

## Scientific report

Project AKTION 70p10

### *Characterization of catalytic systems by low energy ion scattering (LEIS)*

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From the scientific point of view the project was successfully finished at September 2015 by publishing of our joint article by American Chemical Society in Langmur, Volume 31, Issue 35, "**Highly Sensitive Detection of Surface and Intercalated Impurities in Graphene**".

The full article is distributed free of charge as it was selected as ACS Editors' Choice. Additional to that the main article idea was presented at the journal issue cover by original graphics.

The electronic version of the article is available for example through publisher web pages:

<http://pubs.acs.org/journal/langd5>



### Extended article abstract

*Preparation of large-area graphene by chemical vapour deposition (CVD) has become one of the most popular techniques used within the graphene community. However, its charge transport properties are lagging behind those of graphene flakes obtained by the traditional exfoliation method. Therefore, to improve the electronic properties of the CVD graphene, sensitive analytical techniques capable of monitoring graphene imperfections and impurities are a must.*

*We show in this paper that with high-sensitivity LEIS we are able to verify the closure of graphene layers, to detect and quantify various contaminants, and to determine their location in the graphene and the related interface. Also, utilizing the extraordinary strong neutralization of helium ions by graphene carbon atoms, the graphene carbon is distinguished from that in non-graphitic forms (e.g. remains of a resist). For perfect graphene the neutralization is so strong that the detection of graphene carbon atoms with LEIS is almost impossible. A theoretical interpretation of this strong matrix effect is given.*

*We show that LEIS can be used for monitoring the quality of the whole fabrication process of the CVD graphene including its transfer on various substrates. This provides a novel and complementary way for characterization of the graphene system and is therefore directly relevant for scientists that want to understand and improve the electronic properties of graphene.*

Compared with the original project proposal we have decided to focus more to the fundamental analysis of CVD graphene quality (homogeneity, thickness, level of contamination). This was a must because graphene contamination by metals could significantly influence properties of catalytic systems. We firmly believe that the paper could be of significant interest for surface scientists and nanotechnology researchers.

The article combines experimental results measured by conventional TOF-LEIS spectrometers and RBS at Brno University of Technology and partner Johannes Kepler University Linz with quantitative measurements performed on High Sensitivity LEIS (HS-LEIS) equipment Qtac 100 offered by ION TOF company in Munster Germany.

Additional to fundamental outputs from the research the results are being used to improve CVD technology of graphene growth and its consequent transfer to silicon substrates.

The HS-LEIS Qtac100 has been installed in the BUT university Surface Science lab. We would like to use it in subsequent research of graphene based systems, thin films characterisation and investigation of ion stopping powers in cooperation with partners in JKU Linz.

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