



GRAPHENE FLAGSHIP

GRAPHENE CONNECT

FROM DATACOM TO IOT,
ENABLED BY GRAPHENE

2 March 2017
Mobile World Congress, Barcelona, Spain



BARCELONA 27 FEB - 2 MAR 2017



Funded by
the European Union

WELCOME



Dear participant

Welcome to the Mobile World Congress 2017 in Barcelona and the Graphene Connect workshop: From Datacom to IoT, Enabled by Graphene.

The aim of the workshop is to create a platform for industry and academia to meet and share the latest Graphene Flagship research, an insight to industry demands in this field and to find collaboration partners for new projects.

As a participant you will not only learn more about how graphene can improve your products but also build new R&D contacts that could be the starting point for future graphene innovation projects.

The workshop features eleven leading graphene experts who will show how graphene can empower the development of information and communication technology. The day will cover opportunities and challenges on wireless and optical communication, wearables and flexible displays, Internet of Things and sensor systems to guide you into the future.

Besides listening to hands-on experience from leading brands, you will engage in group discussion and networking sessions tailored to your needs and interests.

We will all prosper from open vivid discussions, and hope you take an active part in this with us.

Looking forward to meeting you!

Kari Hjelt

Graphene Flagship's Head of Innovation

PROGRAMME

Thursday 2 March

Fira Gran Via, Barcelona, Spain, Hall 8.0 NEXTech Theatre F

- 09:00-09:30** **Registration**
- 09:30-09:40** **Welcome and Introduction to the Graphene Flagship and Innovation**
Kari Hjelt, Head of Innovation, Graphene Flagship
- 09:40-10:00** **Keynote speaker: Nobel Laureate Konstantin Novoselov**
Graphene: Discovery, unique Properties, Applications
Konstantin Novoselov, Director at the National Graphene Institute at The University of Manchester

Session 1: Data Communication

- 10:00-10:10** **Graphene enabled optical and wireless Datacom for 5G and beyond**
Daniel Neumaier, Head of the Graphene group at AMO GmbH
- 10:10-10:30** **Graphene photonic Devices in Telecom and Datacom Applications**
Paola Galli, Member of Technical Staff at Nokia-Bell Labs
- 10:30-10:40** **Demonstration of high Speed Data-link based on Graphene**
Marco Romagnoli, Head of Advanced Technologies for Photonic Integration at CNIT
- 10:45-11:15** **Coffee Break**

Session 2: Flexible Displays and Wearables

- 11:15-11:35** **Perspective of wearable, flexible and printed Electronics**
Henrik Sandberg, Principal scientist at VTT's centre for Printable and Hybrid Functionalities



PROGRAMME

11:35-11:55 **Industry Perspective: Bringing Surfaces to Life: The Potential of Graphene and graphene-like Materials for flexible Electronics**
Rouzet Agaiby, Senior Business Development Engineer at FlexEnable

Session 3: IoT and Sensors

12:00-12:20 **Seeing the Invisible: Sensors and Cameras for Health, Night Vision, Automotive etc.**
Frank Koppens, Group leader at the Institute of Photonic Sciences (ICFO)

12:20-12:40 **Industry Perspective: High Performance Graphene Sensors – Routes to CMOS Integration**
Tapani Ryhänen, CEO and Co-Founder of Emberion Oy

12:45-13:30 **Lunch Break**

13:30-13:45 **Collaboration opportunities with the Graphene Flagship**
Kari Hjelt, Head of Innovation, Graphene Flagship

13:45-14:30 **Discussion panel**
Our experts will discuss the industrial opportunities and potential challenges using graphene and answer questions.
Moderator: Andrea C. Ferrari, Professor of Nanotechnology; Director, Cambridge Graphene Centre; Science and Technology Officer and Chair of the Management Panel, Graphene Flagship

Panel:

- Tapani Ryhänen, CEO and Co-Founder of Emberion Oy
- Ray Gibbs, CEO Haydale
- Kari Hjelt, Head of Innovation Graphene Flagship
- Marco Romagnoli, Head of Advanced Technologies for Photonic Integration at CNIT
- Frank Koppens, Group leader at the Institute of Photonic Sciences (ICFO)

14:30-16:00 **Parallel Group Discussions**
You will have the possibility to choose one of several key topics related to the use of graphene in the industry and take part in smaller group discussions. This will give all delegates the opportunity to exchange experience on specific issues and solutions, and identify collaborating partners and future projects within the Graphene Flagship programme.

