More than 25 years of experience in s&t cooperation with Japane

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Japanese Science Day

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universität wien
Fakultät für Physik

European Research Council
Executive Agency
Established by the European Commission

Briefly introducing myself

- Since 2008 Professor for low dimensional quantum solids
- Background: solid state physics and surface science and cutting edge spectroscopy
- In-house synthesis of nanomaterials and development of spectrometers and specimen chambers for nanomaterials
- **Ongoing and past cooperations with Japan since 1996:**

  1. **Kazu Suenaga (AIST Tsukuba now Osaka University):** TEM and electron spectroscopy
  2. H. Kataura, T. Saito (AIST, Tsukuba): Nanotubes
  3. S. Maruyama (University of Tokyo): Aligned nanotubes
  4. **K. Yanagi, Y Miyata (Tokyo metropolitan University):** TMDC, nanotubes, layers
  5. H. Shinohara, R. Kitaura (Nagoya University): fullerenes, nanotubes

- I also did a 4 month sabbatical co-financed by the JSPS in Kazu Suenaga `s group at AIST 2019.

MOmentum and position REsolved mapping Transmission Electron energyloss Microscope (MORE-TEM): 2021-2026

ERC-SYNERGY Grant: 6 Years, 14 M€

European Research Council
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PI: Thomas Pichler University of Vienna, Faculty of Physics, Austria
Co-PI: Francesco Mauri La Sapienza University, Rome, Italy
Co-PI: Kazu Suenaga AIST / Osaka University, Japan
Co-PI: Max Haider CEOS GmbH, Heidelberg, Germany

- An electron microscope as revolutionary „table top“ synchrotron
- At that time Second biggest basic research investment of the EU in Japan
- **Outreach: Presenting MORE-TEM in the European Parliament 2023** as best practice example for a successful **cooperation EU/Japan** in the joined STOA/STS meeting on *"Furthering international research cooperation in a fragmented world“*

https://www.europarl.europa.eu/stoa/en/events/details/furthering-international-research-cooper/20230505WKS05301).

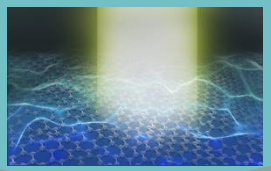
https://more-tem.univie.ac.at

Spectroscopy

EELS

Ab-initio Theory

MORE-TEM



Microscopy

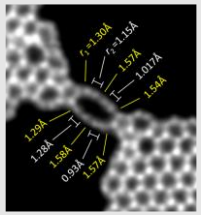
TEM/ EELS

Electron optics

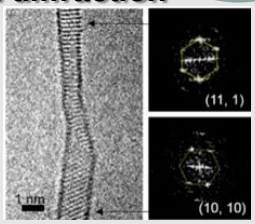
Spatial Mapping

SP 3

Atom resolution & diffraction

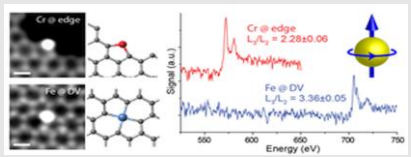


Ref. [1]

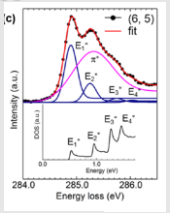


Ref. [12]

Local valence, bonding & site selective density of states

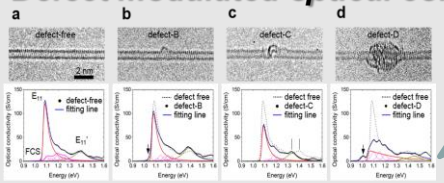


Ref. [23]



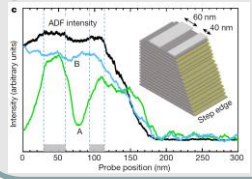
Ref. [12]

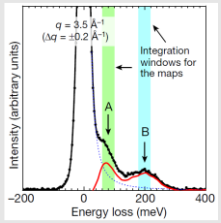
Defect modulated optical conductivity



Ref. [13]

Disentangling edge & bulk phonons modes

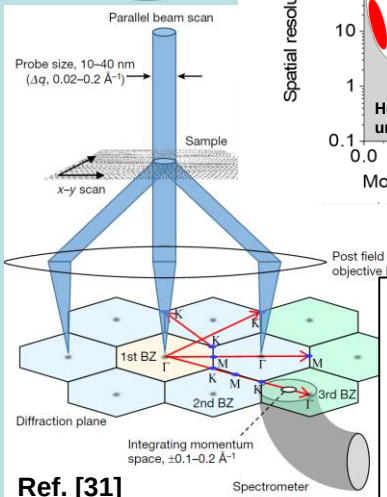




Ref. [31]

