



RESEARCH CONFERENCES

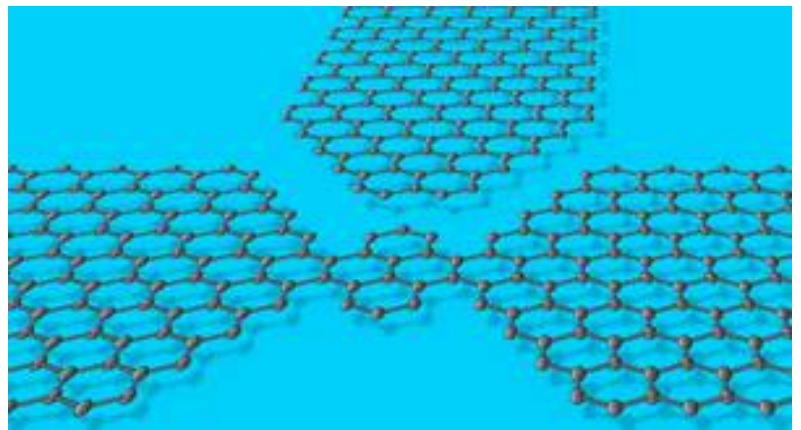
ESF Conference in Partnership with LFUI

Graphene Week 2011: Fundamental Science of Graphene and Applications of Graphene-Based Devices

Universitätszentrum Obergurgl (Ötz Valley, near Innsbruck) • Austria
24 - 29 April 2010

Chairs:

- **Vladimir Falko**, Lancaster University, UK
- **Andre Geim**, University of Manchester, UK
- **Karsten Horn**, Fritz-Haber-Institut Berlin, DE
- **Sankar Das Sarma**, University of Maryland, US



Conference Highlights

Please provide a brief summary of the conference and its highlights in non-specialist terms (especially for highly technical subjects) for communication and publicity purposes. (ca. 400-500 words)

This conference was devoted to science and technology of graphene (atomically thin graphitic films – monolayers, bilayers, trilayers), advances in its growth and chemical processing, manufacturing graphene-based devices, investigation of physical properties, and emerging applications of this new material.

A particular attention has been given to the methods of manufacturing graphene using CVD growth on metals and sublimation of graphene from SiC, as well as extensive characterization of the produced material using Raman spectroscopy, ARPES, STM and AFM studies. The recent progress has enabled the group from SKKU to grow graphene on Cu, which opens routes toward mass production of large area (up to 1m) polycrystalline monolayer films.

Technology of mass production of graphene also opens the doors into its application in optoelectronics, as transparent electrodes in LCD screens. Another optoelectronics application discussed during the conference consists in the use of graphene as a saturable absorber in non-linear optical circuits, and for frequency multipliers in the THz range.

New results on transport studies of graphene p-n junctions, nanoribbons and quantum dots have been reported, in particular, on suspended graphene devices where graphene was cleaned from deposits to an almost pristine condition: a breakthrough has been achieved by several groups in the studies of suspended bilayer graphene. Several breakthrough results on graphene - boron nitride two-layer system have been reported, demonstrating that two graphene layers separated by an atomically thin BN film can give access to both new transistor operation regimes for graphene-based transistors and to the observation of new physics in graphene itself.

X I hereby authorize ESF – and the conference partners to use the information contained in the above section on 'Conference Highlights' in their communication on the scheme.

Scientific Report

Executive Summary

(2 pages max)

The conference has attracted a lot of attention, and it has been oversubscribed 2.5:1, with the number of participants limited by the capacity of the venue. Total number of attendees was 118 (male 90% ; female 10%, and young researchers (age <35) 51%).

Attendees affiliation (by country):

AT 1%
BE 4%
BR 1%
CH 12%
CN 3%
DE 19%
FI 1%
FR 7%
HU 1%
JP 6%
KR 4%
IR 1%
IT 1%
NL 4%
PO 1%
SG 1%
UK 9%
US 13%

The Conference had a balanced programme of 46 talks and two poster sessions, with a mid-day break enabling the participants to both listen to the presentations and have time for informal contacts and networking.

The ESF support has been used to fund the participation of invited speakers and junior researchers. Also, 24% of the attendees were from the groups participating in the ESF Eurocores programme in 'EuroGraphene', thus, interlinking the ESF conference activities with the ESF-run topical research programmes.

