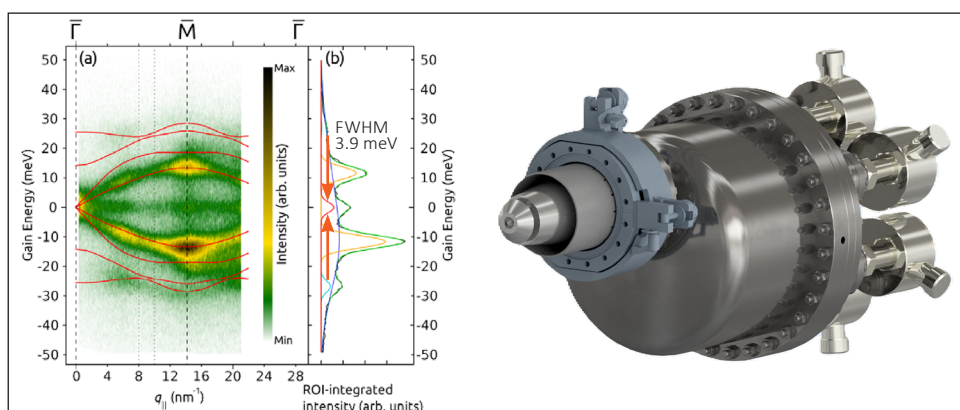


MCES150

Multichannel HREELS for exploring phonon dispersions and beyond

Multichannel high resolution electron energy loss spectroscopy (HREELS) enables direct observation of the dispersion of collective excitations at surfaces, such as phonons. The Scienta Omicron MCES150 monochromatic electron source, combined with an electron analyser for angle-resolved photoemission spectroscopy (ARPES) such as the DFS30, DA30-L and DA20, creates a powerful platform for multichannel HREELS measurements. The combination of a highly collimated electron beam and the analyser's 2D detector delivers excellent energy and angular resolution, while simultaneous multichannel acquisition reduces the measurement time by orders of magnitude compared to conventional HREELS approach.

HREELS probes surface excitations by directing a monochromatic electron beam onto a sample and analysing the scattered electrons. The resulting energy and momentum changes provide insight into a wide range of excitations, including phonons, plasmons, magnons, excitons, and vibrational modes. As such, it is a fantastic complementary technique to ARPES, which probes electronic band structure.



Efficient multichannel 2D detection

Traditional HREELS systems achieve angular resolution by mechanically rotating a single-channel electron analyser. This approach is inherently time-consuming and limits measurement throughput and angular resolution.

To overcome these limitations, Forschungszentrum Jülich developed a highly collimated, monochromatic electron source and integrated it with a Scienta Omicron electron analyser. By leveraging the analyser's 2D detector, which captures hundreds of energy and angular channels

simultaneously, the phonon dispersion measurements are accelerated from days/weeks to minutes/hours (Figure 1, left).

Building on this innovation and partnering with Forschungszentrum Jülich, Scienta Omicron has developed the MCES150 monochromatic electron source into a commercial solution, engineered to Scienta Omicron's standards for electrical and mechanical stability (Figure 1, right). The system demonstrated an outstanding energy resolution of 1.8 meV, which is less than 1 % of typical phonon energy (~200 meV) and is comparable to high resolution ARPES (Figure 2).

Key advantages:

- Explore surface collective excitations: phonons, plasmons, magnons, and excitons
- Boost measurement efficiency by >100x using proven 2D ARPES analysers
- Complete solution for dispersion measurements
- Multimodal characterisation combining multichannel HREELS with ARPES and XPS

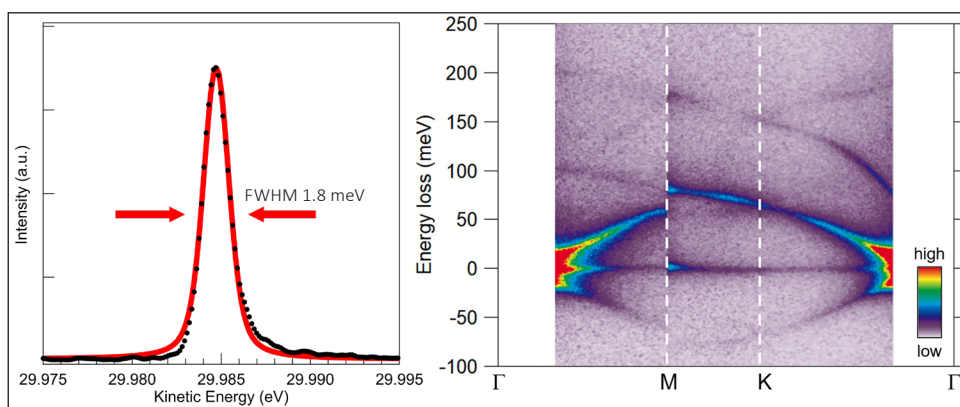


Figure 2: Demonstration using MCES150 electron source and DFS30 analyser.

Left: Elastic peak from Cu(111).

Right: Phonon dispersion of graphene/SiC(0001). Spectra measured at two different sample orientations (along Γ -M and Γ -K-M direction) are stitched together.

Data courtesy: Prof. Choongyu Hwang at Pusan National University

Ready for dispersion measurements

The combination of the MCES150 and a Scienta Omicron electron analyser provides a complete, out-of-the-box solution for multichannel HREELS. The MCES150 incorporates a sophisticated monochromator and lens design to optimise the electron beam for multichannel HREELS measurements. Supported by electron-optics simulations and monitoring of the elastic peak using 2D detector of the analyser, the dedicated parHREELS software automatically tunes the electron beam to optimise energy/angular resolution and intensity for multichannel HREELS (Figure 3).

