Mönch 4107 / High throughput and high efficiency Cathodoluminescence for STEM

Overview

The **Mönch 4107** is a cathodoluminescence detector for STEM that has been designed from the ground up to achieve unprecedented signal-to-noise ratio and spectral resolution. It is used by demanding researchers who want to measure simultaneously ultra high resolution images and hyperspectral maps of individual nano-particles, quantum dots or atomic defects. The **Mönch 4107** has a solid publication track record, which includes reports on nano-plasmonics, quantum nano-optics, simultaneous measurements of cathodoluminescence and EELS, non-linear spectroscopy of individual quantum wells and more.

When acquiring a cathodoluminescence map in your STEM, it is crucial that you reach the desired signal-to-noise ratio in the shortest amount of time possible, so that you can generate images with a large amount of pixels. Yet, you can only achieve ultrahigh resolution with weak probe currents, leading to weak cathodoluminescence emission. As a result, the ideal cathodoluminescence detector is bound to achieve the impossible: it should collect photons over an extensive solid angle and fit in the millimeter gap between your sample and the pole pieces of your STEM; it should also preserve brightness, spectral resolution and collection efficiency over large scanning areas.

The Attolight **Mönch 4107** achieves all this. First, its collection optics is crafted by our engineers with the utmost care to achieve unprecedented curvature radius and miniaturization level; it is so thin that it can be accommodated in most aberration corrected or analytical STEMs on the market, while maintaining enough degrees of freedom and stiffness to allow for perfect sub-micrometer alignment of the mirror. Then, the **Mönch 4107** collects and couples cathodoluminescence directly into a fiber bundle and carefully preserves the intensity of the signal throughout a spectrometer, so that constant spectral resolution is achieved. Finally, an ultrafast EMCCD camera measures the signal and generates massive hyperspectral maps in seconds. Data can be directly acquired and visualized in your favorite acquisition software in parallel with other techniques (EELS, EDS, ...).

The **Mönch 4107** is not yet another add-on. It is a solution developed by a company that builds electron microscopes and has years of expertise in optics and spectroscopy. Attolight took all the know-how it acquired designing and manufacturing dedicated cathodoluminescence scanning electron microscopes and brought it to STEMs.

The **Mönch 4107** includes a proprietary actuated collection mirror for fast and perfect optical alignment, a fiber coupled spectrometer for high resolution spectral analysis, a scientific grade high speed camera for fast hyperspectral acquisitions, as well as a scanning module for optimal control of the STEM beam.

Key Benefits

- Brightness conservation from emission to detection
- Constant spectral resolution (no trade-off with intensity)
- Sub-micrometer precision mirror actuators with three degrees of freedom to achieve perfect collection efficiency at any position on the sample
- Full sample area can be investigated
- Fits within a 2 mm gap between the sample and the polar piece (contact Attolight to learn about the compatibility of your system)
- Ultrafast cameras and scanning unit for millisecond hyperspectral imaging in the UV, visible and NIR
- Retractable mirror
- Compatible with most STEMs techniques, such as HAADF, BF, diffraction, EELS (detector inserted) or EDS, tomography (detector retracted)
- Compatible with Gatan Digital Micrograph

Applications

- Study of advanced materials, such as:
  - Nitrides (GaN, InGaN, AlGaN, ...);
  - III-V (GaP, InP, GaAs, ...);
  - II-VI (CdTe, ZnO, ...)
- Wide band-gap materials (diamond, AlN, BN)
- Measure compositional inhomogeneities in compound materials (e.g. Indium clustering in InGaN)
- Correlate confined structures or heterostructures morphology to their optical properties
- Characterize defects (vacancies, threading dislocations, stacking vaults, ...)
- Plasmonics

Product Specifications

Measurements Mode

- Hyperspectral mapping of cathodoluminescence

Light Optics

- Proprietary reflective mirror
- Optical coupler for fiber bundle
- Collection optics optimized for transition from 200 nm to 1.7 µm
- Fiber bundle to decouple the light optics from the spectral detection and minimize vibrations
- All numerical apertures match each other in order to keep brightness throughout the device
- Possibility to couple the cathodoluminescence output to a user optical set-up (e.g. interferometer, light injector, ...)
- Possibility to quickly exchange the fiber bundle to adapt to specific user needs

Light detectors

- Dispersive spectrometer with two imaging exits (320 mm focal length) and a 3-grating turret (gratings to be specified by the customer at time of order)
- High speed EMCCD camera for UV-Visible or high speed CCD camera for UV-NIR
- InGaAs linear array for NIR (optional)

