Rosa 4634 / Quantitative Cathodoluminescence Dedicated to Photovoltaic and Silicon Applications

Overview

The **Rosa 4634** is a nanometer resolution UV to NIR 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 specially designed to assists device makers in lowering their production costs, while increasing device reliability.

The **Rosa 4634** is a state-of-the-art offline instrument ideal for the photovoltaic and silicon industries. With applications across the PV manufacturing supply chain – from ingots to wafers and cells – the system enables yield efficiency improvements and generates high valuable data for failure analysis and new technology introduction.

In scientific and industrial research, the **Rosa 4634**'s ability to clearly map spectroscopic features on nanoscale objects over an extended spectral range opens brand new areas of investigations for researchers, especially on materials such as Silicon, InGaAs or InAlAs.

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. Similarly to the Allalin 4027, the **Rosa 4634** incorporates a 6-degrees-of-freedom cryogenic stage for arbitrary positioning of the specimen with 1 nm increments and zero drift and vibration at low temperature (10–300 K). Yet, the **Rosa 4634** is superior to the Allalin 4027 as it covers an extended spectral range from 180 nm to 1.6 µm, addressing the characterization needs for the NIR emitting materials.

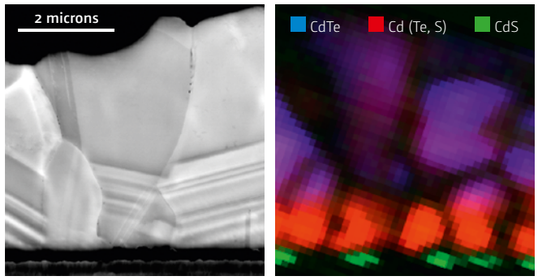
The **Rosa 4634** includes a spectrometer, a high speed EMCCD camera for UV-Visible, an InGaAs camera for NIR, a Helium cryostat, a 6-degrees-of-freedom nano positioning stage and additional electronic hardware to run fast hyperspectral acquisitions.

Key Benefits

- Zero alignment: patented achromatic light microscope embedded in the column of a proprietary scanning electron microscope. Operating the **Rosa 4634** is intuitive thanks to its context-based user interface and does not require to be an expert
- No compromise: simultaneous generation of a SE image and a CL image with no degradation of the electron probe size
- Blazing fast: generation of hyperspectral maps from UV to NIR in minutes
- 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
- Low temperature stability: acquire an hour-long map at 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
- High light collection efficiency: a numerical aperture of 0,71 (f/0,5) makes low emission cathodoluminescence a reality; indirect band-gap semiconductors such as silicon or diamond can be studied
- Optical hub: for integration of the Attolight CL instrument in a larger spectroscopic system

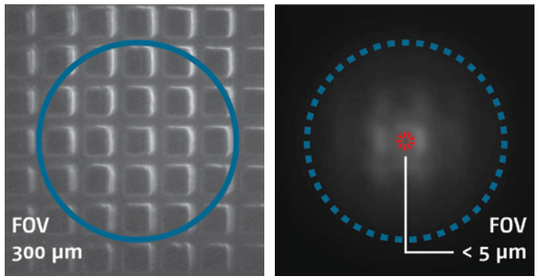
Applications

– Photovoltaic industry:
  Off-line quality control and failure analysis of wafers, ingots and cells
  Solar cells yield improvement
  Introduction and validation of new technologies in manufacturing
– Silicon industry:
  Research and development of new opto and/or electronic devices
  Analysis of dopants and contaminants
– Plasmonics
– Research of silicon and InGaAs materials

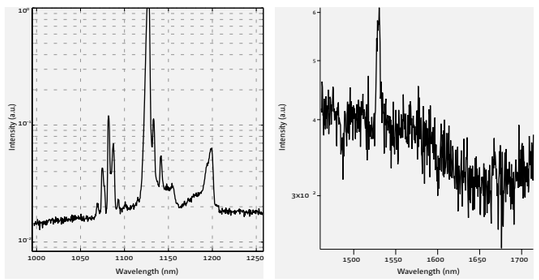


SEM image of a CdTe/CdS photovoltaic heterojunction in cross-section.

CL map of the same cross section colour-coded by emission frequency. The interdiffusion of sulfur at the junction is clear in the CL dataset.



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).



Spectral analysis in Silicon: exciton peak (left) and detection of defects around the 1.6µm region (right).

Product Specifications

Measurements Mode

– Cathodoluminescence mapping (polychromatic and monochromatic)
– Ultrafast hyperspectral mapping from 180 to 1600 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
– 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: > 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
– InGaAs camera for near infra-red 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 (Ø) x 300 mm (H)
– 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

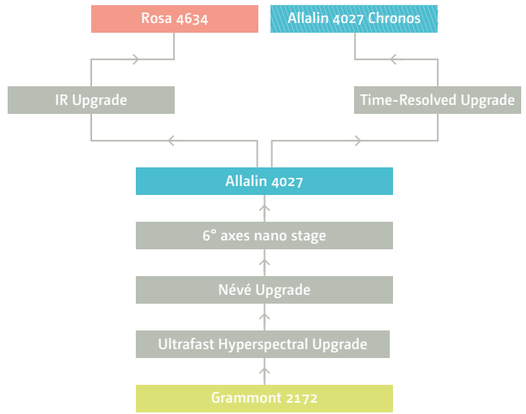
Consumables (partial list)

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

Installation Requirements

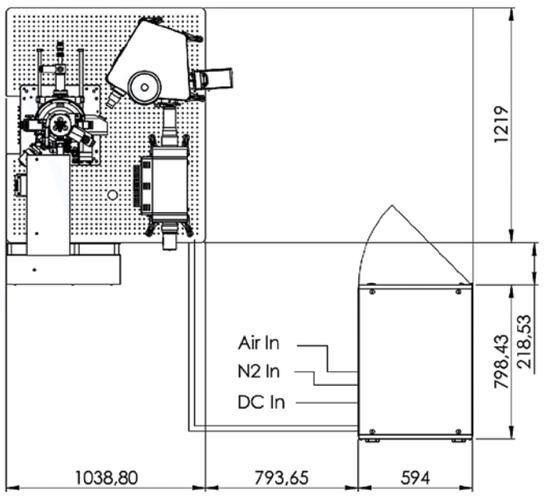
– Power: 1 standard wall plug (230 V, 50 Hz) delivering 10 A
– Weight: 800 kg
– Environment: temperature 20°C +/-3°C, relative humidity below 60% RH, stray AV magnetic fields
  < 100 nT asynchronous
  < 300 nT synchronous for line times > 20 ms (50 Hz mains)
– Preferred door width: 120 cm (100 cm possible 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



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.



attolight™

Attolight AG
EPFL Innovation Park / Building D
1015 Lausanne / Switzerland

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

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			