Expand your ARPES capabilities

Multimodal characterisation, where the same sample is investigated using multiple complementary techniques, provides a powerful route to understanding quantum materials while eliminating uncertainties arising from sample-to-sample variations. In particular, combining multichannel HREELS with ARPES and/or XPS using the same electron analyser enables direct correlation between surface excitations and electronic structure. Access to both spectroscopies over the relevant energy range (0.1–1 eV) makes this approach ideally suited for studying phenomena such as electron-boson coupling, many-body interactions, and topologically protected excitations. Since multichannel HREELS shares similar sample preparation requirements for clean surfaces and

data analysis workflows with ARPES, it is a natural extension for ARPES users looking to broaden their research capabilities.

By adding the MCES150 to an existing ARPES and/or XPS system, the instrument is transformed into a versatile multimodal

characterisation platform (Figure 4).

It is also an attractive addition to ARPES endstations at synchrotrons, providing a highly complementary technique for beam downtime without significant increase in system complexity.



– The HR-EELS system combined with ARPES and MBE will provide a key to understand strongly correlated electron phases in air-sensitive low-dimensional systems by investigating both electron band structures and low-energy collective excitations in-situ.

Professor Choongyu Hwang,
Pusan National University, South Korea

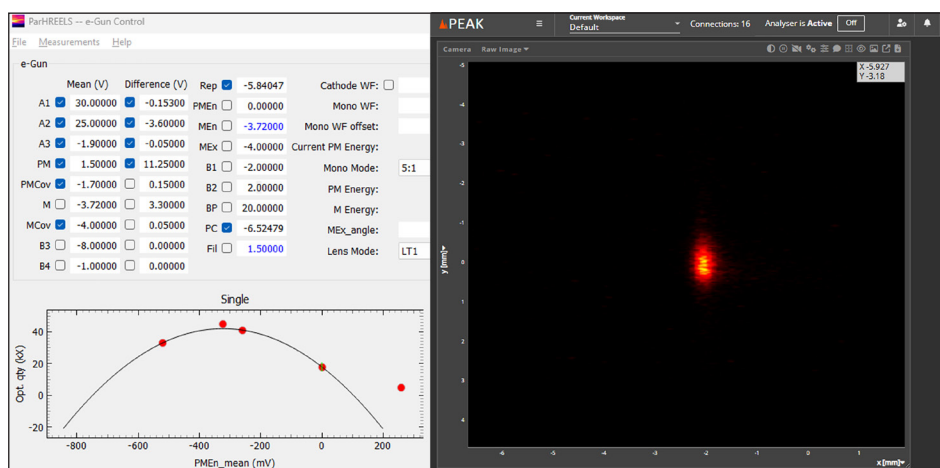


Figure 3: Optimisation of the electron source. Dedicated parHREELS software automatically tunes the electron beam to optimise energy/angular resolution and intensity by monitoring the signal of an elastic peak using the 2D detector of the DFS30, DA30-L, or DA20 analyser.

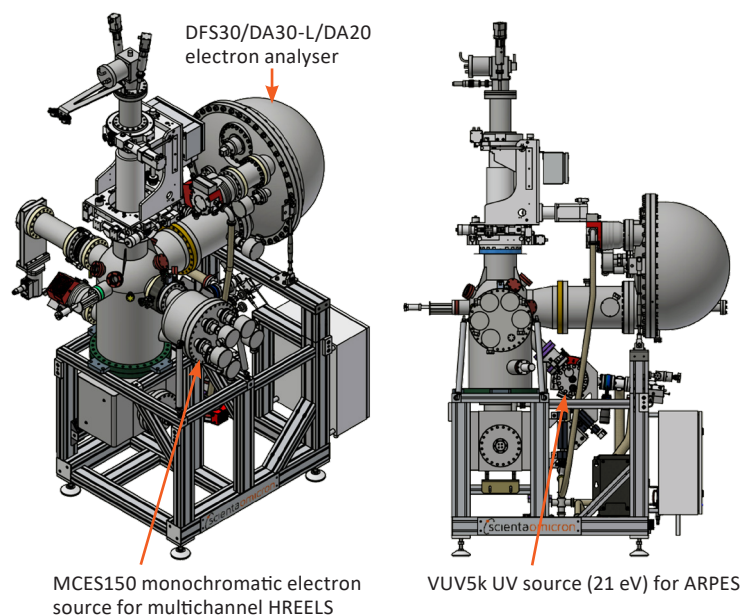


Figure 4: ARPES Lab for multimodal characterisation using multichannel HREELS and ARPES at the same analysis chamber. The system is optionally connected to a Materials Innovation Platform for sample growth and characterisation.

Technical data

Property	Specification
Energy resolution (MCES150 + DA30-L analyser):	< 5 meV FWHM *
Spot size area:	0.1 mm × 1 mm **
Kinetic energy range:	15 – 200 eV
Working distance	54 mm
Mounting flange	DN100CF (6.0" O.D.)
Bake-out temperature	< 130 °C

* Demonstrated with MCES150 and DA30-L analyser (without a sample). Actual experimental resolution depends on the sample quality.
** Optimised for intensity, energy resolution, and angular resolution.