: Hyeon Suk Shin		
09:25 – 09:30		Introduction
09:30 – 10:00	*Jong-Hyun Ahn*	Development Status and Future Prospect for Graphene and 2D materials in Korea
10:00 – 10:30	*Jari Kinaret*	Graphene Flagship
10:30 – 11:00	*Hoseok Park*	Ultracapacitive Energy Storage Using 2D Nanomaterials Under Extreme Conditions
11:00 – 11:30	*Paolo Samorì*	Controlled Doping of 2D Materials with Responsive Molecules
11:30 – 12:00	*Hyeon-Jin Shin*	Potential Electronic Applications of Graphene and 2D Layered Materials
12:00 – 13:30	**Lunch**	
Chair: Hyeonsik Cheong		
13:30 – 14:00	*Mun Seok Jeong*	Defect evaluation of Transition Metal Dichalcogenides Monolayer using Tip-Enhanced Resonance Raman Spectroscopy
14:00 – 14:30	*Clare Chisu Byeon*	International Standards on Graphene and related 2D materials
14:30 – 15:00	*Georg Düsberg*	Nobel Metal Dichalcogenides for Sensing Applications
15:00 – 15:30		
15:30 – 16:00	***Coffee break***	
Chair: Georg Düsberg		
16:00 – 16:30	*Hyeonsik Cheong*	Raman Spectroscopy of 2-Dimensional Layered Antiferromagnetic Materials
16:30 – 17:00	*Stephan Roche*	Advancing Spintronics with Two-dimensional Materials
17:00 – 17:30	*Su-Hyun Gong*	Chiral valley-photon coupling in a 2D semiconductor layer
17:30 – 18:00	*Irina Grigorieva*	Controlling spin transport in graphene-based spintronic devices: doping and proximity effects.

October 22, 2019		
Chair: Xinliang Feng		
09:30 – 10:00	*Sang Ouk Kim*	Graphene Oxide Liquid Crystal towards Real World Graphene Applications
10:00 – 10:30	*Xinliang Feng*	Organic 2D Materials for Electronics
10:30 – 11:00	*Youn-Su Kim*	Innovative CVD Graphene Technology
11:00 – 11:30	*Hyesung Park*	In-situ Local Phase-Transitioned MoSe2 in Perovskite Oxide Heterostructure and Excellent Overall Water Electrolysis
11:30 – 12:00	*Peter Bøggild*	Nanostructuring graphene: clearing the path for graphene nanoelectronics
12:00 – 13:30	**Lunch**	
Chair: Hyesung Park		
13:30 – 14:00	*Seongil Im*	Adjusting Threshold Voltage of 2D TMD FETs by Charge Transfer from Organic Small Molecules
14:00 – 14:30	*Max Lemme*	Electronic Device Applications of 2D Materials
14:30 – 15:00	*Moon-Ho Jo*	Atomically Thin 2D Electrical Circuitry by Van der Waals Heteroepitaxy
15:00 – 15:30	*Manuela Melucci*	Graphene oxide-based composites and coatings for selective recognition processes in biosensing and water purification
15:30 – 16:00	***Coffee break***	
Chair: Paolo Samori		
16:00 – 16:30	*Unyoung Jeong*	Growth of Wafer-Scale Single Grain Si2Te3 Thin Films by Epitaxy-Driven Reorganization
16:30 – 17:00	*Vittorio Pellegrini*	Graphene-based electrodes for Lithium batteries
17:00 – 18:00		Discussion & Conclusion

October 23, 2019	
10:00 – 14:00	Tour - LG Science Park & LG Electronics (The tour schedule may be changed)

Participants list

Title	Last name	First name	Institution	Country
Prof.	Ahn	Jong-Hyun	Yonsei University	Republic of Korea
Prof.	Bøggild	Peter	Technical University of Denmark	Denmark
Prof.	Byeon	Clare Chisu	Kyungpook National University - KNU	Republic of Korea
Prof.	Cheong	Hyeonsik	Sogang University	Republic of Korea
Prof.	Düsberg	Georg	Universität der Bundeswehr München	Germany
Prof.	Feng	Xinliang	Dresden University of Technology	Germany
Prof.	Gong	Su-Hyun	Korea University	Republic of Korea
Prof.	Grigorieva	Irina	University of Manchester	UK
Prof.	Im	Seongil	Yonsei University	Republic of Korea
Prof.	Jeong	Unyoung	Pohang University of Science and Technology - POSTECH	Republic of Korea
Prof.	Jeong	Mun Seok	Sungkyunkwan University - SKKU	Republic of Korea
Prof.	Jo	Moon-Ho	Pohang University of Science and Technology - POSTECH	Republic of Korea
Prof.	Kim	Sang Ouk	Korea Advanced Institute of Science and Technology - KAIST	Republic of Korea
Dr.	Kim	Youn-Su	LG Electronics	Republic of Korea
Prof.	Kinaret	Jari	Chalmers University of Technology	Sweden
Prof.	Lemme	Max	RWTH Aachen University/ AMO GmbH	Germany
Dr.	Melucci	Manuela	Institute for Organic Syntheses and Photoreactivity ISOF - CNR	Italy
Prof.	Park	Hoseok	Sungkyunkwan University - SKKU	Republic of Korea
Prof.	Park	Hyesung	Ulsan National Institute of Science and Technology - UNIST	Republic of Korea
Dr.	Pellegrini	Vittorio	Italian Institute of Technology - IIT	Italy
Prof.	Roche	Stephan	Catalan Institute of Nanoscience and Nanotechnology - ICN2	Spain
Prof.	Samorì	Paolo	University of Strasbourg	France
Dr.	Shin	Hyeon-Jin	Samsung Advanced Institute of Technology - SAIT	Republic of Korea
Prof.	Shin	Hyeon Suk	Ulsan National Institute of Science and Technology - UNIST	Republic of Korea

Speakers and abstracts

List of Abstracts

Development Status and Future Prospect for Graphene and 2D materials in Korea

Jong-Hyun Ahn
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Abstract:

Over the past decade, the Korean government and the major companies, such as LG and Samsung have considerably invested in research and development in graphene, particularly for practical applications and commercialization. Recently, R & D investments have been made on two-dimensional materials as well. In this workshop, I would like to present the status of research and development in Korea.

Short Biography:

Prof Jong-Hyun Ahn received Ph.D degree at POSTECH, Korea in 2001. He joined SKKU as an assistant professor in 2008 after the postdoctoral experience in the University of Illinois at Urbana-Champaign for several years and moved to Yonsei University in 2013. He holds Underwood distinguished professor at Yonsei University, Korea. He has worked as the president of Korean Graphene Society and an associate editor of NPG Asia Materials. His research includes fundamental and applied aspects of graphene and 2D materials and recent interest focuses on 2D material based wearable electronics with an emphasis on bio-applications. Jong-Hyun Ahn has authored more than 165 papers (H-index 64, Citation # > 35,000), and is an inventor of more than 60 patents and has received numerous scientific awards, including the Korean National Academy Award (2018), the National Young Scientist Award (2011) and the IEEE George Smith Award (2009).

Graphene Flagship

Jari Kinaret
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Abstract:
In this presentation I will briefly describe the current status and future plans of the Graphene Flagship. I will not address specific scientific or technological topics apart from a few highlights that are indicative of our current activities.

