Improving graphene-based devices:
New developments studied on the nanoscale via nano-FTIR microscopy and spectroscopy

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Abstract

The performance of the next-generation optoelectronic devices based on graphene is strongly influenced by the structure-function relationship. For example, a long life time of the surface plasmons is, although theoretically predicted, still lacking due to strong damping mechanisms. New ideas have thus been introduced, and they strongly demand for an analytic tool that allows to study the plasmonics behavior with nanometer resolution in real space.

With scattering-type scanning near-field microscopy (s-SNOM) such a tool has been invented, enabling the nanoscale mapping of nano-devices. It combines the best of two worlds: the high spatial resolution of atomic force microscopy (AFM) and the analytical power of infrared spectroscopy. The spatial resolution of about 10 nm of nano-FTIR microscopy opens a new era for modern nano-analytical applications such as chemical identification, free-carrier profiling and plasmonic vector near-field mapping.

Recent graphene related research will be highlighted, demonstrating the power of nano-FTIR microscopy due to its contact-free direct access to the plasmonic properties, local conductivity, electron mobility and intrinsic doping via plasmon interferometry imaging [1-4]. Using plasmon interferometry, nano-FTIR microscopy can investigate losses in graphene by exploring real-space profiles of plasmon standing waves formed between the tip of our nano-probe and the edges of the samples (fig1). Plasmon dissipation quantified through this analysis is linked to the exotic electrodynamics of graphene.

Using femtosecond light sources, s-SNOM has successfully be extended towards ultrafast experiments with up to 10-femtosecond temporal resolution. Investigation of carrier-relaxation dynamics in graphene [5] demonstrates the high potential for ultrafast near-field microscopy.

A new s-SNOM configuration even combining near-field microscopy with photocurrent nanoscopy (fig2) [6]. The symbiosis of these two complementary techniques opens up a complete new research field for nano-spectroscopy, bringing together optical, opto-electronic and electronic analysis on the nanoscale in a complete non-destructive and non-invasive way.

Beyond the mentioned examples a further overlook of the latest research will be given in this presentation.

References

[1] A Woessner *et al.*, Nature Materials **14** (2015) 421.
[2] S. Dai *et al.*, Nature Nanotechnology **10** (2015) 682.
[3] Z. Fei *et al.*, Nature **487** (2012)
[4] J. Chen *et al.*, Nature **487** (2012) 82.
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Figures

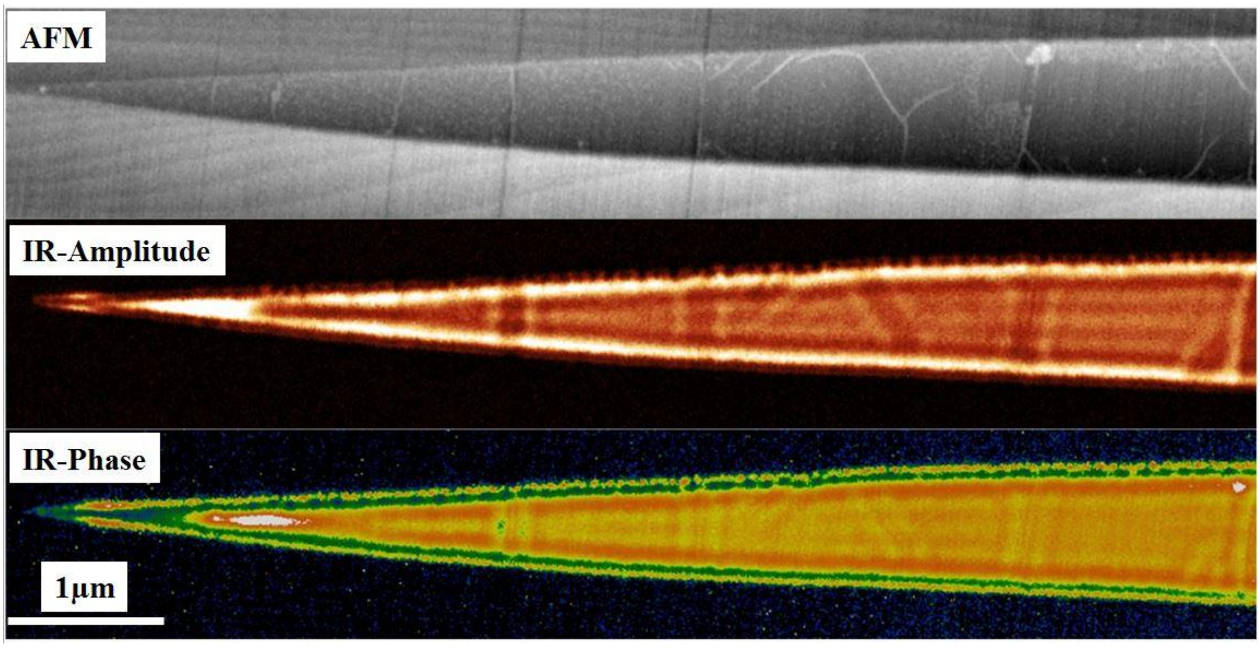

Fig1. Correlative AFM and nano-FTIR microscopy. Contact-free direct access to local conductivity, electron mobility and intrinsic doping via plasmon interferometry imaging.

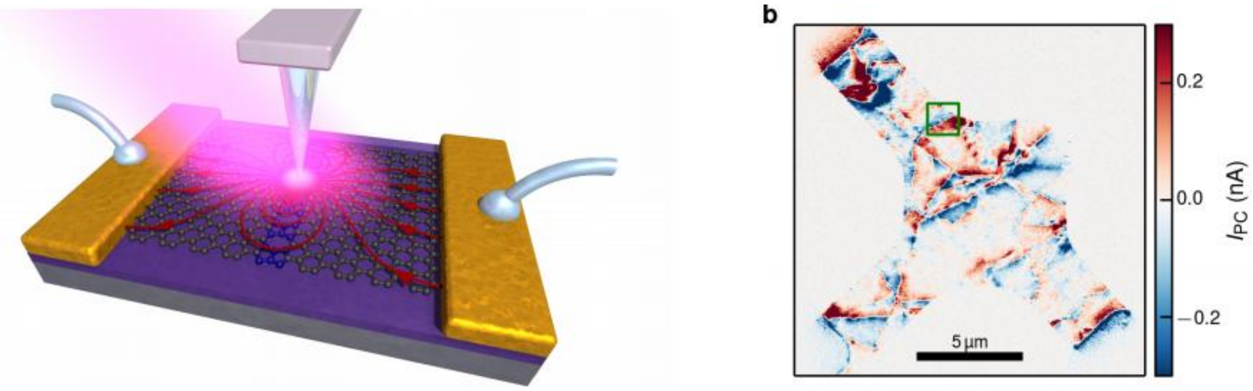

Fig2. Schematic of near-field photocurrent experiment. Right: Photocurrent near-field map of a graphene sheet revealing characteristic patterns on the nanoscale. (From [6].)