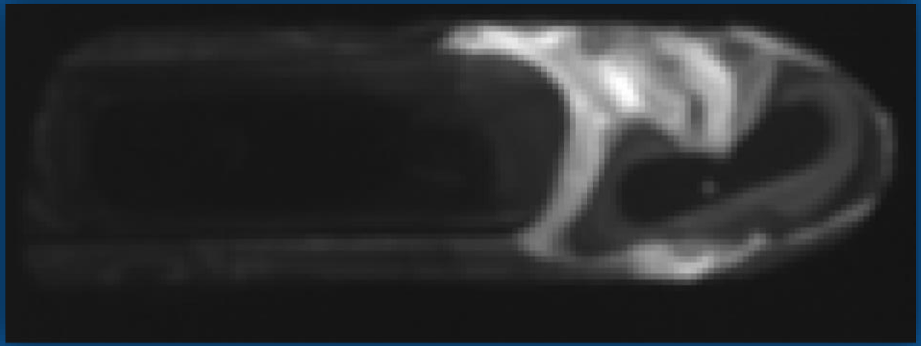
Table-top Cathodoluminescence Microscopy for Geology



Prof. Albert Polman
Dion Ursem
Hans Zeijlemaker

Thomas van der Heijden
Sudiksh Srivastava
Dorus elstgeest
Wouter Roelofsen
Andries Effting
Sander den Hoedt