Short Biography:
Jari Kinaret is the initiator of the Graphene Flagship and serves since October 2013 as its Director. He received his M.Sc degrees in Theoretical Physics and in Electrical Engineering at the University of Oulu in Finland in 1986 and 1987, respectively. Kinaret graduated with a Ph.D. in Physics from the Massachusetts Institute of Technology in 1992, whereupon he spent two years in Copenhagen as a post-doctoral researcher and as an Assistant Professor. In 1995 he moved to Gothenburg where he works as Professor of Physics at the Chalmers University of Technology. His research interests lie in theoretical studies of nanoscale carbon structures, with focus on nanoelectromechanical devices and graphene plasmonics. He is a member of the Royal Swedish Academy of Engineering Sciences and the board of directors of Tampere University (Finland).

Ultracapacitive Energy Storage Using 2D Nanomaterials Under Extreme Conditions

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Abstract:

With increasing demand for high performance energy storage devices, the feasibility of reliable and functional energy storage devices that well operates under extreme conditions is of prime importance for expanding applicative fields as well as for understanding materials' intrinsic and extrinsic properties and device physics. In this talk, I will introduce the control in the physical structure and chemical composition of 2D nanomaterials for ultracapacitive energy storage devices under limited circumstances, where conditions are classified into thermodynamic (e.g. pressure, volume and temperature) and kinetic (e.g. high rate and frequency) variables.[1,2] In addition, a fundamental foundation via in-situ spectroscopic techniques will be presented to understand charge storage phenomenon of new materials and devices occurring on a nanoscale under extreme circumstances.[1]

References:

1. P. Nakhanivej, X. Yu, S. K. Park, S. Kim, J. Y. Hong, H. J. Kim, W. Lee, J. Y. Hwang, J. E. Yang, C. Wolverton, J. Kong, M. Chhowalla, H. S. Park, Nature Materials, 18 (2019) 156-162.
2. G. S. Gund, J. H. Park, R. Harpalsinh, M. Kota, J. H. Shin, T. Kim, Y. Gogotsi, H. S. Park, Joule 3 (2019) 1-13.

Short Biography:

Ho Seok Park is an associate professor of Chemical Engineering at the Sungkyunkwan University (SKKU), an adjunct professor of the Samsung Advanced Institute for Health Science & Technology (SAIHST) and SKKU Advanced Institute of Nano Technology (SAINT), and SKKU Fellow. He received his Ph.D. from Korea Advanced Institute of Science & Technology (KAIST) in 2008 and worked as a Postdoctoral Researcher in the Department of Biological Engineering at Massachusetts Institute of Technology (MIT) from 2008 to 2010. His current research interests focus on energy and chemical storage materials and devices based on 2D and carbon nanomaterials. He has published ~160 peer-reviewed papers on top journals, such as Nat. Mater., Joule, Energy & Environmental Science, JACS, ACS Nano, Nano Lett., Adv. Mater., and Adv. Energy Mater. and being taking editorial board member or associate editor in "Batteries & Supercaps" (Wiley), "Materials", "Carbon Letters", and "Macromolecular Research". He gave more than 30 keynote or invited talks in Nature Conference, MRS, ACS, ECS, and so on, as well as more than 20 invited talks in top universities such as U PENN, UCLA, Monash University, UQT, etc. Moreover, he also won several awards such as the Scientist of the Month, SKKU fellow, LG Young Researcher, Miwon Young Researcher, RSC Emerging Young Investigator, etc.

Controlled Doping of 2D Materials with Responsive Molecules

Paolo Samorì
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Abstract:

The already exceptional properties of 2D materials can be further tuned, enriched and leveraged by interfacing them with ad hoc molecules, by mastering principle of supramolecular chemistry. By taking full advantage of the almost unlimited variety of molecules that can be designed and synthesized with functionalities at will, one can engineer 2D materials exhibiting dynamic physical and chemical properties, by imparting them novel functions, with the ultimate goal of generating multifunctional hybrid systems for applications in (opto)electronics, sensing and energy. [1]

In my lecture, I will review our recent findings on the use of non-covalent functionalization in order to controllably dope different 2D materials including Graphene, MoS_2, WSe_2, BP by exploiting the effect of either surface dipoles [2] or charge transfer [3] with the goal of engineering artificial responsive hetero-structures.

Our approaches provide a glimpse on the chemist's toolbox to generate multifunctional 2D materials-based hybrids with ad-hoc properties to address key global challenges in electronics, sensing and energy applications.

References:

[1] For reviews: (a) S. Bertolazzi, M. Gobbi, Y. Zhao, C. Backes, P. Samorì, "Molecular chemistry approaches for tuning the properties of two-dimensional transition metal dichalcogenides", Chem. Soc. Rev. 2018 47, 6845-6888. (b) M. Gobbi, E. Orgiu, P. Samorì, "When 2D materials meet molecules: opportunities and challenges of hybrid organic/inorganic van der Waals heterostructures", Adv. Mater. 2018, 30, 1706103. (c) Y. Zhao, S. Ippolito, P. Samorì, "Functionalization of 2D materials with photosensitive molecules: from light-responsive hybrid systems to multifunctional devices", Adv. Optical Mater. 2019, s, 1900286.

[2] For the use of molecular-dipole-induced shift in work function: (a) M. Gobbi et al. Nat. Commun. 2018, 9, 2661. (b) M. Gobbi et al Nat. Commun. 2017, 8, 14767. (c) Y. Zhao, S. Bertolazzi, P. Samorì, ACS Nano, 2019, 13, 4814–4825.

[3] For the use of charge transfer: H. Qiu, Y. Zhao, Z. Liu, M. Herder, S. Hecht, P. Samorì, "Modulating the charge transport in two-dimensional semiconductors via energy level phototuning", Adv. Mater. 2019 in press (doi.org/10.1002/adma.201903402).

Short Biography:

Prof. Paolo Samorì is Distinguished Professor at the Université de Strasbourg, Director of the Institut de Science et d'Ingénierie Supramoléculaires (ISIS) and Director of the Nanochemistry Laboratory. He is also Foreign Member of the Royal Flemish Academy of Belgium for Science and the Arts (KVAB), Fellow of the Royal Society of Chemistry (FRSC), Fellow of the European Academy of Sciences (EURASC), Member of the Academia Europaea and Junior Member of the Institut Universitaire de France (IUF). He obtained a Laurea (master's degree) in Industrial Chemistry at University of Bologna in 1995. In 2000, he received his PhD in Chemistry from the Humboldt University of Berlin (Prof. J. P. Rabe). He was permanent research scientist at Istituto per la Sintesi Organica e la Fotoreattività of the Consiglio Nazionale delle Ricerche of Bologna from 2001 to 2008 and Visiting Professor at ISIS from 2003 to 2008. He has published 300+ papers on nanochemistry, supramolecular sciences, materials chemistry, and scanning probe microscopies with a specific focus on graphene and other 2D materials as well as functional organic/polymeric and hybrid nanomaterials for application in optoelectronics, energy and sensing. His work has been awarded various prizes, including the E-MRS Young Scientist Award (1998), the MRS Young Scientist Award (2000), the IUPAC Prize for Young Chemists (2001), the "Vincenzo Caglioti" Award (2006), the "Nicolò Copernico" Award (2009), the "Guy Ourisson" Prize (2010), the ERC Starting Grant (2010), the CNRS Silver Medal (2012), the Spanish-French "Catalán-Sabatier" Prize (2017), the German-French "Georg Wittig - Victor Grignard" Prize (2017), the RSC Surfaces and Interfaces Award (2018), the Blaise Pascal Medal in Materials Science of EURASC (2018), the Pierre Süe Prize of the French Chemical Society (2018) and the ERC Advanced Grant (2019). He is Associate Editor of Nanoscale and Nanoscale Advances (RSC) and Member of the Advisory Boards of Advanced Materials, Small, ChemPhysChem, ChemNanoMat, ChemPlusChem and ChemSystemsChem (Wiley-VCH), Chemical Society Reviews, Chemical Communications, Nanoscale Horizons and Journal of Materials Chemistry (RSC), ACS Nano and ACS Omega (ACS).