Scientific Content of the Conference

(1 page min.)

- *Summary of the conference sessions focusing on the scientific highlights*
- *Assessment of the results and their potential impact on future research or applications*

This conference was devoted to science and technology of graphene (atomically thin graphitic films – monolayers, bilayers, trilayers), advances in its growth and chemical processing, manufacturing graphene-based devices, investigation of physical properties, and emerging applications of this new material. The Conference sessions were focused on: Electronic Transport in Graphene-Based Devices; Methods of Graphene Manufacturing; Characterization of Graphene and its Derivatives.

A particular attention has been given to the methods of manufacturing graphene using CVD growth on metals and sublimation of graphene from SiC, as well as extensive characterization of the produced material using Raman spectroscopy, ARPES, STM and AFM studies. The recent progress has enabled the group from SKKU to grow graphene on Cu, which opens routes toward mass production of large area (up to 1m) polycrystalline monolayer films (SKKU).

Technology of mass production of graphene also opens the doors into its application in optoelectronics, as transparent electrodes in LCD screens. Another optoelectronics application discussed during the conference consists in the use of graphene as a saturable absorber in non-linear optical circuits (Cambridge), and for frequency multipliers in the THz range (MIT).

New results on transport studies of graphene p-n junctions, nanoribbons and quantum dots have been reported, in particular, on suspended graphene devices where graphene was cleaned from deposits to an almost pristine condition: a breakthrough has been achieved by several groups in the studies of suspended bilayer graphene (Manchester, Basel, Columbia U). The studies of the quantum Hall effect in graphene synthesized on SiC has shown that this material is ideal for making the fundamental quantum resistance standard (NPL).

Several breakthrough results on graphene - boron nitride two-layer system have been reported, demonstrating that two graphene layers separated by an atomically thin BN film can give access to both new transistor operation regimes (group at Columbia University) for graphene-based transistors and to the observation of new physics in graphene itself. In particular, the use of two-layer graphene devices enabled the group at Manchester to study drag effect in graphene and to access the true properties of disordered graphene at low carrier densities.

Forward Look

(1 page min.)

- *Assessment of the results*
- *Contribution to the future direction of the field – identification of issues in the 5-10 years & timeframe*
- *Identification of emerging topics*

The material presented in the Conference has shown that graphene research is on the rise, diversifying into a broad range of applications of graphene in electronics, optoelectronics, and ultra light materials engineering, and into the studies of fundamental physics of two-dimensional electronic materials.

The following trends have been identified during the Conference:

on the side of fundamental science, the studies of suspended graphene devices at a high magnetic field represent a viable direction to reach extreme corners of physics of strongly correlated systems;

on the side of new systems, graphene - boron nitride hetero-systems open a new direction of materials research, with the long-term prospect for the development of novel devices;

on the side of applications of graphene in consumer products, the most promising direction of research is related to the use of graphene as a transparent conductor in optoelectronic devices, and the most challenging direction of graphene chemistry will be in the growth of large-area graphene films on metals;

The Conference was a success, making the whole series of 'Graphene Weeks' a flagship conference in the field. The Graphene Week Conference will continue, following the growth of the field, and the next one, in Delft 2012 will be run with the help of ESF.

- Is there a need for a foresight-type initiative?
-

There is already one in graphene run by the ESF.

Atmosphere and Infrastructure

▪ *The reaction of the participants to the location and the organization, including networking, and any other relevant comments*

The participants have been highly impressed by the atmosphere of the venue and the excellent organization of the event by the ESF team.

The Conference had a balanced programme enabling the participants to both listen to the presentations and have time for informal contacts and networking.

Sensitive and Confidential Information

This report will be submitted to the relevant ESF Standing Committees for review.

In order to promote transparency, it is ESF policy to also publish the Scientific Reports on its website. Any confidential information (i.e. detailed descriptions of unpublished research, confidential discussions, private information) should therefore not be included in this report. Confidential issues can be addressed in the next page, which will not be published.

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Confidential Issues

▪ Any other issues, not to be included in the published report.

none

Date & Author:

1 September 2011

Vladimir Falko

A handwritten signature in blue ink, appearing to read 'V. Falko', is written over the printed name 'Vladimir Falko'. The signature is stylized and cursive.