

Allalin 4027 / Blazing Fast Multi-Channel Cathodoluminescence at Low Temperature



Overview

The **Allalin 4027** is a nanometer resolution spectroscopy instrument, based on a disruptive technology called low-temperature quantitative cathodoluminescence, that tightly integrates a scanning electron microscope, a light microscope and a cryogenic stage into one tool. It is designed for those who need to follow a tight technology roadmap and quickly access to extremely precise spectroscopic information that has been unavailable from traditional techniques.

In the semiconductor industry, the **Allalin 4027's** 1600 color channels offer an unmatched solution for measurement of energy transfer in second generation solar cells and band-gap energy in Gallium Nitride based devices such as power transistors and LEDs. It can speed up technology development process and perform advance failure analysis (Indium clustering, band-gap shifts, etc.). In scientific and industrial research, the **Allalin 4027's** ability to produce spectroscopic maps with nanometer resolution at various temperatures makes it the ultimate tool to obtain a deep insight into the physics of nanoscale objects.

The system was built from the ground up to achieve superior cathodoluminescence performance without compromising on the electron microscope performance: the light microscope and the objective lens of the scanning electron microscope are carefully intricated so that their focal planes match each other; the light microscope is machined with sub-micrometer precision in order to reach perfect achromatism, high numerical aperture (N.A. 0.71) and constant and superior photon collection efficiency over a field of view of 300 μm , so that quantitative cathodoluminescence benchmarking becomes possible for the first time; the electron microscope also operates at low electron beam energy (3–10 kV) for enhanced cathodoluminescence resolution. The **Allalin 4027** incorporates a 6-degrees-of-freedom cryogenic stage for arbitrary positioning of the specimen with 1nm increments and zero drift and vibration at low temperature (10–300 K).

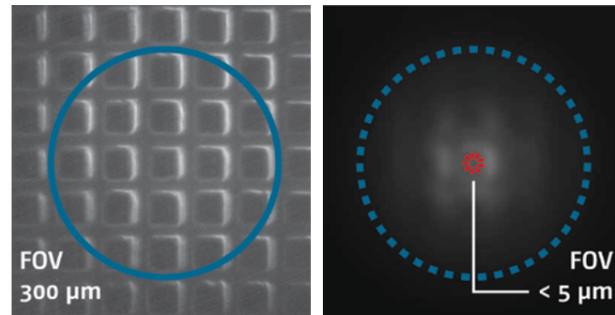
The **Allalin 4027** includes a spectrometer, a high speed EMCCD camera, a zero-drift liquid Helium cryostat, a 6-degrees-of-freedom nano positioning stage and additional electronic hardware to run fast hyperspectral acquisitions.

Key Benefits

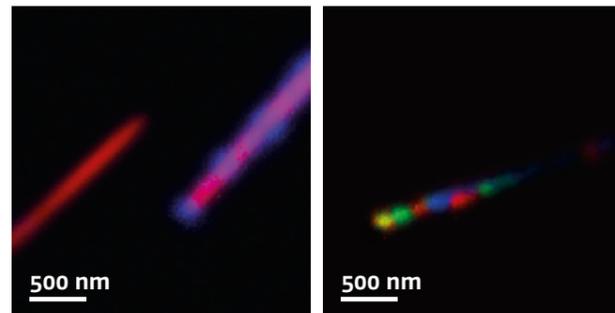
- Zero alignment: patented achromatic light microscope embedded in the column of a proprietary scanning electron microscope. Operating the **Allalin 4027** is intuitive thanks to its context-based user interface and does not require to be an expert
- No compromise: simultaneous generation of a SEM image and a hyperspectral CL image with no degradation of the electron probe size
- Quantitative: the photon collection efficiency is constant over a large field of view of 300 μm with 0% photon loss due to vignetting in polychromatic mode; a mapping of 300 micron is performed without any displacement of the specimen: cathodoluminescence results are reproducible and comparable
- High light collection efficiency: a numerical aperture of 0,71 (f/0,5) makes low emission cathodoluminescence a reality
- Low temperature stability: acquire a hour-long map 10 K without observing any drift
- Nanometer positioning system: nanometer scale measurements thanks to the most advanced nano positioning system ever built in an electron microscope
- Upgradable: the core components (scanning electron microscope and light microscope) of the Grammont 2172, **Allalin 4027** and Rosa 4634 are the same; it is possible to upgrade anytime to another system by adding various modules
- Optical hub: for integration of the Attolight CL instrument in a larger spectroscopic system

Applications

- LED performance and reliability
- GaN power transistors
- Threading Dislocation Density (TDD) counting
- Failure analysis
- Solar cells efficiency
- Development of nanoscale optoelectronic devices

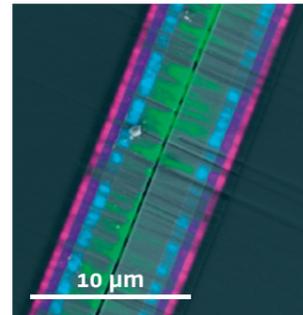


Attolight optical microscope features constant resolution and photon collection efficiency over a field of view of 300 µm (left). Quantitative cathodoluminescence, i.e. comparison of emission intensities between various points is now possible. The traditional parabolic mirror approach is plagued by blur and vignetting (right).