Toon Coenen

Business unit owner CL solutions
coenen@delmic.com

6th May 2020

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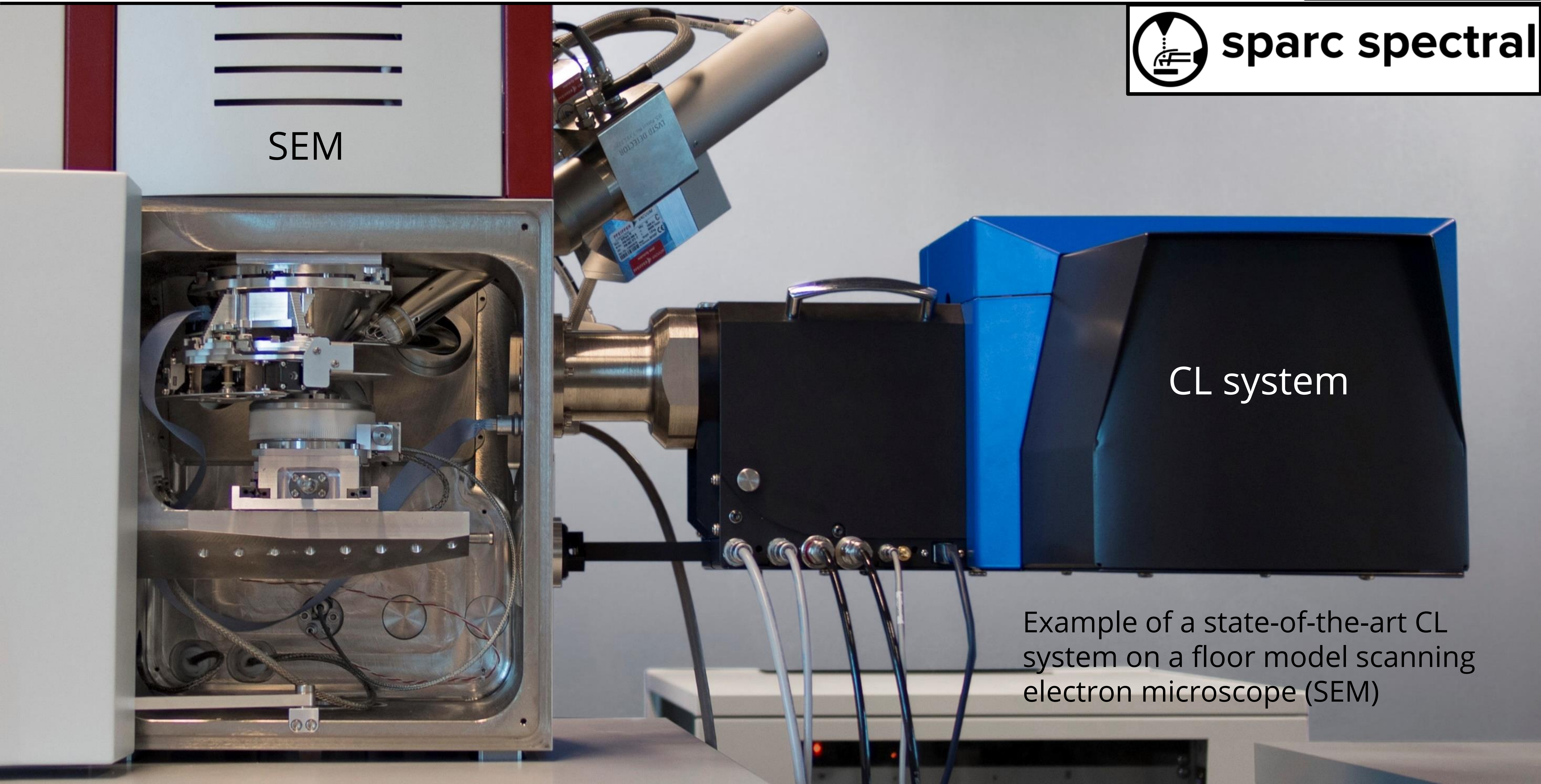
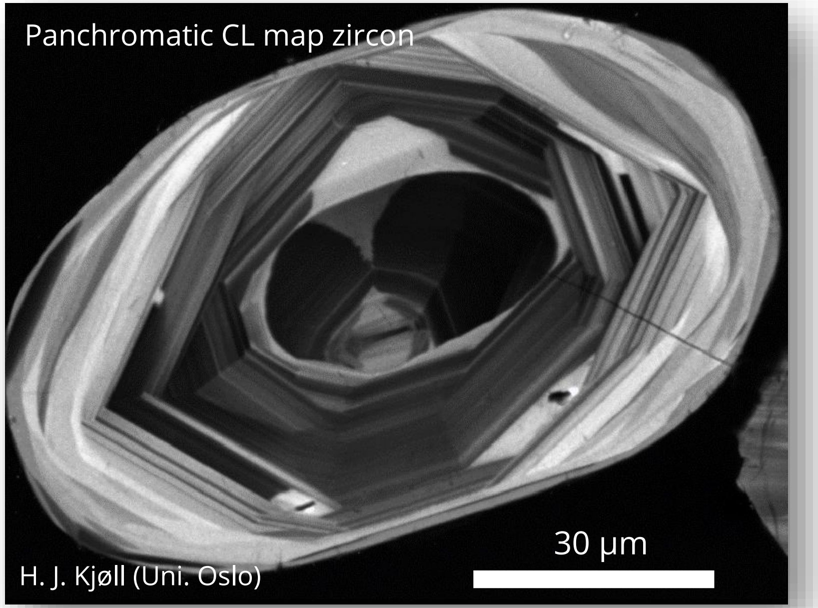
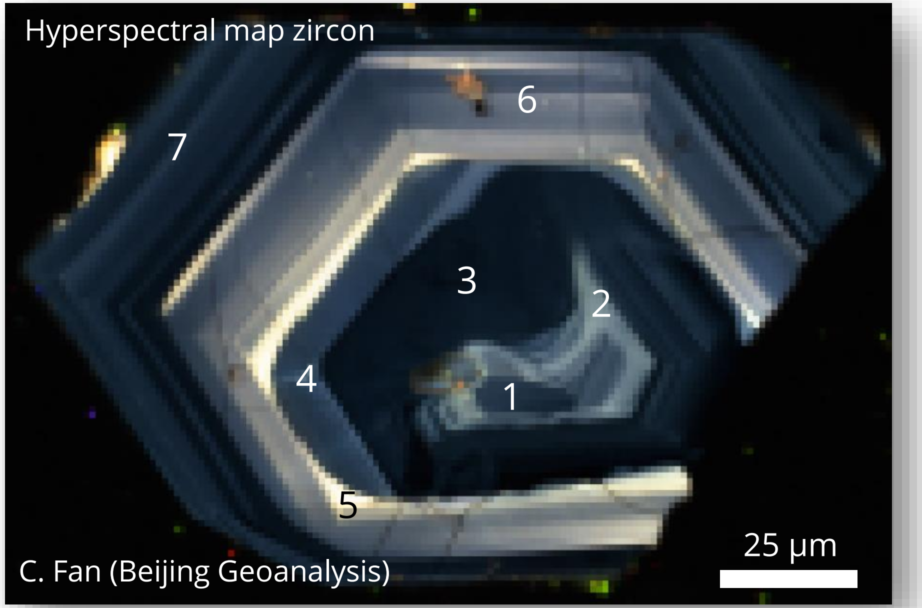
Cathodoluminescence system on floor model SEM