Potential Electronic Applications of Graphene and 2D Layered Materials

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Abstract:
Two dimensional (2D) layered materials are crystalline materials with layered structures, including Graphene, h-BN, and Transition Metal Di-chalcogenides (TMD's). We have studied 2D layered materials in two directions.

For the near future application, we have been investigated 2D layered materials for Si technology to enhance their performance. To overcome performance limit for the long-term downscaling of Si technology, we have focused 2D layered materials as interface materials due to the chemical inertness and their atomically thin nature. We investigated Graphene/metal hybrid interconnect. Although high-quality graphene can be produced on catalyst metals, their practical applications, especially Si technologies, are limited by the high-temperature growth and the post transfer process. W/nanocrystalline graphene (nc-G)/TiN is realized by direct growth on noncatalytic TiN, up to 12 inch in diameter, at a low temperature of ≈560 °C which is below the semiconductor integration temperature. nc-G acts in the interconnect not only a diffusion barrier to metal-silicide formation but also a promoter of the preferential grain growth of the W layer. Overall, a significant reduction (27%) in the resistance of the interconnect is achieved by the insertion of nc-G between W and TiN. This work points to the possibility of practical graphene applications via direct nc-G growth that is compatible with current Si technology.[1] Also, We demonstrated that 2D layered materials are good candidates for interface materials between metal and Si to reduce the Schottky barrier heights and contact resistance in source and drain, which is one of the most critical issues for scaling down.[2,3,4] We found that 2D materials may change the pinning point of Schottky barrier and end up reducing contact resistance. We realized the lowest specific contact resistivity of 1.47 nΩcm^2 (n-type Si, ~10^{21}/cm^3) via Graphene and h-BN insertion in 6'' wafer are approaching the theoretical limit of 1.3 nΩcm^2.[3]

As one of the long term applications, we are developing transistors beyond the 5-nm node for high integration / high performance / low power, and beyond-silicon devices for optoelectronic applications in the IR domain. In pursuit of these research directions, we are studying a large-area growth and doped structure growth. Recently, we grew MoS2 monolayer on 6 inch wafer within 10 min by sequential growth method. [5] To explore 2D application, we examined triboelectric nanogenerator (TENG) for energy harvesting, which has been explored as one of the possible candidates for the auxiliary power source of portable and wearable devices. [6] We investigates the triboelectric charging behaviors of various 2D layered materials, including MoS_2, $MoSe_2$, WS_2, WSe_2, graphene, and graphene oxide and confirms the position of 2D layered materials in the triboelectric series. It is also demonstrated that the results are related to the effective work functions. This study provides new insights

to utilize 2D layered materials in triboelectric devices, allowing thin and flexible device fabrication. [7]

References:

[1] C.-S. Lee, et al., “Fabrication of Metal/Graphene Hybrid Interconnects by Direct Graphene Growth and Their Integration Properties”, Advanced Electronic Materials 4, 1700624 (2018)

[2] K.-E. Byun, et al., “Graphene for True Ohmic Contact at Metal-Semiconductor Junctions”, Nano Letters 13, 4001 (2013)

[3] M.-H. Lee, et al., “Two-Dimensional Materials Inserted at the Metal/Semiconductor Interface: Attractive Candidates for Semiconductor Device Contacts”, Nano Letters 18, 4878 (2018)

[4] S.-G. Nam, et al., “Barrier height control in metal/silicon contacts with atomically thin MoS2 and WS2 interfacial layers”, 2D Materials 5, 041004 (2018)

[5] In preparation.

[6] K.-E. Byun, et al., “Potential role of motion for enhancing maximum output energy of triboelectric nanogenerator”, APL Materials 5, 074107 (2017)

[7] M. Seol, et al., “Triboelectric Series of 2D Layered Materials”, Advanced Materials 30, 1801210 (2018)

Short Biography:

Hyeon-Jin Shin, Ph.D. is a Research Master at Samsung Advanced Institute of Technology (SAIT), Samsung Electronics. She is a project leader of Graphene team in SAIT. Graphene team is conducting fundamental and applied research about graphene & 2D materials (TMD, h-BN) for electronic, opto electronic, and energy applications. Our team has focused on improving the performance of conventional Si devices using graphene/2D as a component material. Our team is also developing new device concepts such as 2D Memeristor and Energy harvesting device beyond Si devices.

She joined SAIT (2002) where she developed ultra-low-dielectric materials for back-end of lines based on silsesquoxane polymer. Since 2007, she has been researched nano-carbon based materials such as Carbon Nano Tube and Graphene for electronic device. During working at SAIT, she received Ph.D in Sungkyunkwan Advanced Institute of Nano Technology from Sungkyunkwan University (2010). Her thesis topic was electronic structure modulations of nano-carbon based materials by chemical doping for electronic device. She has published over 68 articles, which received over 5116 citations (h-index of 30). She also has been filled over 200 US patents.

Defect Evaluation of Transition Metal Dichalcogenides Monolayer using Tip-Enhanced Resonance Raman Spectroscopy

Mun Seok Jeong
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Abstract:
In this presentation, analysis of 2D nanomaterials with Tip enhanced Raman scattering (TERS) will be provided. TERS is a unique tool for investigating Raman scattering mapping with nanometer spatial resolution beyond optical diffraction limit. Using representative tips fabricated under the optimal etching condition, Our lab. demonstrate the TERS experiment of tungsten disulfide (WS_2) monolayer grown by a chemical vapor deposition method with a spatial resolution of ~40 nm. Monolayer WS_2 has emerged as an active material for optoelectronic devices due to its quantum yield of photoluminescence. Despite the enormous research about physical characteristics of monolayer WS_2, the defect-related Raman scattering has been rarely studied. In this work, we report the correlation of topography and Raman scattering in monolayer WS_2 by using TERS and reveal defect-related Raman modes denoted as D and D' modes. We found that the sulfur vacancies introduce not only the red-shifted A_{1g} mode but also the D and D' modes by the density functional theory calculations. The observed defect-related Raman modes can be utilized to evaluate the quality of monolayer WS_2 and will be helpful to improve the performance of WS_2 optoelectronic devices.