Micro-Positioning System

- 3 degrees of freedom for arbitrary movement of the mirror relatively to the sample
- Automated retractable mirror
- Travel range: ±150 µm (Z), 3 mm (X), 100 mm (Y)
- Smallest increment: 500 nm
- Repeatability (full travel range): 500 nm
- Touch security to avoid damaging the polar piece

System Control

- External scanning card with: 4 inputs (12 bits) for additional single channel detectors (PMTs, ...); 2 outputs for controlling the STEM scan (X and Y); 1 output for blanking the STEM beam
- Fastest measurement speed: 900 Hz (18 s for a 128x128 map)
- Control software compatible with Windows® 7 64 bit
- Acquisition and visualization module for Gatan Digital Micrograph

Installation Requirements

- STEM with at least 2 mm gap between the specimen and the polar piece (the total gap for a symmetric pole piece must be 4 mm)
- Sample holder with less than 300 µm between the sample surface and its holder (most commercial sample holders can be adapted by Attolight to achieve theses specifications)

attolight™

Headquarter – Attolight AG
EPFL Innovation Park / PSE D
1015 Lausanne / Switzerland

t +41 21 626 0100
contact@attolight.com
www.attolight.com

Scientific References

1. Meuret, S., *et al.* **Photon Bunching in Cathodoluminescence**. *Physical Review Letters* **114,** 197401 (2015)
2. Pantzas, K., et al. **Role of compositional fluctuations and their suppression on the strain and luminescence of InGaN alloys**. *Journal of Applied Physics* **117**, 055705 (2015)
3. Losquin, A. *et al.* **Unveiling Nanometer Scale Extinction and Scattering Phenomena through Combined Electron Energy Loss Spectroscopy and Cathodoluminescence Measurements**. *Nano Letters* **15**, 1229–1237 (2015).
4. Tizei, L.H.G., *et al.* **A polarity-driven nanometric luminescence asymmetry in AlN/GaN heterostructures**. *Applied Physics Letters* **105**, 143106 (2014)
5. Bourrellier, R., *et al.* **Nanometric Resolved Luminescence in h-BN Flakes: Excitons and Stacking Order**. *ACS Photonics* **1**, 857 (2014)
6. Kociak, M., *et al.* **Seeing and measuring in colours: Electron microscopy and spectroscopies applied to nano-optics**. *Comptes Rendus Physique* **15**, 158–175 (2014)
7. Kociak, M. & Stéphan, O. **Mapping plasmons at the nanometer scale in an electron microscope**. *Chemical Society Reviews* **43**, 3865–3883 (2014)
8. Tizei, L.H.G., *et al.* **Spatial modulation of above-the-gap cathodoluminescence in InP nanowires**. *Journal of Physics: Condensed Matter* **25**, 505303 (2013)
9. Mahfoud, Z., *et al.* **Cathodoluminescence in a Scanning Transmission Electron Microscope: A Nanometer-Scale Counterpart of Photoluminescence for the Study of II–VI Quantum Dots**. *The Journal of Physical Chemistry Letters* **4**, 4090–4094 (2013)
10. Pierret, A., *et al.* **Structural and optical properties of AlxGa1-xN nanowires**. *Physica Status Solidi RRL* **7**, 868 (2013)
11. Tizei, L.H.G. and Kociak, M. **Spatially Resolved Quantum Nano-Optics of Single Photons Using an Electron Microscope**. *Physical Review Letters* **110**, (2013)
12. Zagonel, L.F., et al. **Visualizing highly localized luminescence in GaN/AlN heterostructures in nanowires**. *Nanotechnology* **23**, 455205 (2012)
13. Tizei, L.H.G. and Kociak, M. **Spectrally and spatially resolved cathodoluminescence of nanodiamonds: local variations of the NV0 emission properties**. *Nanotechnology* **23**, 175702 (2012)
14. Tourbot, G., *et al.* **Growth mechanism and properties of InGaN insertions in GaN nanowires**. *Nanotechnology* **23**, 135703 (2012)
15. Jacopin, G., *et al.* **Single-Wire Light-Emitting Diodes Based on GaN Wires Containing Both Polar and Nonpolar InGaN/GaN Quantum Wells**. *Applied Physics Express* **5**, 014101 (2011)
16. Zagonel, L.F., *et al.* **Nanometer Scale Spectral Imaging of Quantum Emitters in Nanowires and Its Correlation to Their Atomically Resolved Structure**. *Nano Letters* **11**, 568–573 (2011)