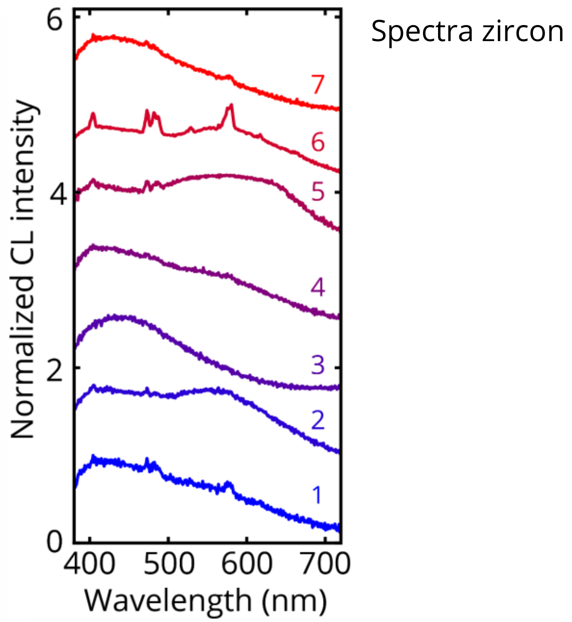


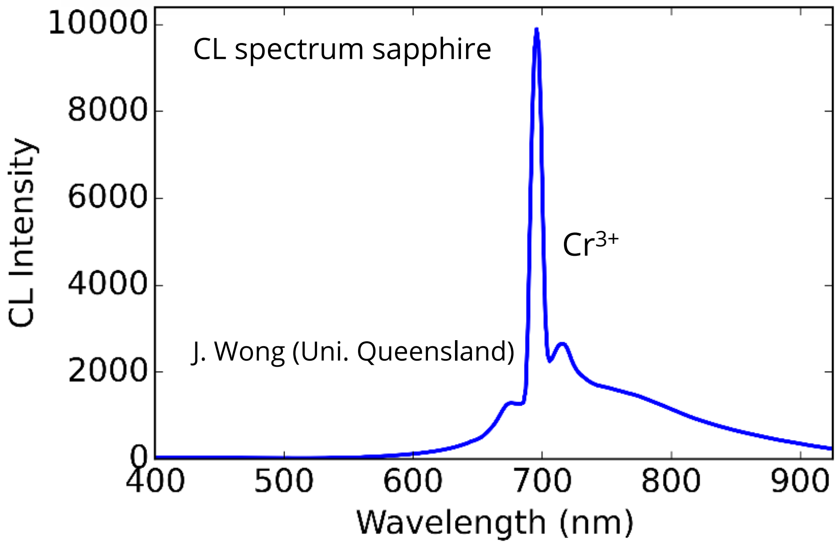
Example of a state-of-the-art CL system on a floor model scanning electron microscope (SEM)

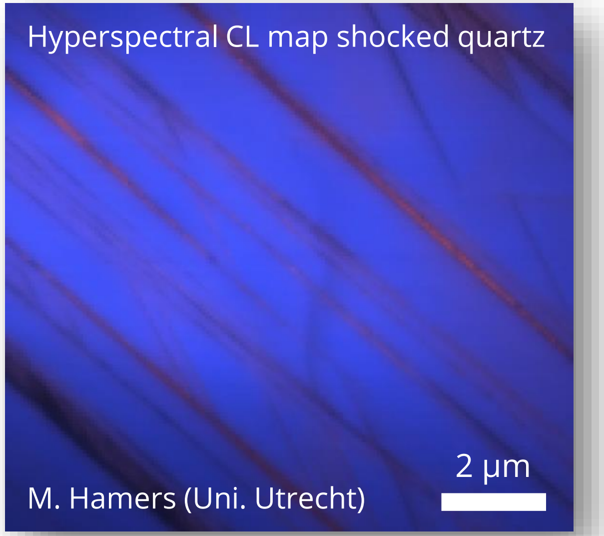
Floor model SEM-CL data examples



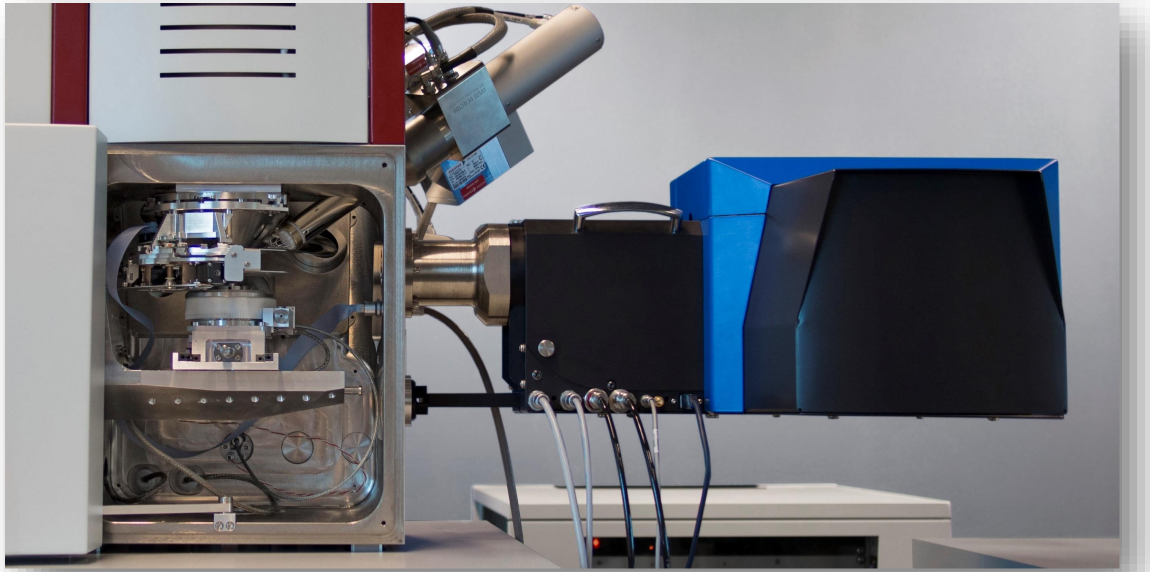








Floor-model SEM CL



Question: How do we make CL imaging more accesible and simpler?