Short Biography:
Mun Seok Jeong is an associate professor at Department of Energy Science, Sungkyunkwan University (SKKU), Korea. He received his PhD from Chonbuk National University in 2000. He then worked as a postdoctoral research associate at University of Illinois at Urbana Champaign, USA (2000-2001), senior research scientist at Electronics and Telecommunications Research Institute(ETRI), Korea (2001-2003), and principal research scientist at Advanced Photonics Research Institute, GIST, Korea (2003-2013). He joined SKKU in 2013. He received Minster Award by Ministry of Education, Science and Technology in 2012, Semiconductor Research Award by Korean Physical Society in 2012. His current research is seeking new physics in the emerging materials including 2-D nanoplates and halide perovskite by novel approaches in synthesis, optical characterization, and optoelectronic devices.

International Standards on Graphene and Related 2D Materials

Clare Chisu Byeon
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Abstract:
Nanotechnology has been expected as future technology for decades, which will influence almost every area of modern technology-driven industry. However, the technology itself is still only at an early stage in industrial applications and product development in many areas except for the semiconductor industry. Recently, carbon based low dimensional materials such as fullerene, carbon nanotube, graphene, and also other nanomaterials are introduced and being developed, and various functional nanomaterials and devices are about to be realized in production. Thus, the technology standards and safety based on the international standards become globally urgent issues to respond the coming global nanotechnology market, which is already forming. To answer such global needs, ISO TC229 and IEC TC113 were founded several years ago, and many new international standards have been developed. I will introduce current activities and directions on developing nanotechnology related international standards in JWG2 Measurement and Characterization of ISO TC229 Nanotechnologies and IEC TC113 Nanotechnolgy for electrotechnical products and systems. I will also discuss the status of graphene related international standards recently being developed.

Short Biography:
Clare C. Byeon is a professor at School of Mechanical Engineering, Kyungpook National University (KNU), Korea. He received his PhD from Department of Physics at University of Alabama at Birmingham in 2002. After his graduate study and a short postdoc period in the same department, he moved to Korea to join as a senior researcher Electronics and Telecommunications Research Institute (ETRI) in Korea. Then, he moved to Advanced Photonics Research Institute in GIST in 2003 and had worked as a group leader both in Nanophotonics Laboratory and Optical Material and Device Laboratory until he joined KNU in 2009. He has been serving as a technical expert in ISO TC229 Nanotechnologies and IEC TC113 Nanotechnology for electrotechnical products and systems and also a member of Nanotechnology National Expert Committee of Korean Agency for Technology & Standards (KATS) since 2008. He is the project leader of recently published ISO TR19733 Matrix of properties and measurement techniques for graphene and related 2D materials. He has expertise in various optical characterization techniques and his current research is focused on low-dimensional nanostructured materials, perovskite materials, 2D materials such as graphene and transition metal dichalcogenides, and their applications in optoelectronics and photonics.

Nobel Metal Dichalcogenides for Sensing Applications

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Abstract:
Two-dimensional materials such as transition metal dichalcogenides (TMDs) are intensively investigated because of their potential applications in future electronics. So far mainly group six (Mo/W) TMDs have been investigated, which show thickness depend electronic and optical properties. Metal-to-semiconductor transitions, high mobilities, and high potential for various sensing applications, now raised interest to the group 10 (Pt/Pd) TMDs or Nobel Metal Dichalcogenides (NMDs).
In this presentation, the low temperature synthesis of various TMDs by thermally assisted conversion (TAC) is presented. [1] The composition and morphology of the resulting large scale layers are investigated by several characterization techniques including Raman spectroscopy, [2] AFM and X-ray photoelectron spectroscopy. In particular, the low temperature TAC synthesis $PtSe_2$ potentially allows back end of line (BEOL) integration compatible with silicon technology. The effects of growth on the underlying substrates or investigated by TOF-SIMS and transmission electron microscopy. Further, as pre-pattered structures can be grown by the TAC, which allows to fabricate electronic devices using standard micro-fabrication technology. [3] In particular, $PtSe_2$ has shown potential for novel sensors. Examples for high performance chemical sensors, [1] IR-photodetectors [4] and MEMS [5] devices with $PtSe_2$ will be presented.

References:
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Short Biography:
Prof. Georg S. Duesberg has the Chair for Sensortechnologies at the Universität der Bundeswehr, Munich. Georg S. Duesberg graduated in Physical Chemistry from the University of Kassel, Germany in 1996. He gained his PhD at Max-Planck-Institute for Solid State Research, Stuttgart from 1997-2001. From 2001-2005 he worked at the Infineon AG, in the Corporate Research Department in Munich, followed by two years in the Thin Films Department at Qimonda AG, Dresden. In 2007 Georg Duesberg became Assoc. Prof. in the School of Chemistry of Trinity College Dublin, Ireland and a Principal Investigator in at the Irish National Research Institute CRANN. In 2017 Prof. Duesberg moved to the Institute of Physics

at the UniBW M in Munich. He has co-authored more than 240 publications with more than 15000 citations (H-index 60, WOS) and has filed more than 25 patents. His research focuses on the synthesis, characterization and devices integration of low-dimensional structures.

Raman Spectroscopy of 2-Dimensional Layered Antiferromagnetic Materials

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Abstract:
Magnetism in low dimensional systems is attracting much interest for the fundamental scientific interest as well as a promising candidate for numerous applications. Intense interest in 2 dimensional magentism has been stimulated by the discovery of ferromagnetism in atomically thin materials, but antiferromagnetic ordering is much more difficult to study because the lack of net magnetization hinders easy detection of such phenomena. Neutron scattering, which is a powerful tool to detect antiferromagnetic order in bulk materials, cannot be used for atomically thin samples due to the small sample volume. Raman spectroscopy has proven to be a powerful tool to detect antiferromagnetic ordering by monitoring the zone-folding due to the antiferromagnetic order or other magnetically-induced changes in the Raman spectrum. In this talk, I will review recent achievements in the study of antiferromagnetism in 2 dimensions using Raman spectroscopy. $FePS_3$ exhibits an Ising-type antiferromagnetic ordering down to the monolayer limit, in good agreement with the Onsager solution for 2-dimensional order-disorder transition. The transition temperature remains almost independent of the thickness from bulk to the monolayer limit, indicating that the weak interlayer interaction has little effect on the antiferromagnetic ordering. On the other hand, $NiPS_3$, which shows an XXZ-type antiferromagnetic ordering in bulk, exhibits antiferromagnetic ordering down to 2 layers with a slight decrease in the transition temperature, but the magnetic ordering is suppressed in the monolayer limit. Furthermore, a Heisenberg-type antiferromagnet $MnPS_3$ exhibits ordering down to 2 layers.

Short Biography:
Hyeonsik Cheong is a professor of physics at Sogang University in Seoul, Korea. He received his B.S. degree in physics from Seoul National University and A.M. and Ph.D. in physics from Harvard University. After working at Harvard as a postdoctoral fellow and as a postdoc and then as a senior scientist at National Renewable Energy Laboratory in Golden, Colorado, he joined the Department of Physics at Sogang University in 1999. At Sogang University, he has served as Director of International and Public Relations, Chair of the Department of Physics, and Vice President for Budget and Planning. His research interest includes spectroscopic studies of graphene and 2-dimensional materials, semiconductor nanostructures, and solar cell materials. He has served as President of Korean Graphene Society from 2015 to 2016 and is currently serving as the Chair of the Division of Applied Physics of the Korean Physical Society.