SPEAKERS

Konstantin Novoselov

Nobel Laureate and Director at the National Graphene Institute at The University of Manchester

Novoselov is best known for isolating graphene at The University of Manchester and being awarded the Nobel Prize for Physics in 2010. His expertise lies within condensed matter physics, mesoscopic physics and nanotechnology. Konstantin Novoselov holds positions of Langworthy Professor of Physics and the Royal Society Research Professor at The University of Manchester.



Kari Hjelt

Graphene Flagship's Head of Innovation

Hjelt is the Graphene Flagship's Head of Innovation. He has extensive experience in building up corporate research and venture activities from being the founder and CEO of several start-up companies, as well as director at Nokia Ventures Organisation and Nokia Research Centre. He holds a PhD in Engineering Physics from Helsinki University of Technology, as well as an MBA from the London Business School.



Daniel Neumaier

Head of the Graphene group at AMO GmbH

Neumaier is the head of the Graphene group at AMO GmbH. He studied physics at the TU Munich and obtained his PhD degree from the University of Regensburg in 2009. He is currently principle investigator in two national projects and four EU projects in the field of graphene. His research interests are graphene based devices for high-frequency electronic, optoelectronic and sensor applications.



SPEAKERS

Paola Galli

Member of Technical Staff at Nokia-Bell Labs

Galli is Member of Technical Staff (MTS) at Nokia-Bell Labs. Project leader for high capacity optical transceivers for telecom applications based on novel technologies, and is currently working on silicon photonics based devices for WDM networks. Her research interests include development of new technologies for next generation Terabit photonics, with particular focus on graphene-enhanced photonics.



Marco Romagnoli

Head of Advanced Technologies for Photonic Integration at CNIT

Romagnoli is Head of Advanced Technologies for Photonic Integration at CNIT in Pisa since 2012 and contract professor at Scuola Superiore S. Anna in Pisa. He has over 35 years of experience in the area of photonic technologies for TLC, working for the IBM Research Centre, the Fondazione Ugo Bordoni, Pirelli R&D Photonics and in PhotonIC Corp.



Henrik Sandberg

Principal scientist at VTT's centre for Printable and Hybrid Functionalities

Henrik Sandberg is a principal scientist at VTT's centre for Printable and Hybrid Functionalities with a PhD in physics from Åbo Akademi University in Finland. His work is currently focussed on printed electronic devices and circuits, polymer device physics, printing technology and printing ink formulation as well as heterogeneous and monolithic integration for flexible electronics.



SPEAKERS

Rouzet Agaiby

Senior Business Development Engineer at FlexEnable

Agaiby has over ten years' experience in a variety of technologies including semiconductor manufacturing, solar cells and flexible electronics with special focus on sensors. Rouzet is responsible for growing the implementation of FlexEnable's flexible electronics technology in X-ray detectors and fingerprint sensors. Rouzet leads the work on integrating graphene and other 2D materials in FlexEnable's flexible electronics technology.



Frank Koppens

Group leader at the Institute of Photonic Sciences

Koppens is a group leader at the Institute of Photonic Sciences (ICFO) in Barcelona. Koppens has a PhD in physics (from the Netherlands) and worked as a scientist at Harvard University. Currently, he is leading the innovation and scientific activities that exploit graphene. Koppens is the leader of the opto-electronics activities in the Graphene Flagship.



Tapani Ryhänen

CEO and Co-Founder of Emberion Oy

After heading a Business Line at Nokia Technologies, Ryhänen became the CEO and Co-Founder of Emberion Oy which is a spin-out from Nokia's R&D, based in Finland and UK. Emberion focuses on design and productisation of high-performance optoelectronics based on graphene. Member of the Graphene Flagship Scientific Advisory Council.



SPEAKERS

Andrea C. Ferrari

Professor of Nanotechnology,
Director, Cambridge Graphene Centre,
Science and Technology Officer and Chair of the Management Panel, Graphene Flagship

Andrea C. Ferrari is Professor of Nanotechnology at the University of Cambridge. He is the Director of the Cambridge Graphene Centre and of the EPSRC Centre for Doctoral Training in Graphene Technology. He is the Science and Technology Officer and Chair of the Management Panel of the European Graphene Flagship. He is Fellow of Pembroke College, Fellow of the American Physical Society, Fellow of the Institute of Physics, Fellow of the Materials Research Society, Fellow of the Optical Society. His research interests cover photonics, optoelectronics, flexible and printed electronics based on graphene and related materials.



Ray Gibbs

CEO Haydale

Ray Gibbs is the Chief Executive Officer of Haydale Graphene Industries Plc. He has over 20 years' experience in high technology and fast moving consumer goods businesses and has been immersed into the graphene and nano world for 5 years. An accomplished international speaker now seen at many Graphene conferences, Ray offers a rare insight into industry and the ability to make the bridge with the academic world.





