specifications sheet | lab cube

LAB Cube specifications sheet

Lifetime and $g^{(2)}$ imaging module for SPARC Spectral

delmic

V01-01 2021-22-04

LAB Cube at a glance

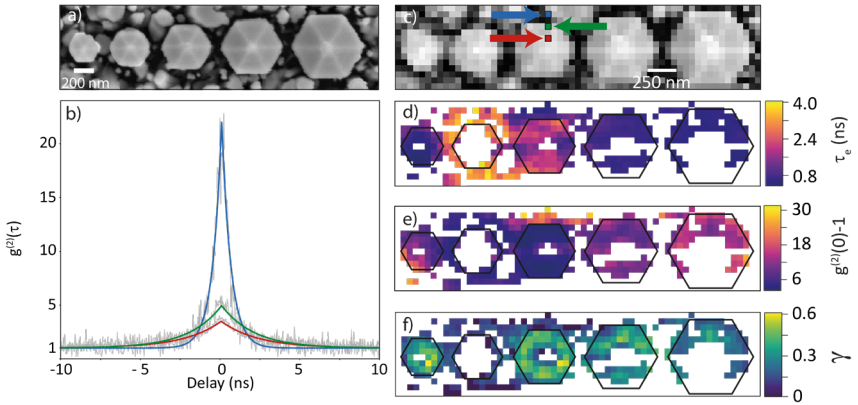
- Add-on to SPARC Spectral CL system
- Works with any SEM
- Time-correlated single-photon counting
- Lifetime mapping with Hanbury Brown-Twiss detection setup, enabling lifetimes and antibunching measurements
- Overnight acquistions for more accurate measurements
- Intuitive and easy to use software integration with remote control capabilities

Why?

Lifetime imaging with cathodoluminescence (CL) gives valuable information that can be used for a large variety of applications. It can give insight into intrinsic material properties and can be used for studying the quantum nature of light and single-photon emitters, as well as nanoscale quality and defect analysis. Materials that are of interest include:

- **(Compound) semiconductors for optoelectronics** such as (In) GaN, perovskites, and GaAs
- **Single-photon emitters** such as epitaxial III/V quantum dots or NV centers in diamond
- **(Rare-earth) phosphor materials** for lighting, displays, scintillators, and biolabels

With the Delmic LAB Cube for SPARC Spectral, it is possible to extend the SPARC Spectral to do lifetime and antibunching experiments. The nanoscale character of the electron beam allows lifetimes measurements with a spatial resolution well below the diffraction limit of light.



Example of lifetime data on InGaN/GaN nanorods: (a) SEM image of nanorods. (b) The $g^{(2)}$ data recorded at three colored squares as indicated by the arrows in panel (c) which shows SE intensity recorded together with the $g^{(2)}$ data set. Maps of (d) lifetime, (e) amplitude $g^{(2)}(0)$-1, and (f) the probability of excitation (γ) are also shown. The contours of the nanorods are indicated by the black lines. Images courtesy of Dr. Sophie Meuret (AMOLF, Amsterdam)

How?

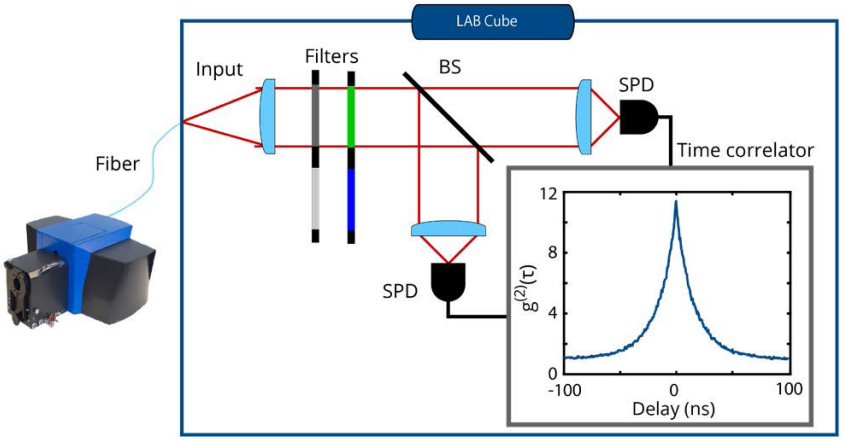
The Delmic LAB Cube module can be coupled to any Delmic SPARC Spectral CL detection system, turning the system into a powerful lifetime measuring setup. The LAB Cube is coupled to the SPARC Spectral with an optical fiber, using the Fiber Coupler Module (see technical note on modules).

