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MCES150
HREELS: Measuring Phonon Dispersion

MCES150 is a highly collimated and monochromatic electron source with an extremely narrow energy distribution. The combination of this source with Scienta Omicron high resolution ARPES analysers creates a platform for vibrational spectroscopy and phonon dispersion measurements.
Using the 2D detector system of the analyser enables massive parallelisation and reduces the measurement time by orders of magnitude compared to the traditional approach.

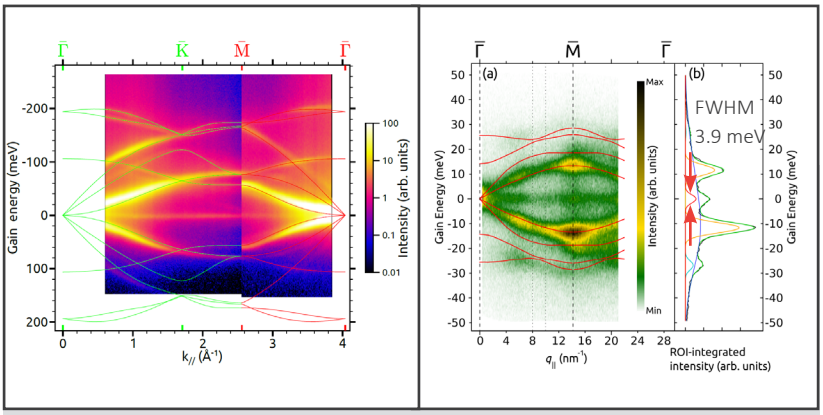


Figure 1, Left: Phonon dispersion of single crystal graphite, measured along the Γ-M direction. Single spectrum, primary energy 110 eV. (Data courtesy: Dr. F. C. Bocquet and Prof. F. S. Tautz, PGI-3 @ FZJülich, Dr. S. Tanaka, Osaka Univ.).

Right: Dispersion of Cu(111) surface phonons, acquired in merely 7 minutes (private communication). The experimental resolution after multi-phonon background subtraction is 3.9 meV (Data: Ibach et al, Review of Scientific Instruments, 88(2017)033903).

High resolution electron energy loss spectroscopy (HREELS) is a surface sensitive technique, which is well established for measuring for example vibrations of adsorbed species, surface phonons, and plasmons. As such, it is a fantastic complementary technique to ARPES electronic band structure mapping.

Traditional HREELS is a dedicated setup, achieving angular resolution by mechanically rotating a single channel energy analyser. Operating such a setup is both time consuming and limits the angular resolution. Similar to the introduction of energy and angular resolved detectors for ARPES in 1994, the latest development in HREELS is a quantum-leap to parallel energy and angular detection.

This quantum-leap becomes possible due to the analysers 2D detector, which simultaneously spans hundreds of channels in both the energy and angular directions. This massive amount of parallel channels drastically improves the measurement time and angular resolution. Scienta Omicron has partnered with Forschungszentrum Jülich and can now offer the MCES150 electron source directly.
It is a great complement to our ARPES products (see Figure 2).

Parallel Detection

Forschungszentrum Jülich has been central in the development of HREELS and the most recent advance is the integration of a user friendly and ultra-stable electron source as an add-on to their ARPES setup (Ibach et al., Review of Scientific Instruments, 88(2017)033903). It is equipped with a Scienta Omicron ARPES analyser and the phonon dispersion for Graphite has been measured (Figure 1, Left). Measuring phonon dispersions now becomes a matter of minutes/hours instead of days/weeks (Figure 1, Right).

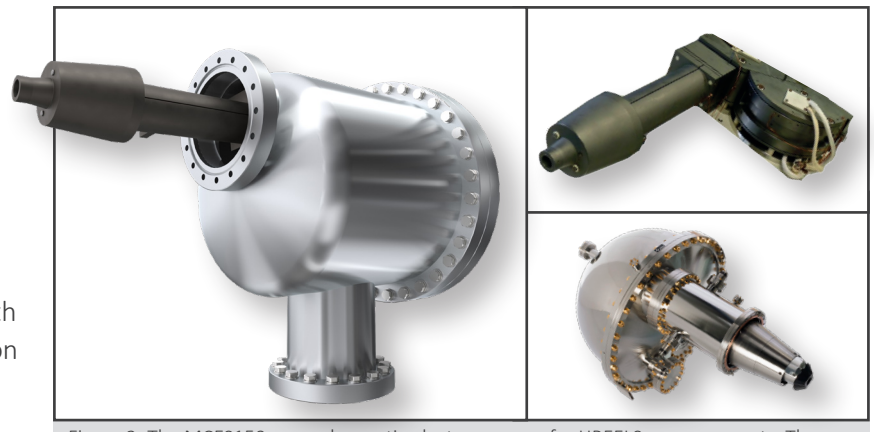


Figure 2: The MCES150 monochromatic electron source for HREELS measurements. The source is like an add-on, similar as our VUV5k, and when combined with a DA30-L analyser a highly efficient setup for ARPES and parallel acquisition of HREELS data is created.