+ High data quality
+ High spatial resolution
+ Modular and flexible
+ Correlation with other advanced SEM techniques

- High price
- Dedicated lab space and complex infrastructure needed
- Large footprint
- Expert user

Table-top CL

Table-top SEM

Table-top scanning electron microscopes are compact, user friendly, and affordable. Currently, there are no proper CL solutions for such systems, however. Here, we integrate a CL system on a table-top SEM

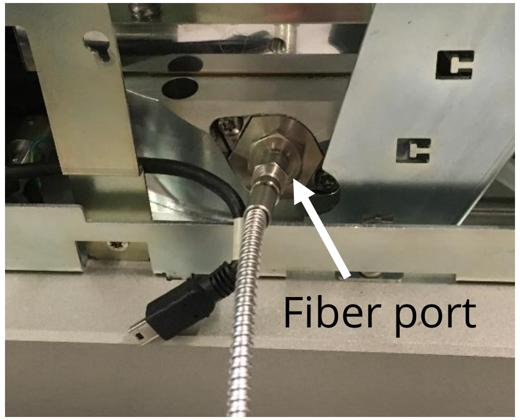
\+ Cathodoluminescence

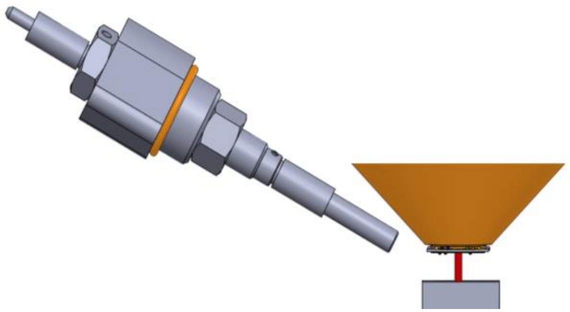
- \+ Low price
- \+ Simple to use
- \+ Fast
- \+ Small footprint
- \+ Little infrastructure required

- \- Lower spatial resolution
- \- Smaller range of acceleration voltages

System approaches

Fiber based collection system

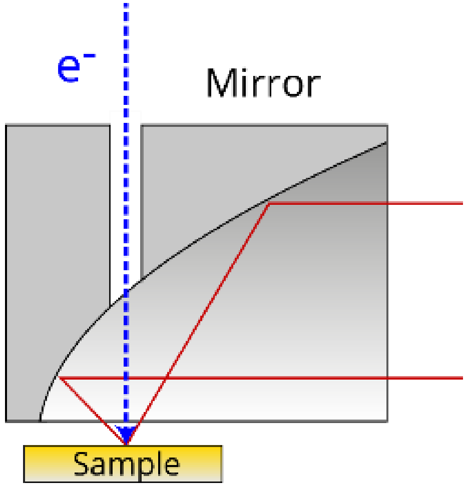




Spectrometer

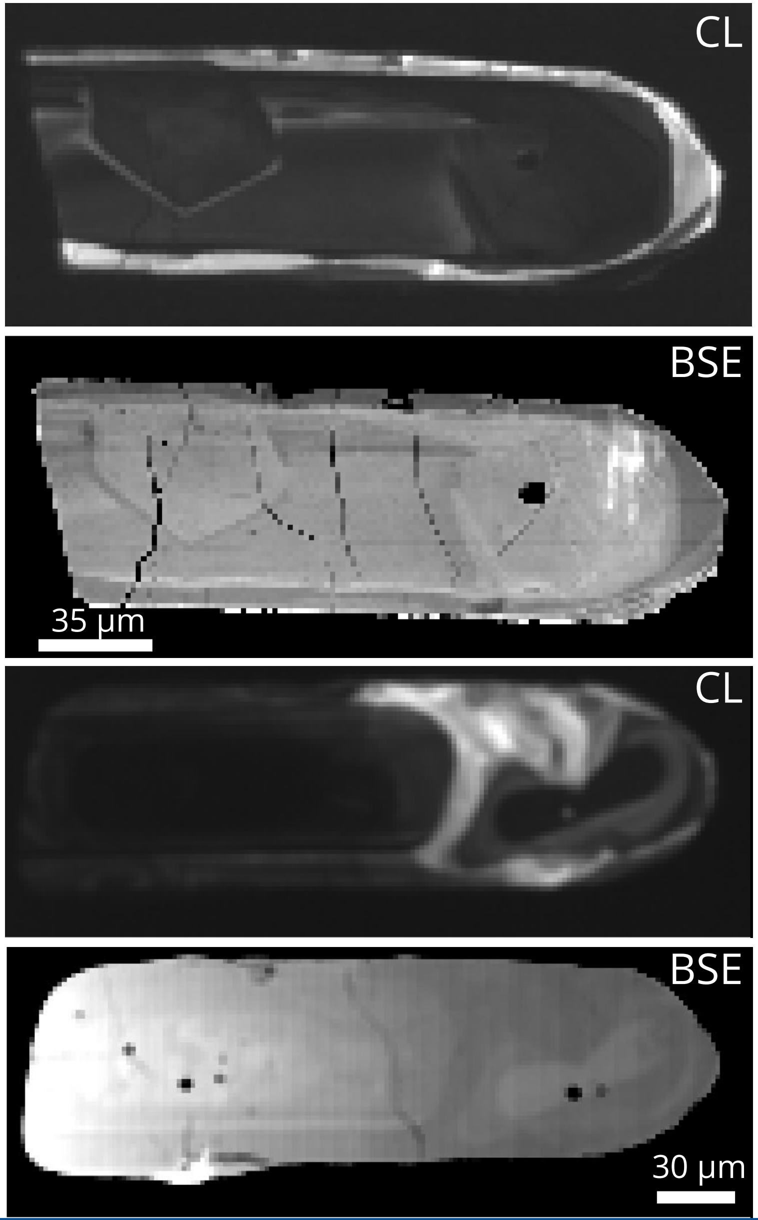
- Simple collection system with fiber and GRIN lens
- Direct coupling into spectrometer
- Relatively low collection efficiency due to reduced NA

