Hybrid Inorganic/Organic Systems for Opto-Electronics

Collaborative Research Centre 951

Colloquium Announcement

of the Collaborative Research Centre 951
"Hybrid Inorganic/Organic Systems for Opto-Electronics"

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Vibrational spectroscopy in the electron microscope

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Momentum-resolved dynamics of phonons, electrons, and excitons

Time: Thursday, 23.01.2020, 15:15

Place: Erwin-Schrödinger-Zentrum, Rudower Chaussee 26, Room 0'119.

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Vibrational spectroscopy in the electron microscope

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Vibrational spectroscopy in the electron microscope has progressed remarkably since it was introduced by us 6 years ago (Nature **514** (2014) 209).

Phonons can be excited by fast electrons in two fundamentally different ways: by dipole scattering, which is similar to exciting the sample by infrared light, and by impact scattering, which bears a closer resemblance to inelastic X-ray and neutron scattering. The two signals can be selected using an aperture that defines the scattering angles accepted by the spectrometer: small angles correspond to dipole scattering, and large angles to impact scattering. Selecting impact scattering allows phonons is solids to be studied with sub-nm level spatial resolution.

The dipole signal is delocalized, and this allows the sample to be probed from a small (~30 nm) distance, by "aloof spectroscopy". In this way, vibrational properties of biological and other "fragile" materials can be probed without significant radiation damage, presently with about 5 meV energy resolution. This promises to revolutionize analysis of organic materials in the electron microscope.

This presentation will review the fundamentals of the technique, and illustrate its progress with several examples of recent applications.

Momentum-resolved dynamics of phonons, electrons, and excitons

H. Seiler, D. Zahn, S. Dong, S. Beaulieu, P. Xian, A. Neef, M. Dendzik, T. Pincelli, W. Windsor, J. Maklar, T. Vasileiadis, Y. Qi, M. Puppin, L. Rettig, M. Wolf,
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In collaboration with CRC 951 projects A8, A12, A13, B11, B12, and B15

Employing ultrafast techniques providing momentum resolution, we aim for quantum-state-resolved observations of vibrational and electronic excitations and their dynamics in crystalline materials and heterostructures. The dynamics of electrons and excitons is measured with four-dimensional time- and angle-resolved photoemisssion spectroscopy (trARPES), which provides access to the time-dependent distribution of excited states in the entire Brillouin zone of photo-excited crystals. I will discuss the signatures of excitonic many-body states in trARPES, exemplified for WSe_2. The complementary view on ultrafast phonon dynamics is obtained with femtosecond electron diffraction (FED). Inelastic electron scattering signals reveal the momentum distribution of transient non-thermal phonon populations, which will be discussed for the case of the anisotropic semiconductor black phosphorous.

Applied to nanoscale heterostructures, our approaches provide information on interfacial energy and charge transfer. I will discuss the current status of FED studies of MoS_2-pentacene heterostructures and our first trARPES data from an organic crystal.