Integration & Software

The MCES150 is easily integrated with our ARPES product range. It requires a flange orthogonal to the analyser port and is compatible with the low temperature manipulators used in our ARPES Lab system (see Figure 3).

The source is controlled and tuned by the dedicated parHREELS software (see Figure 4). It automatically optimises the monochromators and lens system by monitoring the analyser detector. With the 2D detector, intensity optimisation can be extended to include energy and angular resolution criteria. Once tuned, source stability throughout several measurements is easily achieved with the modular and ultra-stable HV electronics supplied with the source. The analyser control software allows to define presets for HREELS measurements. It is operated in the same way as for standard ARPES measurements.

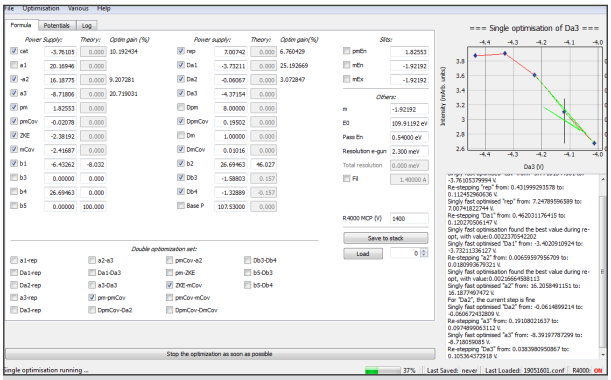
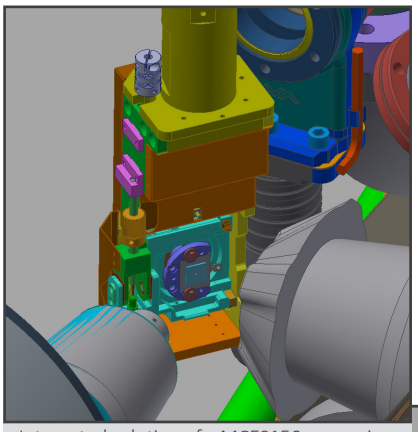


Figure 4: Dedicated parHREELS software for automatic tuning of the MCES150 HREELS source.



Integrated solution of a MCES150 source in a Scienta Omicron ARPES-Lab.

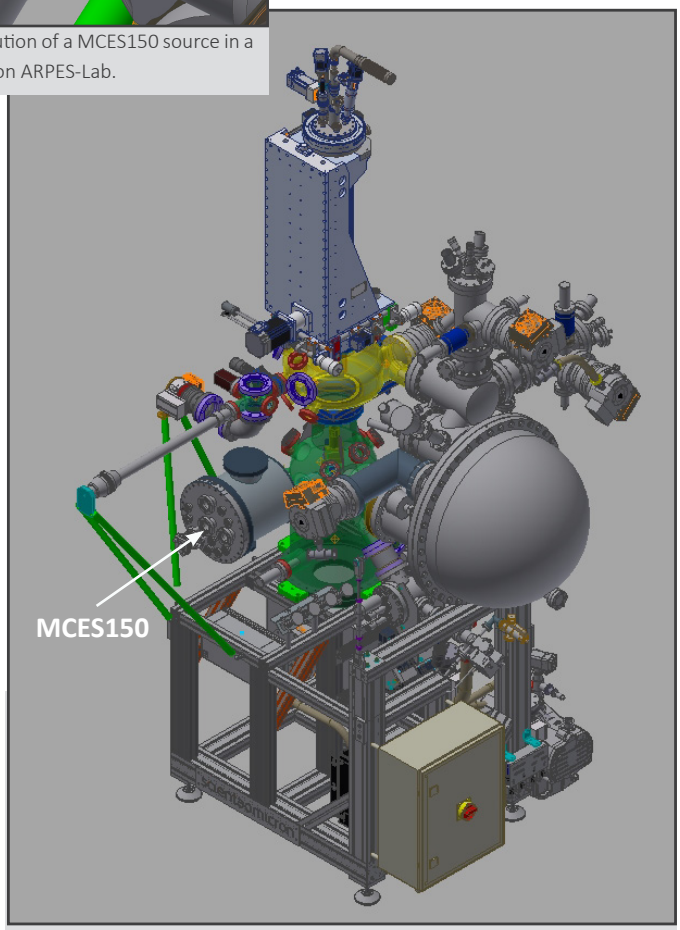


Figure 3: ARPES-Lab equipped with a DA30-L type analyser and MCES150 source for HREELS.

Technical Target Data

Property	Target Specification
Working distance	54 mm
Mounting flange	NW 100 CF, rotatable
Bake-out temperature	< 130 °C
Kinetic energy range	3 - 150 eV
Spot size	0.04 x 1 mm^2
Source resolution	< 3 meV at 200 pA
Experimental resolution	< 5 meV (*)

(*) A resolution of 3.9 meV is demonstrated for the setup at high currents (Figure 1, Right). Deconvolving with the 3.3 meV analyser resolution, the MCES150 source contributes with < 2.1 meV.

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