Advancing Spintronics with Two-Dimensional Materials

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Abstract:

The physics of graphene can be strongly enriched and manipulated by harvesting the large amount of possibilities of proximity effects with magnetic insulators, strong spin-orbit coupling SOC materials (transition metal dichalcogenides (TMD), topological insulators (TI), etc.). Simultaneously, the presence of extra degrees of freedom (sublattice pseudospin, valley isospin) points towards new directions for information processing [1,2], extending the playground to valleytronics, multifunctional electronic devices or novel quantum computing paradigms harnessing all these degrees of freedom in combination with electromagnetic fields or other external fields (strain, chemical functionalization) [2,3]. Here I will present the foundations of spin transport for Dirac fermions propagating in supported graphene devices or interfaced with strong SOC materials, with a particular emphasis on how spin dynamics is monitored by the nature of SOC induced in graphene by nearby TMDs and TIs. We will show that spin transport in these systems is distinguished by giant spin lifetime anisotropy, with spins oriented in the graphene plane relaxing much faster than spins pointing out of the plane [3-5]. This anisotropy arises from the specific nature of the SOC induced in the graphene layer, which depends crucially on the symmetry of the graphene/TMD & TI interfaces. In addition to serving as a probe of SOC induced in graphene, giant spin lifetime anisotropy may also prove useful for spintronics, for example serving as an orientation-dependent spin filter, or for enhancing spin Hall effect or spin-orbit torque efficiencies, in the perspective of spin torque technologies. The presence of weak antilocalization effects and the confirmation of a giant Spin Hall effect in such heterostructures will be also reported [6].

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Short Biography:

Prof. Stephan Roche is a theoretician with more than 25 years of experience in the study of transport theory in low-dimensional systems, including graphene, carbon nanotubes, semiconducting nanowires, organic materials and topological insulators. He has published more than 200 papers in journals such as Review of Modern Physics, Nature Physics, Nano

Letters and Physical Review Letters (40 papers) and is the co-author of book titled Introduction to Graphene-Based Nanomaterials: From Electronic Structure to Quantum Transport (Cambridge University Press, 2014). He has worked as postdoc or visiting faculty in Japan, Germany, Spain and Singapore. In 2009 Prof. Roche was awarded the Friedrich Wilhelm Bessel Research Award by the Alexander Von-Humboldt Foundation (Germany) and since 2011 he has been actively involved in the European Graphene Flagship project, currently as deputy leader of the spintronics work package.

Chiral Valley-Photon Coupling in a 2D Semiconductor Layer

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Abstract:

In the non-paraxial regime of light, spin and angular momentum cannot be separated but are coupled, the so-called spin-orbit interaction of light. This realization has sparked a tremendous activity in the optics community in the last couple of years. One novel consequence of this spin-orbit interaction of light is spin-controlled directional coupling of light. Here, we demonstrate the valley(spin)-dependent directional emission of transition metal dichalcogenides (TMD) into plasmonic eigenstates of a silver nanowire. A monolayer of TMD materials has direct bandgaps consisting of two (energy-degenerate) valleys at the corners of the Brillouin zone (K, K'), which provide an opportunity to manipulate the additional degree of freedom, i.e., the valley degree of freedom. And valley information can be optically addressed and detected using the spin angular momentum of light, due to their valley-dependent optical selection rule. The highly confined mode of a plasmonic nanowire provides a high degree of local transverse optical spin, and its handedness is locked to the propagation direction of the mode. As a result, the emission from the two different valleys of TMDs material will couple to the plasmonic modes propagating in opposite directions. The high valley polarization of TMD and high density of the transverse optical spin of the plasmonic wire together offer a novel platform for a chiral network even at room temperature without any magnetic fields. This result paves the way towards a new platform for exploiting a valley pseudospin in integrated valleytronics devices using nanophotonics structures.

Short Biography:

Su-Hyun is an assistant professor at department of Physics, Korea University. She received her PhD from department of Physics at KAIST in 2015. After working as a postdoctoral fellow at AMOLF and TU Delft in Netherlands, she joined Korea University in 2018. Her current research interest is nanophotonics using 2D semiconductor, especially valley-photon coupling in both weak and strong coupling regimes.

Controlling spin transport in graphene-based spintronic devices: doping and proximity effects

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Abstract:
Graphene is hailed as an ideal material for spintronics due to weak intrinsic spin-orbit interaction that facilitates lateral spin transport and tunability of its electronic properties. In this talk I will review our recent experimental studies where we demonstrate the tunability of both vertical transport through few-layer graphene spacers in vertical magnetoresistive devices (magnetic tunnel junctions) and lateral transport (spin injection) in spin valves. In magnetic tunnel junctions we have demonstrated that few-layer graphene serves as a tunable spin-selecting barrier due to proximity-induced spin splitting and charge transfer from adjacent ferromagnetic metals. In lateral spin valves we are able to control spin transport by gate-tuning the resistance of one-dimensional contacts to the graphene channel. Our results suggest new architectures for both vertical and lateral devices with electrically controlled magnetic response.

Short Biography:
Irina Grigorieva is Professor of Physics at the University of Manchester, UK and a leading expert on electronic and magnetic properties of two-dimensional materials and devices, including graphene, its heterostructures with other atomically thin crystals and (quasi)two-dimensional superconductors. She received PhD in Solid State Physics in 1989 from the Institute of Solid State Physics, Russian Academy of Sciences (Chernogolovka, Russia). Following several postdoctoral positions at the University of Bristol, UK, University of Leuven, Belgium and University of Nijmegen, The Netherlands, she joined the University of Manchester as a Lecturer (Assistant Professor) in 2001.
Irina is particularly well-known for her pioneering studies of intrinsic magnetism in graphene, its role in spintronic devices and doping-induced superconductivity in graphene, phosphorene and other layered materials. She has published 102 peer-reviewed papers, including 37 papers in Nature, Science, Nature Physics, Nature Nanotechnology and Nature Materials. Her publications attracted over 80,000 citations to date; h-index = 47 (Google Scholar). Grigorieva is University of Manchester PI on two Graphene Flagship work packages: Graphene Spintronics and Graphene for Energy Storage. She initiated tuning graphene into an insulating, magnetic or superconducting state by chemical functionalization or controlled introduction of defects and discovered a magnetic response in these materials, despite the absence of ‘magnetic’ d- or f- electrons, and that missing atoms in graphene, as well as some chemical species attached to it, produce unpaired magnetic spins. This settled the long-standing controversy about magnetism’s origin in carbon-based materials. She also demonstrated that

graphene's magnetism can be controlled and switched on/off by tuning the conduction electron density, with implications for spintronics, e.g. spin valves. Developing this line of research further she discovered that few-layer graphene sandwiched between ferromagnetic electrodes in a magnetic tunnel junction plays a role of gate-tunable spin-selecting barrier, demonstrating yet another potential application of graphene for spintronic devices.
Prof Grigorieva is Director of EPSRC Centre for Doctoral Training in Science and Applications of Graphene and Related Nanomaterials (Graphene NOWNANO CDT); she is in charge of PhD training of ca. 100 PhD students. The Centre provides PhD-level training in the science and applications of two-dimensional materials, innovative, cutting-edge research projects and cohort-based programme of training in key skills, including innovation and commercialisation of research and public engagement.