Close-up of two NWs tip. Red now represent emission from the GaAs core (820 nm) of the wire, when blue regions mark the QDs emission (670 nm). Dots at less than 500 nm can be easily resolved. (Specimen temperature: 10 K)

Mapping of the QDs location with respect to the emitted wavelength. Blue, green and red correspond to 3 wavelengths between 650 and 700 nm. Some dots emit at several wavelength, resulting in composite colors (e.g. yellow).



Hyperspectral mapping of different layers in a cross section of a GaN/AlGaIn hetero structure

Product Specifications

Measurements Mode

- Cathodoluminescence mapping (polychromatic and monochromatic)
- Ultrafast hyperspectral mapping from 180 to 1100 nm
- Secondary electrons (SE) mapping
- Simultaneous SE and CL imaging

Electron Optics

- Schottky thermal field emission gun
- Acceleration voltage: 3–10 kV
- Electro-magnetic lenses, electrostatic deflectors and astigmatism correctors
- Electron optics optimized for continuous and pulsed operation
- Highest spatial resolution: 2.8 nm at 10 kV
- Optimum working distance: 3 mm (matches light microscope focal plane)
- High sensitivity SE detector
- No loss of SE resolution in cathodoluminescence mode
- Electron probe current: 30 pA to 20 nA
- Maximum field of view: 600 µm at 3 kV

Light Optics

- Light microscope embedded within the electron optics
- Fully achromatic reflective objective from 180 nm to 1.6 µm
- Numerical aperture: NA 0.71 (f/0.5)
- Field of view: > 300 µm
- Resolution: < 5 µm
- Light collection efficiency: 30% of the photons emitted by a lambertian emitter exit the microscope (constant over the whole field of view)

Light Detectors

- Dispersive spectrometer with two imaging exits (320 mm focal length) and a 3-grating turret (gratings to be specified by customer at time of order)
- High speed EMCCD camera for UV-Visible detection

- Ultrafast hyperspectral mode generates a 128 by 128 pixels map in 18 seconds

Chamber and Vacuum System

- Ion getter pumps for electron gun and electron column
- Turbo molecular pump for the specimen chamber
- Typical specimen exchange time: 20 min
- Internal chamber dimensions: 208 mm (diameter) x 300 mm (height)
- Electron beam and light microscope coincidence plane at 3 mm working distance

Nano-Positioning Stage

- 6 degrees of freedom for arbitrary movements (compatible with the cryostat)
- Travel range: 25 mm (X and Y), 3 mm (Z), 3° tilt (X and Y), 35° rotation (Z)
- Smallest increment: 1 nm
- Repeatability (full travel range): 100 nm
- Repeatability (100 nm range): < 2 nm

Low Temperature Cryostat

- Helium cold finger for low vibrations
- Minimal sample temperature range: 10 K–300 K
- Advanced digital temperature controller

Sample size

- Maximum diameter: 25.4 mm
- Maximum thickness: 1.5 mm

System Control

- Hardware control and data server: 32 bit server with Windows® 7, 7 inch touchscreen monitor for system initialization, wifi router for connection to remote control
- User interface and remote control: wireless tablet computer with 2048 x 1536 touchscreen

Consumables (partial list)

- Replacement electron source module
- Aperture strip for electron beam
- Ion Getter Pumps

