Project name: Graphene on silicon carbide

Beamtime Report

01.08.2013 - 12.12.2013 *(Date of the report to be added)*

General information

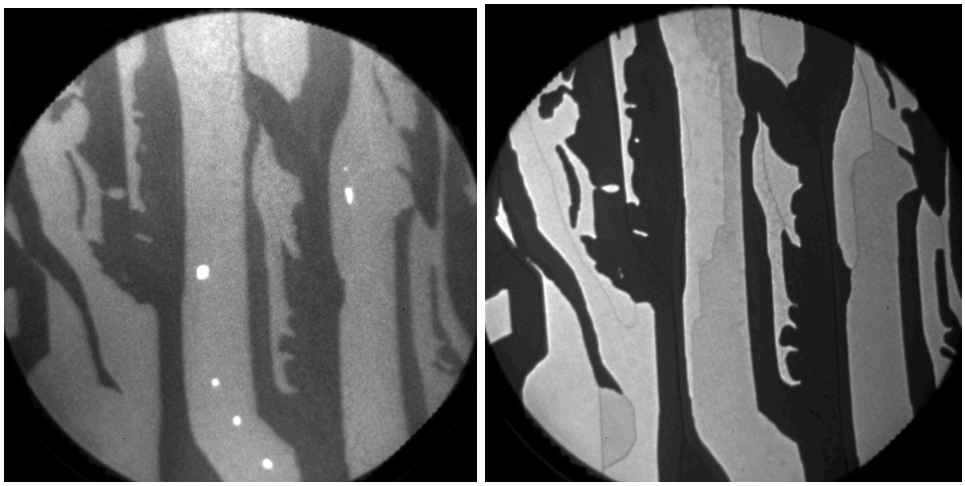
Name of the rapporteur	**Name of the rapporteur's organisation**
Mikael Syväjärvi	Graphensic AB
Type of research (nanotechnology/health care/chemistry etc.)	**Name of the research facility**
Nanotechnology	MAX-lab
Date of the measurement, duration	**Location of the event**
Facility personnel participating in the measurement	
Alexei Zakharov	

Description of the project

Research description (short summary as written in the application)
Graphensic manufactures graphene on silicon carbide. Graphene is moving from research to industry and from materials to applications. There is a need to control and verify the properties of the material in production. There is a balance between influence of the substrate defects and growth conditions. One issue is coverage of monolayer graphene, and possibly other issues like adsorbates.
Summary of activities (experiments performed, beamtime used, preliminary overview of results, next steps and other relevant information)
Graphensic is increasing the production. The graphene produced in new reactors and higher volume production material is compared with what has been possible to achieve in the research reactor. The new reactor is in start-up phase, and first samples from this are being produced in early 2014. The activity so far has been to study the results that are obtained regarding adsorbates that could appear post-growth and long term storage of manufactured material. There is an interest from customers to get feedback from measurements that are possible at Maxlab. Potentially such leads could be more regular users of Maxlab. In particular we have studied adsorbates, using the SPELEEM instrument at the I311 beamline at MAX-lab, that could be on the surface of graphene on silicon carbide. The as-produced graphene samples are usually clean from any possible contamination. We

have noticed that adorbates may form on samples that are stored, which is important to consider when it comes to having products that are offered as on-stock material to decrease delivery times of our products (graphene material) to customers. The adsorbates are naturally occurring in contact with air after some weeks. In contrast to silicon, the graphene does not form an oxide. The true nature of adsorbates is not yet known, but could be carbon inclusions related. In standard samples, such adsorbates may be removed by a heating to 500 deg C.

However, in some cases, a higher temperature may be required for cleaning. In any case, as cleaning procedure before device preparations on graphene material, it seems that a heating of material may be routinely applied to remove adsorbates. Our SPELEEM results indicate that heating to 600 deg C can remove adsorbates, see figure below. However, in order to determine a more exact temperature for sufficient removal of adsorbates more statistics on the issue are needed.



Left: an XPEEM secondary electron image of a 1ML graphene/SiC(0001) sample (gray area) with 2ML islands on it (bright grey areas). FoV=10mkm, photon energy 130eV. The X-rays have been used to emphasize contaminations on the surface (bright dots) which have a carbon nature. Right: after annealing at 600^{o}C the contaminations are gone which can be seen in the LEEM image at electron energy of 1.6eV.

How would you describe cooperation and assistance from industrial liaison officers and national contact points while preparing and carrying out the research at large scale facilities?

It has been very fruitful.

Other personal remarks

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Annexes

Annexes (list of annexes; meeting minutes, graphical illustrations, tables and other supplementary data)

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