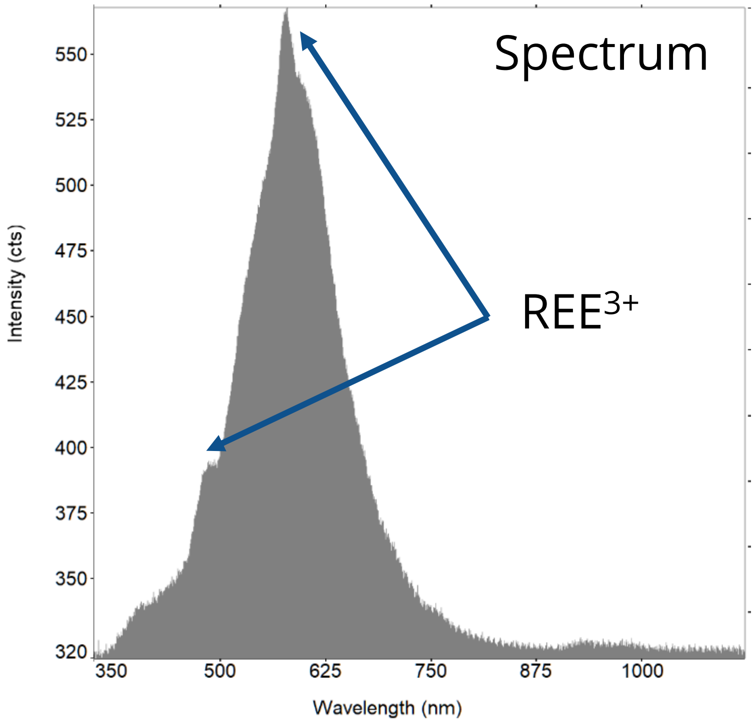
Mirror based collection system



- Higher collection efficiency
- Design is finished
- Results coming soon!

First results with fiber based CL system





- Hyperspectral CL maps for zircons with a full spectrum in every scanning pixel
- BSE and CL image show inverted contrast which is common in zircons
- Emission from Lanthanide ions is visible in the spectrum

More results are coming, stay tuned!

Settings: 15 kV, 500 ms dwell time

More CL

If you have any questions about cathodoluminescence imaging in general or about table-top cathodoluminescence feel free to contact me at coenen@delmic.com or visit our website www.delmic.com

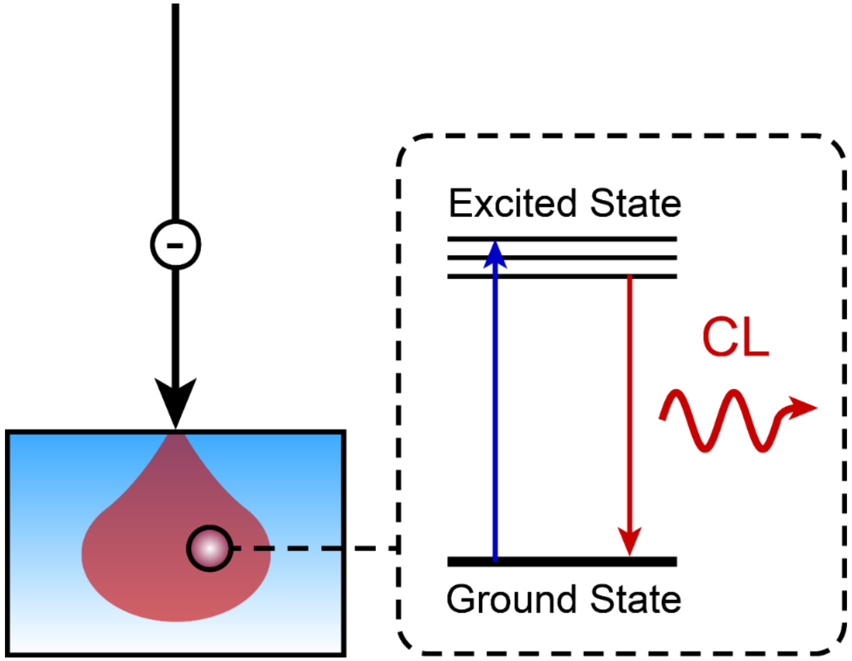
More CL imaging at the EGU:
Please visit this presentation if you are interested!