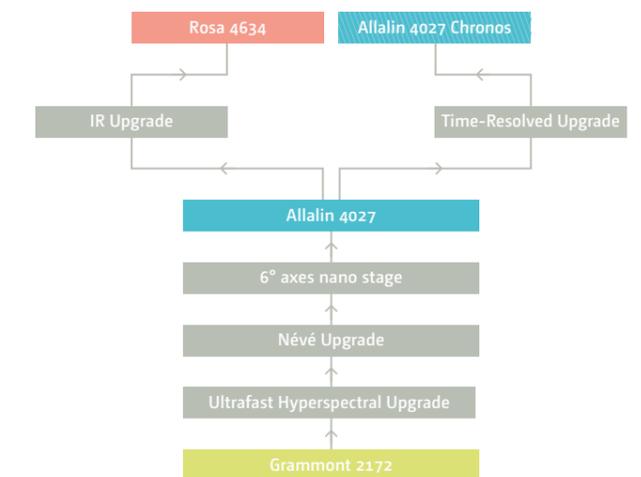
Installation Requirements

- Power: 1 standard wall plug (230 V, 50 Hz) delivering 10 A
- Weight: 800 kg
- Environment: temperature 20° C +/- 3° C, relative humidity below 60% RH, stray AV magnetic fields < 100 nT asynchronous < 300 nT synchronous for line times > 20 ms (50 Hz mains)
- Preferred door width: 120 cm (100 cm possible when removing isolator posts)
- Dry nitrogen: (0.1–0.5 bar)
- Compressed air: 551 kPa/80 psi, clean, dry and oil free

- Acoustic guidelines: < 55 dBC (site survey required as floor spectrum relevant)
- Floor vibrations (site survey required as floor spectrum relevant)

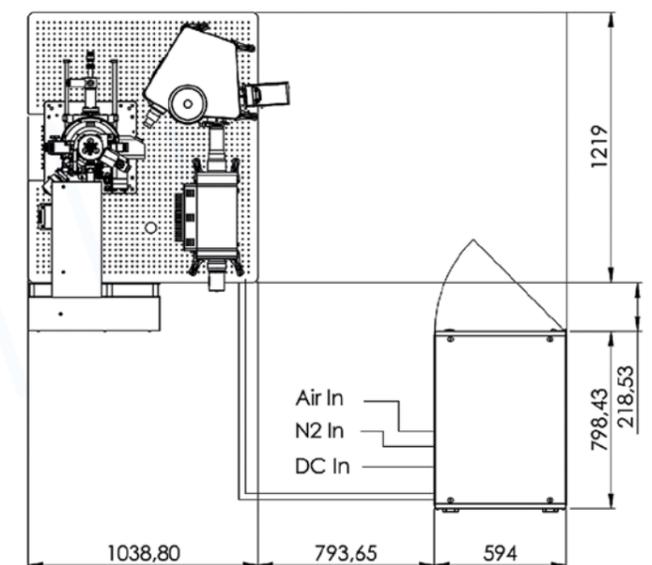
Common Upgrades

- Infrared: hyperspectral mapping up to 1600 nm
- Time-resolved: time-resolved cathodoluminescence measurements from 180 to 850 nm



Lay-out

The Attolight CL Tool sits on an optical breadboard mounted on 4 isolator posts to achieve vibration isolation. A typical recommended layout is shown below.



Product Portfolio

| Features and Benefits | Grammont 2172 | Allalin 4027 | Rosa 4634 |
|---|---------------|--------------|-----------|
| SEM | | | |
| Adjustable acceleration voltage | 3–10 keV | 3–10 keV | 3–10 keV |
| Electron beam probe size | < 2.8 nm | < 2.8 nm | < 2.8 nm |
| Optimized for continuous and pulsed operation | Yes | Yes | Yes |
| Light microscope embedded within the electron optics | Yes | Yes | Yes |
| CL | | | |
| Monochromatic mode | Yes | Yes | Yes |
| Polychromatic mode | Yes | Yes | Yes |
| Hyper spectral mode | Basic | Ultrafast | Ultrafast |
| UV-Visible range | Yes | Yes | Yes |
| Near Infra Red (NIR) range | No | No | Yes |
| Field of View (µm) with 0% photon loss due to vignetting in polychromatic mode | 300 | 300 | 300 |
| Hight Light Collection Efficiency | Yes | Yes | Yes |
| No vignetting | Yes | Yes | Yes |
| Quantitative Measurements | Yes | Yes | Yes |
| Easy alignment | Yes | Yes | Yes |
| Number of degrees of freedom for the positioning | 3 | 6 | 6 |
| Additional Features | | | |
| Touchscreen remote control device | Yes | Yes | Yes |
| Sample Positioning accuracy | 1 nm | 1 nm | 1 nm |
| Easy Sample Repositioning | Yes | Yes | Yes |
| Sample Temperature Control | No | Yes | Yes |
| Mounted on a optical table | Yes | Yes | Yes |
| Software | | | |
| Proprietary Attolight GUI controlling both SEM and CL | Yes | Yes | Yes |
| Visualization software for Hyper spectral maps | Yes | Yes | Yes |
| Option Névé | No | Included | Included |
| Temperature from 10 to 350 K with 0,1 K stability / Zero drift / Zero vibration / Easy sample repositioning | | | |
| Ultrafast Hyperspectral Upgrade | No | Included | Included |
| Ultrafast hyper spectral mode in the UV-Vis range | | | |
| Ultrafast IR Upgrade | No | No | Included |
| Ultrafast hyper spectral mode in the NIR range | | | |