Graphene Oxide Liquid Crystal towards - Real World Graphene Applications

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Abstract:
Graphene Oxide Liquid Crystal (GOLC) is a newly emerging graphene based material, which exhibits nematic type colloidal discotic liquid crystallinity with the orientational ordering of graphene oxide flakes in good solvents, including water. Since our first discovery of GOLC in aqueous dispersion [1], this interesting mesophase has been utilized over world-wide for many different application fields, such as liquid crystalline graphene fiber spinning, highly ordered graphene membrane/film production, prototype liquid crystal display and so on [2,3]. Interestingly, GOLC also allow us a valuable opportunity for the highly ordered molecular scale assembly of functional nanoscale structures. This presentation will introduce our current status of GOLC research particularly focusing on the nanoscale assembly of functional nanostructures. Besides, relevant research works associated to the nanoscale assembly and chemical modification of various nanoscale graphene based materials will be presented particularly aiming at energy and catalytic applications [4,5].

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Short Biography:

2019-Present: College Committee Chair for External Collaboration, KAIST, Daejeon, Korea
2017-Present: Co-Director, KIST-KAIST Joint Research Laboratory, Korea
2016-Present: Director for Graphene Oxide Liquid Crystalline Fiber Research Center, KAIST, Daejeon, Korea
2015-Present: Director for National Creative Research Initiative (CRI) Center for Multi-dimensional Directed Nanoscale Assembly, College of Engineering, KAIST, Daejeon, Korea
2004-Present: Assistant, Associate & Full Professor, Department of Materials Science & Engineering, KAIST, Daejeon, Korea

2001-2002:	Research Associate, Chemical Engineering Department, University of Wisconsin-Madison, WI, USA
2000:	Ph. D. from the Department of Chemical Engineering, KAIST, Daejeon, Korea
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Organic 2D Materials for Electronics

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Abstract:
In the past decade, as inspired by the discovery of graphene, two-dimensional (2D) materials which possess a periodic network structure and with a topographical thickness of atomic/molecular level, have emerged as the new paradigm of materials with enormous potentials, ranging from electronics and optoelectronics to energy technology, membrane, sensing and biomedical applications. Various fabrication strategies have been developed to attain high quality 2D materials. Among of them, mechanical exfoliation remains the most popular protocol to isolate single-layer high quality 2D materials for fundamental physical studies.

In contrast to the tremendous exploration of graphene and inorganic 2D materials such as metal dichalcogenides, boron nitride, black phosphorus, metal oxides and nitrides, the study on organic 2D material systems including the bottom-up organic synthesis of graphene nanoribbons, 2D metal-organic frameworks, 2D polymers/supramolecular polymers as well as supramolecular approach to 2D organic nanostructures remains under development. In this lecture, we will present our recent efforts on the bottom-up synthetic approaches towards novel crystalline organic 2D materials with structural control at the atomic/molecular-level. 2D conjugated polymers and coordination polymers thus belong to such materials classes. The unique structures with possible tailoring of conjugated building block and conjugation length, adjustable pore size and thickness, as well as interesting electronic structure make them highly promising for a number of applications in electronics and spintronics.

Short Biography:
Prof. Feng is a full professor and the head of the Chair of Molecular Functional Materials at Technische Universität Dresden. He has published more than 460 research articles which have attracted more than 51000 citations with H-index of 108 (Google Scholar). He has been awarded several prestigious prizes such as IUPAC Prize for Young Chemists (2009), European Research Council (ERC) Starting Grant Award (2012), *Journal of Materials Chemistry* Lectureship Award (2013), *ChemComm* Emerging Investigator Lectureship (2014), Fellow of the Royal Society of Chemistry (FRSC, 2014), Highly Cited Researcher (Thomson Reuters, 2014-2018), *Small* Young Innovator Award (2017), Hamburg Science Award (2017), EU-40 Materials Prize (2018), ERC Consolidator Grant Award (2018), member of the European Academy of Sciences (2019) and member of the Academia Europaea (2019). He is an Advisory Board Member for *Advanced Materials*, *Chemical Science, Journal of Materials Chemistry A*, *ChemNanoMat*, *Energy Storage Materials*, *Small Methods*, *Chemistry -An Asian Journal,*

Trends in Chemistry, etc. He is the Head of ESF Young Research Group "Graphene Center Dresden", and Working Package Leader of WP Functional Foams & Coatings for the European Commission's pilot project "Graphene Flagship".

Innovative CVD Graphene Technology

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Abstract:

Although graphene is widely considered as a next-generation material, it has yet to be released as a commercial product. The biggest obstacles in order to get on the market are price, quality equality and mass production.

To address this problem, LG Electronics has been developing R2R high-speed production technology for low-cost, high-quality and mass production since 2012, and as a result, it has secured graphene synthesis and process technology that can be produced reliably now.

In addition, various size control of graphene crystals, high electron mobility characteristics and high quality graphene synthesis technology with low defects were secured.

High-level quality control is managed within 10% of uniformity deviation of crystal size, defects, and electrical characteristics through a total inspection of continuous graphene synthesis using R2R.

And these results are pushing for graphene's big data through a database that features processes, analyses and assessments.

Based on these technologies, LG Electronics will supply raw materials around the world to accelerate the application of CVD Graphene and will work with related research groups to contribute to the discovery of CVD Graphene's Killer Application, which is needed for the IT/BT industry in the future.

Short Biography:

Youn-Su Kim is a Chief research engineer in Materials & Devices Advanced Research Institute of LG Electronics, Korea. He received Ph. D (2009) in Material Science and Engineering from Gwangju Institute of Science and Technology (GIST), Korea. He worked at Stevens Institute of Technology as Postdoctoral Researcher on applications of CNT/Graphene for Energy devices. From 2013 he joined at LG Electronics Inc. and developed the application of graphene flake and CVD graphene. He is currently working for commercialization of CVD graphene project (R2R CVD grapheme production and applications).

In-situ Local Phase-Transitioned $MoSe_2$ in Perovskite Oxide Heterostructure and Excellent Overall Water Electrolysis

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Abstract:
Developing efficient bifunctional catalysts for overall water splitting that are earth-abundant, cost-effective, and durable is of considerable importance from the practical perspective to mitigate the issues associated with precious metal-based catalysts. In the present study, we introduce a heterostructure comprising perovskite oxides ($La_{0.5}Sr_{0.5}CoO_{3-\delta}$ (LSC)) and transition metal dichalcogenides (TMDs, $MoSe_2$) as an electrochemical catalyst for overall water electrolysis. Interestingly, formation of the heterostructure of LSC and MoSe2 (LSC&$MoSe_2$) induces a local phase transition in $MoSe_2$, 2H to 1T phase, owing to electron transfer from Co to Mo, and the semiconducting $MoSe_2$ transforms to the metallic phase. In addition, LSC becomes more electrophilic, and Co-O and Co-OH bonds are favored owing to partial oxidation of the Co cation due to the electron transfer. Together with the electrochemically active nature of 1T $MoSe_2$ and the increased amount of Co-O and Co-OH bonds in LSC, the electrochemical activities are significantly improved for both hydrogen evolution reaction and oxygen evolution reaction. In the overall water splitting operation, LSC&$MoSe_2$ showed excellent stability at the high current density of 100 mA cm^{-2} over 1,000 h, which is exceptionally better than the stability of the state-of-the-art Pt/C || IrO_2 couple.