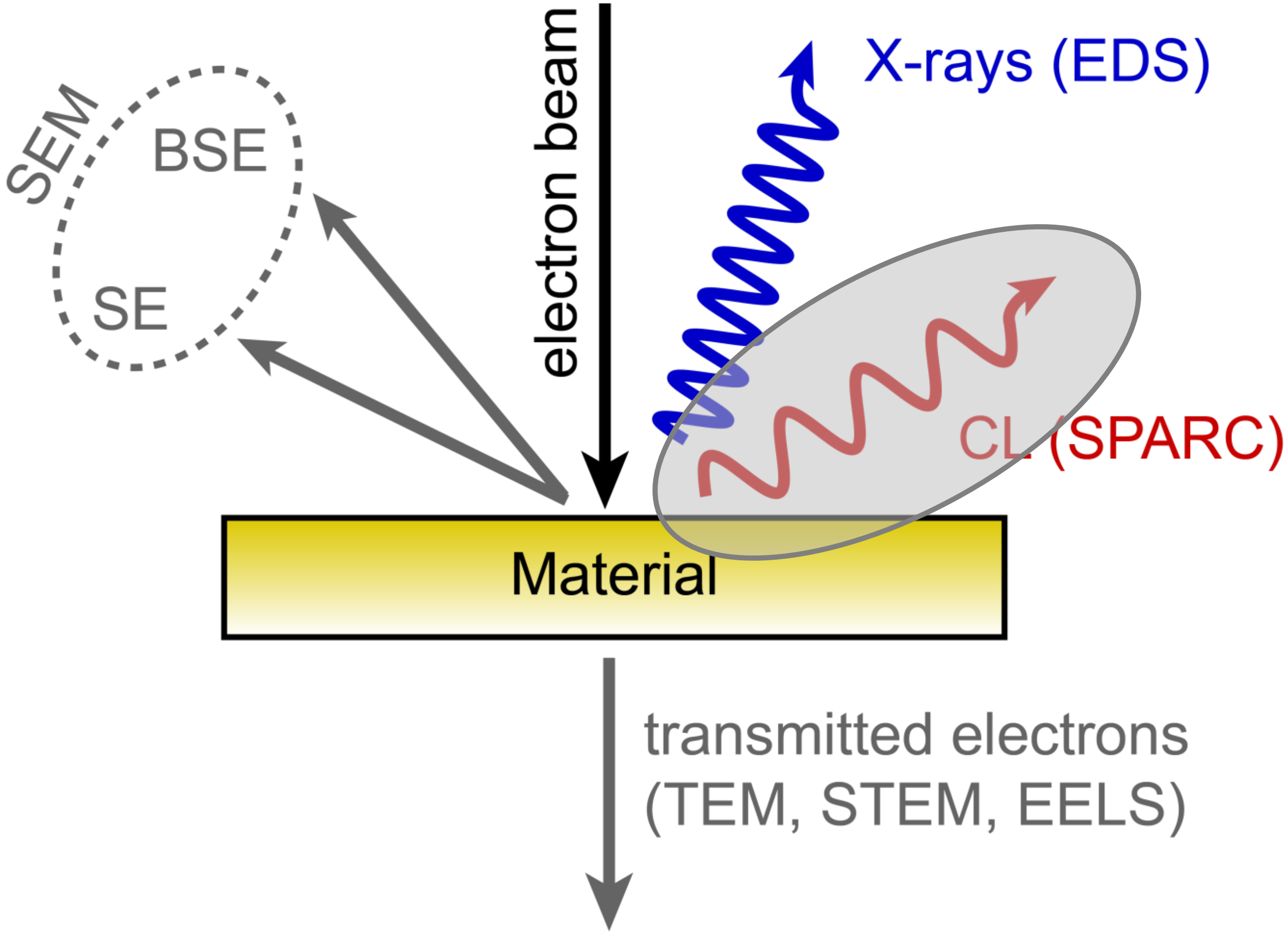
EGU2020-20478 Session BG4.4
"Correlative cathodoluminescence and EDS imaging of the benthic agglutinated foraminifer Liebusella goesi"
Sangeetha Hari *et al.*, Wednesday, 06 May 2020, 08:30-10:15