Session 1: Data Communication

10:00-10:40

Graphene enabled optical and wireless Datacom for 5G and beyond

Daniel Neumaier, Head of the Graphene group at AMO GmbH

The outstanding electronic and electro-optical properties of Graphene make it a perfect material for high-performance modulators, photodetectors and receivers, meeting the demands of future optical and wireless communication systems in terms of bandwidth, energy consumption and on-chip CMOS-integration. This talk will discuss the opportunities of graphene based electronic and opto-electronic devices, focusing on on-chip photonic components and receiver circuits operating at frequencies up to 100 GHz. A critical assessment with competing technologies will be given.

Graphene photonic Devices in Telecom and Datacom Applications

Paola Galli, Member of Technical Staff at Nokia-Bell Labs

The strong demand for transmission bandwidth at low cost to face the growing 5G mobile communications market and the development of IoT, requires a new technology that overcomes the well-established ones in which costs and performance scaling are limited. The presentation will address applications in future telecom and datacom markets in which Graphene could play a role as rule breaker and provide low cost, energy efficient photonics devices.

Demonstration of high Speed Data-link based on Graphene

Marco Romagnoli, Head of Advanced Technologies for Photonic Integration at CNIT

Datacom and Telecom require continuous improvement in bandwidth at constant level of consumption and cost reduction. According to the Ethernet roadmap the bandwidth doubles every two years and the candidate technology for large volume and reduced cost must scale on all of these key aspects.

In this presentation we show the roadmap towards graphene integrated photonics devices with very high performances. We report on first transmission experiments on 100km of standard fiber at 1550nm carried out with graphene electroabsorption modulation at 10Gb/s showed performances comparable with well-established technologies. These results indicate the potentiality of scalability of graphene photonics.



Session 2: Flexible Displays and Wearables

11:15-11:55

Perspective of wearable, flexible and printed Electronics

Henrik Sandberg, Principal scientist at VTT's centre for Printable and Hybrid Functionalities

Graphene and related two dimensional materials (GRMs) are particularly suitable for applications in flexible devices. The GRMs can withstand repeated bending down to very small curvatures, can be applied using a wide variety of methods and onto almost any substrate material. Furthermore, GRMs offer a versatile platform for highly sensitive and selective sensors through their diverse functionalization potential. Thus, both printed low end electronic applications and high performance devices based on grown GRM can be achieved. Wearable applications benefit from those unique GRM properties as devices can be made light-weight, thin, flexible, and potentially even stretchable. Utilizing printed electronics and hybrid integration manufacturing methods devices could also be very low cost – further boosting the strongly expanding wearable electronics market.

Industry Perspective: Bringing Surfaces to Life: The Potential of Graphene and graphene-like Materials for flexible Electronics

Rouzet Agaiby, Senior Business Development Engineer at FlexEnable

Graphene and other 2D materials possess inherent unique properties that, if fully utilised in electronic devices, can prove to be transformational. Graphene's excellent electronic characteristics make it a suitable contender to replace ITO to develop truly flexible OLED displays. On the other hand, the promising semiconducting properties of other 2D materials like molybdenum disulphide can replace conventional silicon technology to enable high performance flexible devices. The talk will address the challenges associated with maintaining the inherent properties of graphene and 2D materials as they are integrated into the device stack as well as challenges related to scalability in order to transfer the technology from lab to fab.



Session 3: IoT and Sensors

12:00-12:40

Seeing the Invisible: Sensors and Cameras for Health, Night Vision, Automotive, etc.

Frank Koppens, Group leader at the Institute of Photonic Sciences (ICFO)

There is a large demand for sensors that can be easily integrated with many different objects. The rising trend of the internet-of-things illustrates the need for sensing by any object surrounding us. Sensors should be cheap, invisible and easy to integrate with many different surfaces such as bendable plastic, fabric and glass. And they should “see” things we cannot see. Here we present a novel sensor platform that does just that.

Application examples include wearable health and fitness monitors that are flexible and ultra-thin as well as low-cost CMOS night vision cameras.

Industry Perspective: High Performance Graphene Sensors - Routes to CMOS Integration

Tapani Ryhänen, CEO and Co-Founder of Emberion Oy

Graphene charge transducers enable a variety of sensors and photodetectors when combined with other chemically-, optically- or physically-sensitized materials. Emberion, a newly-formed SME, employs such graphene photonics and electronics to produce infrared photodetectors and thermal sensors. In this presentation, we discuss the principles of graphene sensors and their performance, the use of graphene in the context of complex CMOS circuitry and finally, Emberion’s vision and focused mission to commercialize graphene photonics. Key applications and customer value are discussed.



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