Instrument Development

SP 1



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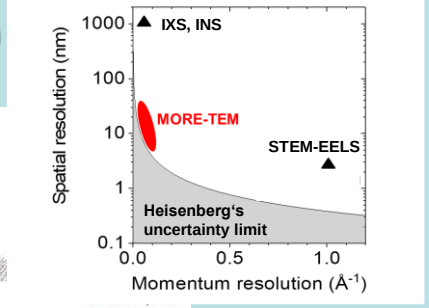
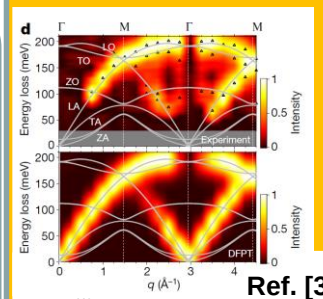


P ~ 10^{-9} mbar
T ~ 4.2-700 K
ΔE: 1 meV @30keV
Δq: 0.01 $Å^{-1}$

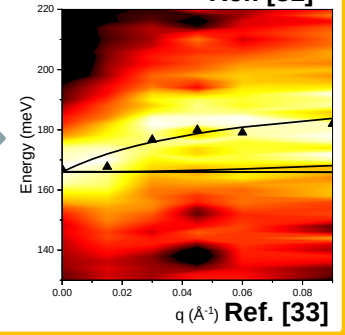
Momentum Mapping



Phonon dispersion from eperiment & density functional perturbation theory

Ref. [31]

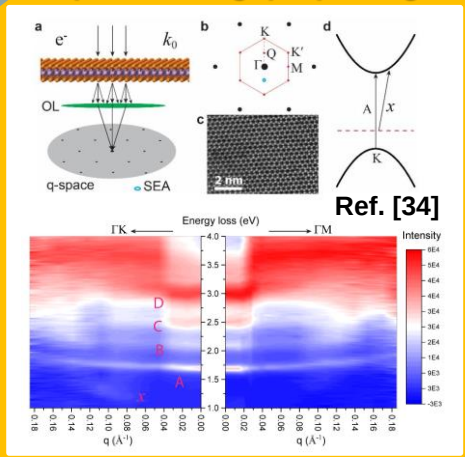
SP 4



Highest momentum (q-)resolution: Link to Optics & Plasmonics

Ref. [33]

Interband plasmon, exciton dispersion & gap opening.

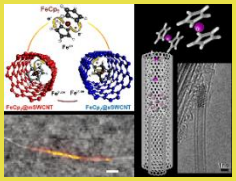


Ref. [34]

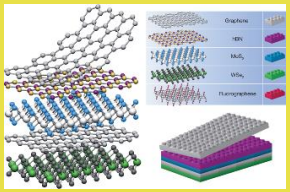
Nanoscale Matter & Sample Preparation

SP 2

Molecules & 1D Nanotubehybrids



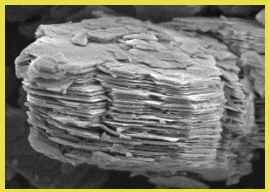
Ref. [10,45,75]



Monolayers 2D heterostructures

Ref. [44]

3D Nano- & Microcrystrals

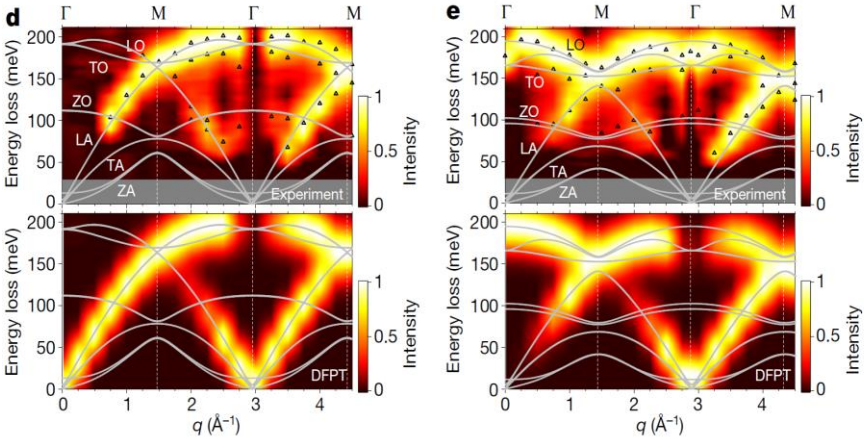


Ref. [47]