The LAB Cube setup measures the lifetime which describes the probability to observe two photons by a time delay τ. This will enable to:

- Measure photon bunching → extract lifetimes [1-3] and excitation probability (see techinal notes for more information) [3-4]
- Measure photon antibunching → identify and study single-photon emitters [5-6]

Installation and use is straightforward:

- No modifications to SEM required
- Measure with a continuous electron beam
- Retrofit on any SPARC Spectral system without any modifications
- No compromises to existing hardware and functionalities
- Coupling through SPARC Spectral fiber module
- Switch readily from lifetime imaging to any other CL mode



Schematic overview of the LAB module in the SPARC Spectral system. CL is coupled into the LAB Cube through an optical fiber. The light is sent to a Hanbury Brown-Twiss (HBT) system with a beam splitter (BS) and two ultrafast Single Photon Detectors. The signals from the detectors are read out by the time-correlator system.

System specifications

Detection system

Ultrafast PMT detectors

- Large detector area
- High timing resolution
- Broad spectral range
- Overload protection

Time-correlator

- 16 bit time-histogram
- Adjustable time-bin size (4 – 512 ps) corresponding to total range of 260 ns – 33 µs
- Up to 84 MHz synchronization possible, < 10 MHz optimal

Filters

- Exchangeable color filters in motorized filter wheel with 8 filter position
- Neutral density filter wheel for intensity adjustment (OD 0 - 4)

Data

Acquisition

- Acquisition of lifetime maps
- Overnight acquisitions with remote control
- Control of time-correlator settings
- Electron beam fuzzing for sub-pixel averaging
- Advanced drift correction for longer acquisitions

Analysis

- Include the access to a proprietary database for advanced data analysis
- Visualize time-resolved CL data in space and time
- Overlay with SEM data
- Simple data export in open data format (HDF5, TIFF, PNG, CSV)

References

1. S. Meuret, L. H. G. Tizei, T. Cazimajou, R. Bourrellier, H. C. Chang, F. Treussart, and M. Kociak, Phys. Rev. Lett. **114**, 197401 (2015)
2. S. Meuret, L. H. G. Tizei, T. Auzelle, R. Songmuang, B. Daudin,B. Gayral, and M. Kociak, ACS Photonics **3**, 1157-1163 (2016)
3. S. Meuret, T. Coenen, H. Zeijlemaker, M. Latzel, S. Christiansen, S. Conesa-Boj, and A. Polman, Phys. Rev. B **96**, 035308 (2017)
4. S. Meuret, T. Coenen, S. Y. Woo, Y.-H. Ra, Z. Mi, and A. Polman, Nano Lett. 18, 2288-2293 (2018)
5. L. H. G. Tizei and M. Kociak, Phys. Rev. Lett. **110**, 153604 (2013)
6. R. Bourrellier, S. Meuret, A. Tararan, O. Stéphan, M. Kociak, L. H. G. Tizei, and A. Zobelli, Nano Lett. **16**, 4317-4321 (2016)

Interested?

For more information on this topic visit **www.delmic.com**

About

Delmic is a passionate high-tech company based in Delft, the Netherlands that develops powerful and user-friendly solutions for light and electron microscopy. Our systems are used by researchers and companies all over the world in fields ranging from life sciences, geology, material sciences to nanophotonics.

The SPARC Spectral system is a unique cathodoluminescense (CL) solution which allows you to acquire high-quality CL data in a fast and simple manner. The system is flexible, modular and can be customized according to your research needs.

Stay up to date

Subscribe to our newsletter to stay up to date with our latest CL developments

SIGN UP

delmic

DELMIC B.V.
Kanaalweg 4
2628 EB Delft
The Netherlands
www.delmic.com
info@delmic.com
+31 1574 401 58