Supplementary slides

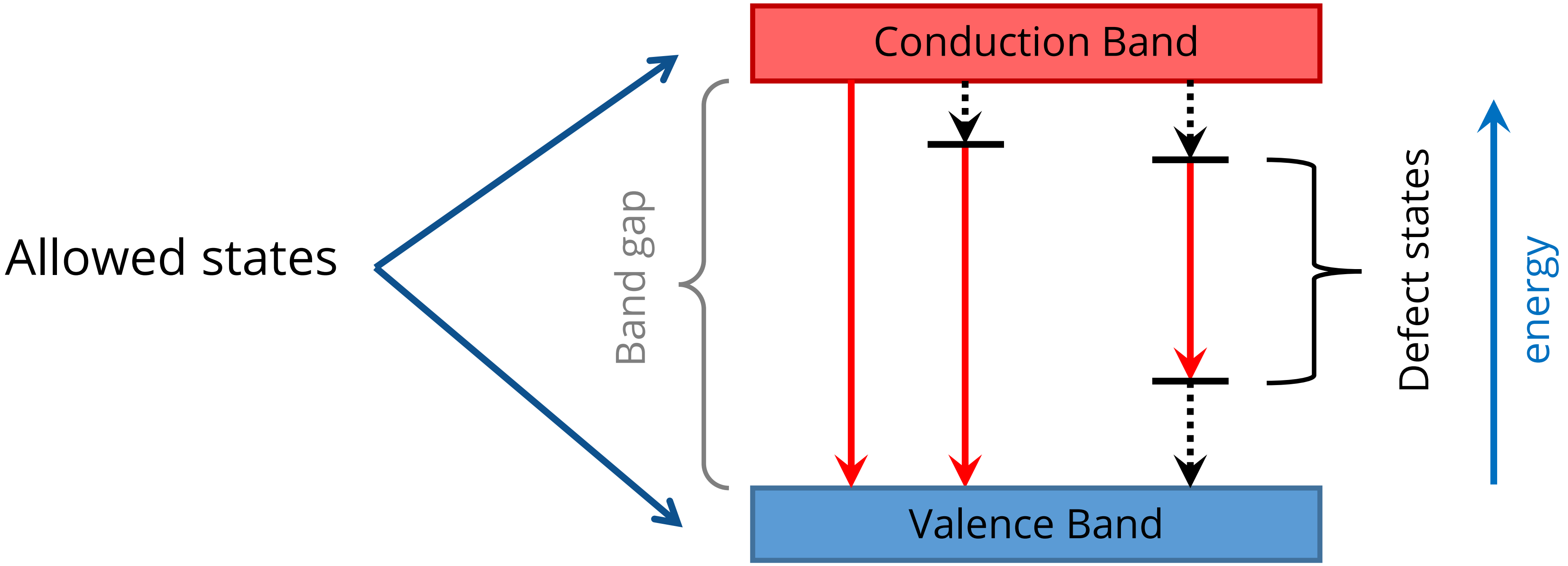
Cathodoluminescence generation

Cathodoluminescence is the process whereby light (UV-VIS-IR) is generated when an electron beam hits a specimen. The emitted light carries a signature of the electronic structure of the material





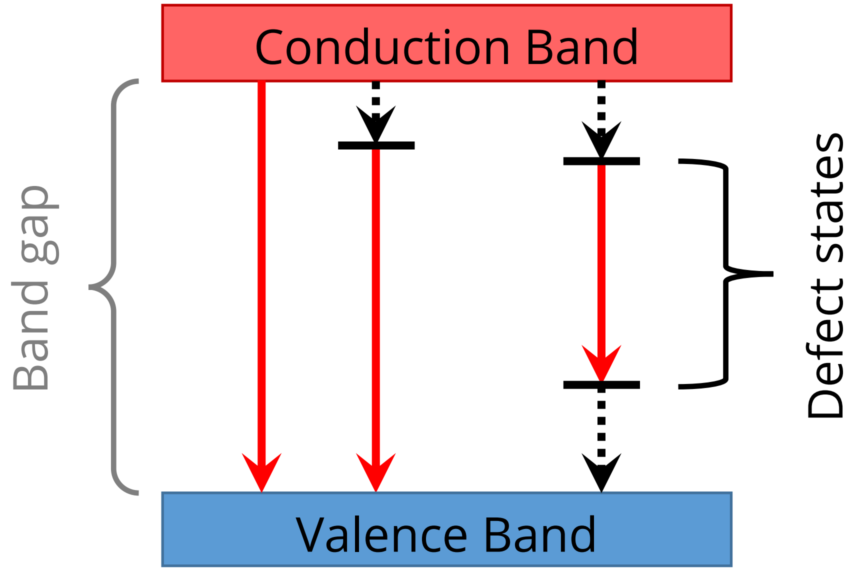
Cathodoluminescence process in rocks



For a crystalline material, electrons in that material can only occupy certain energy states. Typically, (almost) all electrons reside in the valence band

- Rocks are typically insulators with wide band gaps between 5 - 15 eV (DUV-EUV)
- In CL we measure in the 0.8 – 6 eV range
- Defect states play an important role