Short Biography:
Hyesung Park is currently an Associate Professor in School of Energy and Chemical Engineering at Ulsan National Institute of Science and Technology (UNIST), South Korea. He received his M.S. and Ph.D. degrees in Mechanical Engineering and Electrical Engineering and Computer Science from Massachusetts Institute of Technology (MIT) in 2007 and 2012. He was a postdoctoral associate at MIT from 2012 to 2013 and postdoctoral fellow at Northwestern University in 2014. His research interests focus on synthesis of low-dimensional materials such as graphene, transition metal dichalcogenides, and nanowires, and their applications into functional devices in nanoelectronics, nanophotonics, energy harvesting, and bioelectronics.

Some Attempts to Overcome Graphene Electronics Roadblocks

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Abstract:
Graphene is a unique and highly promising material for a broad range of electronic applications, not just because of its high carrier mobility and extreme thinness, but also the opportunity to support next-generation computation and storage technologies. I will point out some of the obvious and less obvious challenges for graphene to fulfil the promise of becoming a future electronic material, and discuss our recent results on making graphene transfer easier, faster and better, on improving large-scale metrology using terahertz timedomain spectroscopy, as well as on ultradense patterning of graphene without ruining the predicted quantum transport properties.

Short Biography:
Peter Bøggild is a full professor at Department of Physics at the Technical University of Denmark (DTU). He received his PhD degree at Copenhagen University in 1998 in low temperature quantum physics and moved to DTU to develop metrology and applications for thin films and surface science based on microscale four point probes. His research interests expanded towards mechatronics, nanomanipulation and robotics, and through that carbon nanomaterials. Since 2009 his research group has been focused mainly on two-dimensional materials and their use in van der Waals heterostructures, large scale graphene metrology (terahertz time-domain spectroscopy), corrosion/barriers, electron microscopy/defect engineering as well as large scale growth, transfer and characterisation of 2D materials.

Adjusting Threshold Voltage of 2D TMD FETs by Charge Transfer from Organic Small Molecules

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Abstract:
Since transition metal dichalcogenide (TMD) semiconductors are found as two dimensional Van der Waals materials with a discrete energy bandgap, many TMD based field effect transistors (FETs) are reported as prototype devices. But, overall reports indicate that threshold voltage (V_{th}) of those FETs are located much away from 0 V whether the channel is p- or n-type. This definitely causes high switching voltage and unintended OFF-state leakage current. Here, a facile way to simultaneously modulate the V_{th} of both p- and n-channel FETs with TMDs is reported. The deposition of various organic small-molecules on the channel results in charge transfer between the organic molecule and TMD channels. Especially, HAT-CN molecule is found to ideally work for both p- and n-channels, shifting their V_{th} toward 0 V concurrently. As a proof of concept, a complementary metal oxide semiconductor (CMOS) inverter with p-$MoTe_2$ and n-MoS_2 channels shows superior voltage gain and minimal power consumption after HAT-CN deposition, compared to its initial performance. When the same TMD FETs of the CMOS structure are integrated into an OLED pixel circuit for ambipolar switching, the circuit with HAT-CN film demonstrates complete ON/OFF switching of OLED pixel, which was not switched off without HAT-CN.

Short Biography:
Seongil Im, applied physicist and device engineer, earned his BS from the dept. of Metallurgical Engineering at Yonsei University, Seoul Korea in 1984. After spending several years in Korea as researchers, he moved to Univ. of California at Berkeley for his Ph.D study in Materials Science and Engineering. He achieved Ph.D from UC at Berkeley in 1994 and worked as a research fellow at the dept. of Applied Physics and Electrical Engineering, California Institute of Technology (CALTECH) from 1995 till 1996. He joined the dept. of Materials Science and Engineering at Yonsei Univ. as an assistant professor in 1997. However, in 1999 he moved to the dept. of Physics of the same university as an associate professor. His research expertise is device physics and detailed research subjects are Oxide and Organic Thin-Film Electronics, Field Effect Transistors, Nanowire and 2D Nanosheet FETs, and Photon-probing to characterize device stabilities. He has been awarded many times as an excellent researcher from Yonsei university and Ministry of Science in Korean Government. Currently, he is Underwood Distinguished Professor in the dept. of Physics and Director of van der Waals Materials Research Center (vdWMRC) at Yonsei. He has published more than ~280 peer-review journal papers including Applied Physics Letters, Advanced Materials, Advanced Functional Materials, Small, Nano Today, ACS Nano, Nano Letters, IEEE Electron Device Letters, etc.

Electronic Device Applications of 2D Materials

Max Christian Lemme
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Abstract:
Graphene has been researched intensely over the past 15 years. Its intrinsic electronic and physical properties are unrivaled in many aspects. Hundreds of related two-dimensional (2D) materials with different properties have since been added to the "2D Zoo". Physicists, chemists, material scientists and engineers continue to report new highlights on a daily basis. Yet, there are no end-customer products on the market today where 2D materials are utilized as active elements in in electronics, optoelectronics or sensing, because the process technology is not yet mature. In this talk, I will introduce promising applications, for which 2D materials clearly could make a difference, such as photodetectors [1], [2] and sensors [3]-[6]. I will further discuss the major bottlenecks towards integration of graphene and 2D materials into semiconductor processing lines [7].

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Short Biography:
Max Lemme is Full Professor at RWTH Aachen University and Scientific Director of AMO GmbH, a nanotechnology company in Aachen, Germany. He obtained his PhD degree from RWTH Aachen in 2004. He has worked in the field of nano-CMOS devices, including FinFETs

and SOI-MOSFETs, novel high-k /metal gate stacks and graphene and 2D materials. The latter includes the world's first top-gated graphene MOSFET, a novel graphene-based non-volatile memory, vertical graphene transistors and graphene NEMS. He received the "NanoFutur" young researchers' award from the German Ministry for Education and Research in 2006 and a Lynen Research Fellowship from the Alexander von Humboldt Foundation in 2007. From 1998 to 2008, he worked at AMO, where his last position was as Head of the Technology Department. In 2008, he joined Harvard University in Cambridge, USA, where he pioneered a helium ion-based nanolithography method for graphene and investigated graphene photodetectors. In September 2010, he became Guest Professor at KTH, where he initiated the graphene activities on Hot Electron Transistors and NEMS. He received an ERC Starting Grant in 2012 and became Heisenberg Professor at the University of Siegen in Germany in the same year. In February 2017, Prof. Lemme was appointed Full Professor at RWTH Aachen University and Scientific Director of AMO GmbH. In 2018, he received an ERC Proof of Concept grant. He has managed several national and international research projects with academic and industrial partners.

