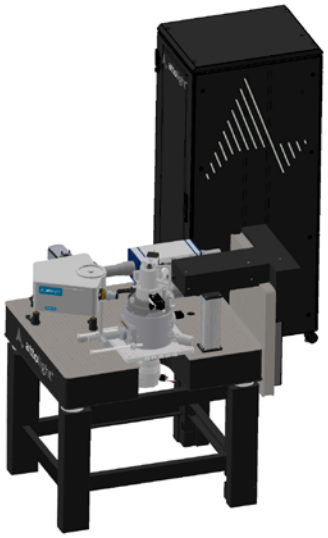
Grammont 2172 / The First Comprehensive Quantitative Cathodoluminescence Solution



Overview

The **Grammont 2172** is a nanometer resolution spectroscopy instrument, based on a disruptive technology invented by Attolight and called quantitative cathodoluminescence, that tightly integrates a scanning electron microscope and a light microscope into one tool. It requires zero alignment, features zero photon loss and houses a CCD detector for those who need to deliver high resolution quantitative luminescence maps reproductively.

In the semiconductor industry, the **Grammont 2172**'s offers an unmatched solution for defect identification in Gallium Nitride (GaN)-based devices such as power transistors and LEDs. It can perform failure analysis or speed up process development.

In scientific and industrial research, the **Grammont 2172**'s ability to clearly map spectroscopic features on nanoscale objects such as nanoparticles, nanotubes, quantum dots, defects or dopant inclusions, gives researchers a unique insight into the physics of their material. Applied to materials such as phosphors, compound semiconductors (e.g. ZnO, GaAs or GaN and its alloys), or high-band semiconductors (e.g. BN or diamond), the **Grammont 2172** boosts researchers' productivity and opens new areas of investigation.

The system was built from the ground up to achieve superior cathodoluminescence performance without compromising on the electron microscope performance. First of all, the light microscope and the objective lens of the scanning electron microscope are carefully intricated so that their focal planes match each other. Then, 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. Finally, the electron microscope operates at low electron beam energy (3–10 kV) for enhanced cathodoluminescence resolution.

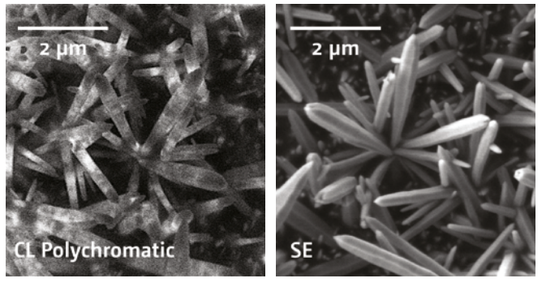
The **Grammont 2172** serie is the first entry modular product among the fully integrated CL Attolight solutions. The system is comparable to the Allalin 4027 but with a simpler design to minimise cost: it can be easily upgraded for a much higher speed of detection, helium temperature cooling, near-infrared sensitivity or, ultimately, picosecond time-resolution.

Key Benefits

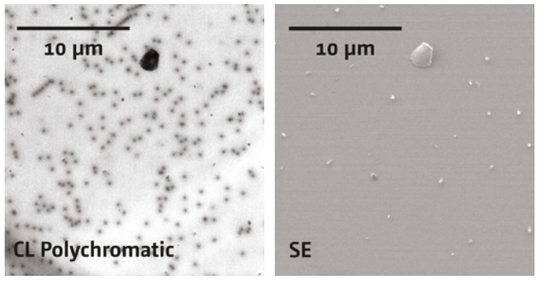
- Short time to result/Easy: Sample alignment can be done within seconds by any user, no prior spectroscopy experience is needed. Operating the **Grammont 2172** is intuitive thanks to its context-based user interface
- No compromise: simultaneous generation of a SEM image and a hyperspectral CL image 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
- Upgradable: the core components of the **Grammont 2172** are the same as for the Allalin 4027 and the Rosa 4634; 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

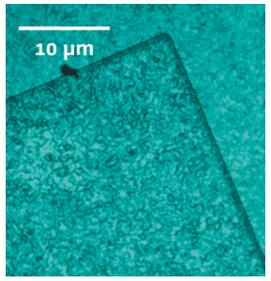
– LED performance and reliability
– GaN power transistors
– Threading Dislocation Density (TDD) counting
– Development of nanoscale optoelectronic devices



ZnO nano-belts. The acquisition of a CL map (left) does not affect the detection of secondary electrons (right)



Cathodoluminescence is the ideal tool to measure threading dislocations density in GaN (left); they appear as dark spots because of non radiative recombination in their vicinity. A secondary electron scan of the same region cannot identify any threading dislocation (right).



Defect network on substrate for power transistor

Product Specifications

Measurements Mode

– Cathodoluminescence mapping (polychromatic and monochromatic)
– 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
– Field-upgradable to picosecond pulsed photoelectron gun
– 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 of 300 µm with 0% photon loss due to vignetting in polychromatic mode
– 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); basic hyperspectral mode generates a 128 by 128 pixels map in 235 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

– Piezoelectric nanopositioning stage with 3 degrees of freedom
– XY: ±12.7 mm
– Z: ±1.5 mm
– XYZ accuracy: 1 nm

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)

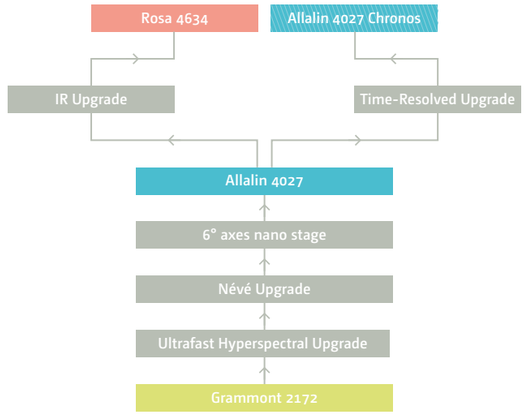
– Replacement electron source module
– Aperture strip for electron beam
– Ion Getter Pumps

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)

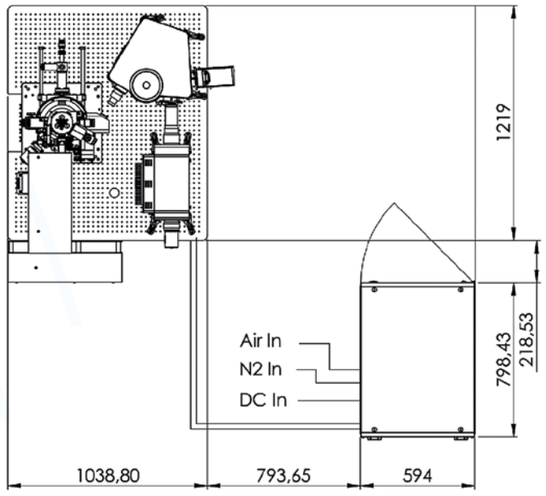
Common Upgrades

– Névé: proprietary cryostat design with extremely low drift and vibrations from 10 to 350 K. Drift at 10 K below 10 nm/min. Enables easy sample repositioning
– Ultrafast hyperspectral mapping from 180 to 1100 nm
– 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.



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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			