Defect emission in rocks



There are many types of defects in rocks some of which have a distinct CL signature

Defects

<u>Intrinsic</u>

- Vacancies
- Interstitials
- Dislocations
- Growth
- Damage

<u>Extrinsic</u>

- Foreign dopants
- Rare earths (Eur, Yb, Nd)
- Transition metals (Mn, Fe, Cr, Ti)
- Sensitizers
- Quenchers

CL versus other SEM-based techniques

SE detection:
- Surface topography
- (Minor) Material contrast

BSE detection:
- Density/atomic number
- Material contrast

EBSD:
- Crystal structure
- Crystal orientation

WDS/EDS detection:
- Core transitions
- Quantitative composition

Cathodoluminescence:
- Composition
- Crystal structure
- Trace elements/dopants
- Crystal defects
- Ionization state

CL can be used to extract various types of information and gives a unique contrast

Sample preparation for SEM-CL

Thin section

Rock sample

Surface quality

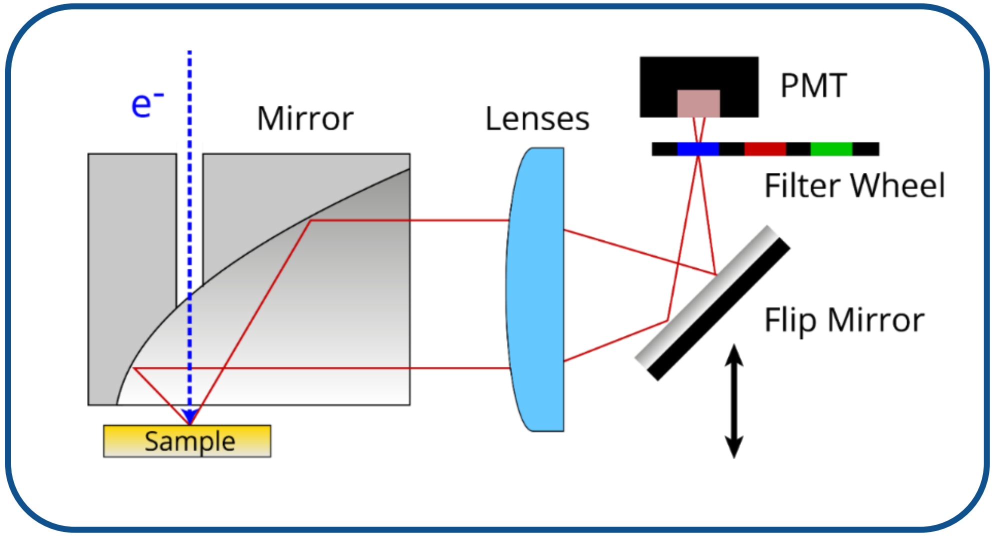
Surface conductivity

Plug

- Polishing
- Coating with metal or carbon
- High-pressure SEM

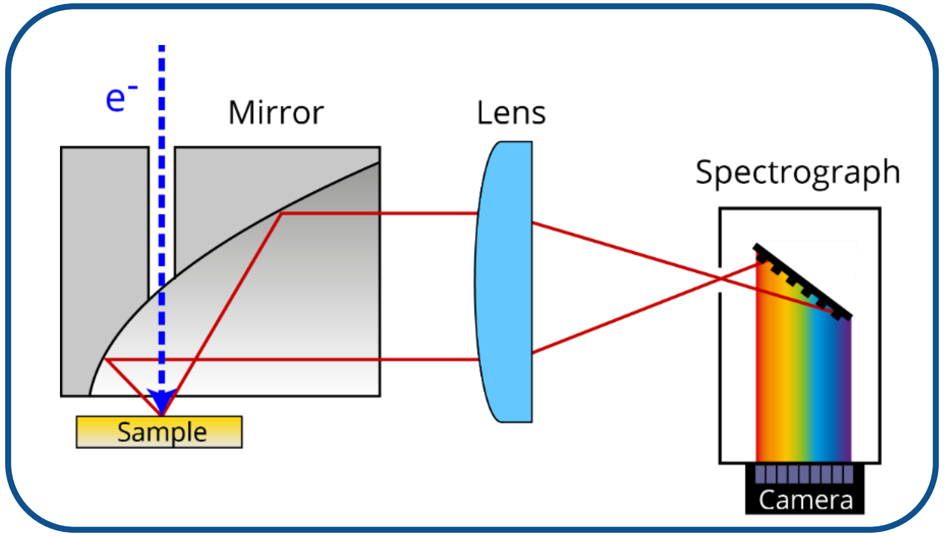
CL imaging modes

CL intensity mapping



- Measure CL intensity
- Short dwell times (10 - 100 μs) → video-rate imaging
- Coarse spectral filtering and RGB mapping

CL spectroscopy



- Measure CL spectrum
- Longer dwell times (10 - 1000 ms)
- Hyperspectral imaging with high spectral resolution