Atomically Thin 2D Electrical Circuitry by Van der Waals

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Abstract:
We report new device architectures of two-dimensional (2D) integrated circuits (ICs), where atomically thin circuit components are seamlessly integrated within the single atomic-planes by atomic heteroepitaxy. The first type was achieved by coplanar heteroepitaxy of 2D transition-metal dichalcogenide (TMDC) polymorphs, [1-3] where the distinct metallic and semiconducting atomic layer crystals were stitched by a sequential chemical vapor deposition. It was verified that these coplanar metal-semiconductor contacts are atomically coherent, showing the lowest contact barrier height ever-reported, which immediately contributed to the substantial outperformance of the coplanar field-effect transistors (FETs) over conventional top-contact 2D TMDC FETs. The second one was realized by exploiting a novel concept of light-induced doping of a TMDC semiconductor film with a scanning light probe, [4-8] with which both n- and p-doped channels were self-assembled to form lateral p-n junctions [9]. Therein, we provide direct evidence of a microscopic doping mechanism by atomic scale imaging and spectroscopy. This real-time writing process is precisely controllable within a minute, in that diffusive doping profiles can be controlled at the sub-micrometer scale, and doping concentrations are tunable to vary the channel sheet resistance over five orders of magnitudes. As such, we assembled both n- and p-doped channels within the same atomic planes to fabricate 2D device arrays of n-p-n (p-n-p) bipolar junction transistor amplifiers and radial p-n photovoltaic cells in high performances. This doping method can be potentially used to fabricate designer 2D circuits based on atomically thin semiconductors in arbitrary shapes.

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Short Biography:

Prof Moon-Ho Jo is Mueunjae Chair Professor of Dept. of Materials Science and Engineering, Pohang University of Science and Technology (POSTECH) and Associate Director of Center for Artificial Low Dimensional Electronic Systems, Institute for Basic Science (IBS). Moon-Ho Jo received his Ph.D. in Materials Science at University of Cambridge (2001), with a dissertation on electron spin tunneling in half-metallic manganites. He joined the faculty of the Department of Materials Science and Engineering at POSTECH in 2004 after a postdoctoral fellowship in Department of Chemistry/Physics at Harvard University. His current research interests include (1) atomic scale heteroepitaxial growth of semiconductors and strongly correlated materials, (2) light-matter interactions at atomically thin materials, as well as (3) electron transport and laser transport spectroscopy in atomic scale materials.

Graphene Oxide-Based Composites and Coatings for Selective Recognition Processes in Biosensing and Water Purification

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Abstract:
Graphene oxide (GO) is a versatile platform to build up materials with pre-defined surface chemistry and hierarchical structures. Chemical modifications of the oxygen-based groups on the nanosheet surface as well as non-covalent interactions can be exploited to realize new hybrid materials and structures with specific chemo-physical recognition properties and controlled nanoporosity.

In this presentation, we report on GO tailored composites and coatings, specifically designed for realizing:

- Filters for drinking water purification, with particular emphasis on GO enhanced polysulfone membranes for the removal of contaminants of emerging concern from drinking water;
- Biosensors for electrochemical glucose and lactate detection mainly based on commercial electrodes coated with covalently modified GO;
- Biodevices for neural cells interfacing based on membranes of biomimetic GO i.e. GO modified with synthetic phospholipid brushes.

In particular, synthetic strategies, processing, performances in comparison to the state of the art together with the level of readiness for lab.to market transition will be discussed.

Short Biography:
Manuela Melucci obtained her Ph.D. in Chemistry Sciences from the Department of Chemistry "G. Ciamician", Alma Mater Studiorum- University of Bologna in 2005. She is currently responsible of the synthetic activities of the Laboratory of Advanced materials of CNR-ISOF (Bologna, Italy), and of the Laboratory of Industrial Research and Technology Transfer of the Regional High Technology Network (Mister Smart Innovation). MM research interest spans from the design and synthesis of organic materials to the functionalization of more complex systems such as graphene oxide, for the realization of multifunctional hybrids and composites to be developed and tested in the framework of several National (SAMBA, MEDFIL, NANO-CARBO-CAT) and EU projects (GRAPHENE FLAGSHIP). MM is author of more than 90 papers, review and perspective articles on international peer review journals focused on different aspects of material engineering and applications in electronics, sensing and water purification fields. She is also inventor of more than 10 patents in partnerships with leading industries in the fields of electronics and filtration membranes.

Growth of Wafer-Scale Single Grain Si_2Te_3 Thin Films by Epitaxy-Driven Reorganization

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Abstract:
Given the potential advantages of the metal chalcogenides (MCs) in next-generation devices, the essential requirement for device fabrication is the high throughput synthesis of high-quality single crystal thin films on the entire surface of a substrate. The growth of the single crystal MC thin films is a great challenge. This talk first introduces a solution-based fast easy way to produce various 2D materials including amorphous carbon thin film, graphitic thin film, and MC thin films. Then, it suggests a method to grow a single grain MCs over entire surface of a substrate. The concept is using a substrate as an epitaxy provider and a metal source for obtaining single grain thin films of 2D materials. The solution-based MC thin films are used as the chalcogen source in the synthesis. Similarly to the typical N&G mechanism, the grains in the polycrystalline thin film are merged and reorganized to create a single grain on the entire substrate surface. This epitaxy-driven reorganization opens a new horizon to produce a single grain 2D material thin films.

Short Biography:
Unyong Jeong is a professor of Material Science and Engineering at Pohang University of Science and Technology (POSTECH) in Korea and a member of Korea academy of science and technology. He received B.S. degree (1998), M.A. degree (2000), and Ph.D. degree (2003) in chemical engineering in POSTECH. After working as a postdoctoral fellow at Universit of Washing in Seattle, he started his independent research career as a assistant professor in Yonsei University in Korea (2006). He moved to POSTECH (2015) as a young Se-Ah distinguished professor. He received the young researcher award from the Korean Academy of Science and Technology (2012). His work includes solution-based synthesis of nanostructured and their applications. His research also includes fabrication of flexible stretchable electronic devices for the uses in wearable healthcare devices and electronic skin for robots.

Graphene-Based Electrodes for Lithium Batteries

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Abstract:
In this talk I will discuss how graphene can be employed in electrodes for Li-based batteries. I will first discuss a hybrid anode material for lithium-ion batteries, encompassing silicon nanoparticles embedded onto graphene and synthesized via a scalable wet-jet milling method [1]. This synthesized composite, reinforced by a network of conductive carbon black exhibited electrochemical behavior that significantly supersedes the performance of a Si-dominant electrode structures [2,3]. I will also cover application for lithium-sulphur batteries. I will present a novel strategy to create a sulfur-graphene composite material showing high and stable capacity at large current rates [4]. These results highlight the impact of graphene in bringing novel technologies for energy storage closer to the market [5].

References:
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[3] R. Malik et al. submitted
[4] L. Carbone, et al. submitted.
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Short Biography:
Vittorio Pellegrini holds a PhD degree in condensed matter physics and he is currently a research scientist at the Istituto Italiano di Tecnologia (IIT) in Genova and director of the IIT Graphene Labs. He is member of the management panel of the European flagship project on graphene. He is also leader of the graphene flagship work-package ENERGY STORAGE. His current interests focus on the exploitation of two-dimensional crystals for energy devices and for applications in composites. Vittorio Pellegrini has published more than 180 peer-reviewed papers and he is co-inventor of several patents. He gave more than 100 invited/keynote talks. He was Fellow of the Italian Academy at Columbia University (USA) in 2008, Winner of Campisano prize for condensed matter physics of the Italian National Research Council in 2008. He is co-funder of the start-up BeDimensional (www.bedimensional.it). He has published several articles for the general public in newspapers and scientific magazines and routinely gives talks at science festivals and at other public events.