MORE-TEM Scientific basis: team involved: T. Pichler, K. Suenaga, F. Mauri, Machine: JEOL ARM 200F at AIST

Spatial and Momentum Mapping of Quasiparticles:

Momentum mapping of phonons in graphene nanostructures



R. Senga K. Suenaga, P. Barone, S. Morishita, F. Mauri, T. Pichler, **Nature 573,** 247 (2019)

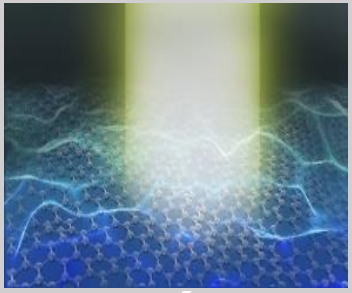
LETTER

https://doi.org/10.1038/s41586-019-1477-8

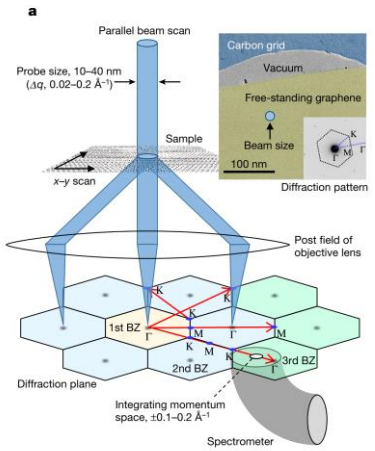
Position and momentum mapping of vibrations in graphene nanostructures

Ryosuke Senga[1], Kazu Suenaga[1]*, Paolo Barone[2], Shigeyuki Morishita[3], Francesco Mauri[4,5] & Thomas Pichler[6]

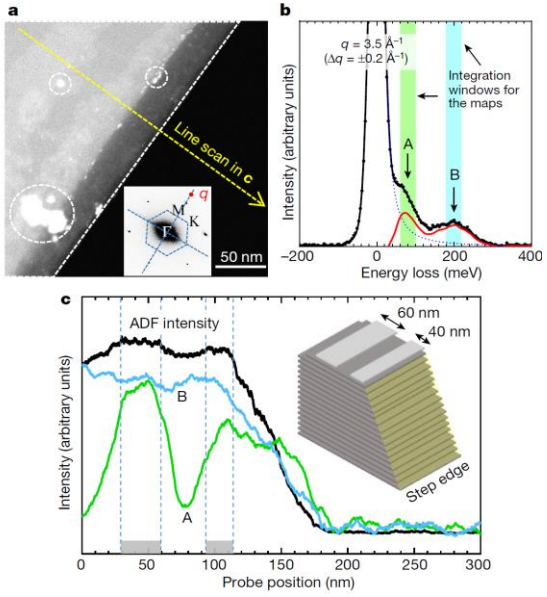
→ New scattering theory for phonons
→ Accessing Phonons of all materials



High-resolution nanoscale spectroscopy: Electron energy-loss spectroscopy in transmission electron microscopy



Spatial mapping of phonons in graphene nanoribbons



→ Tunable momentum resolution
→ Opens new pathway for new detection modes in STEM as basis for MORE-TEM

MORE-TEM implementation in Vienna at Sternwarte:

Team involved: T. Pichler, M. Haider (CEOS), JEOL for installing the ARM 200F platform

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New: *OVID* (Osaka Vienna International Development Laboratory) *webpage: ovid.univie.ac.at*

Mission Statement: *OVID* tackles the major challenge in condensed-matter physics to understand material properties via the complete knowledge of the energy vs. momentum (q) dispersion and lifetime of fundamental excitations with microscopic resolution.

Development Platforms at the Vienna Node:

1) MORE-TEM project: → **initiated OVID**
2) PORTES: Platform combining (angle resolved) photoemission with optical spectroscopy in one UHV system
3) DOM: Development of optical methods

Development Laboratories at the Osaka Node:

1) Triple-C project: developing dedicated low voltage TEM/STEMs for high-sensitivity analysis with the supports of Japanese funding agency.
2) OASP project: Osaka Advanced Specimen Preparation (OASP)