

# Lumis Electron Backscatter Diffraction Detector

## Crystallography and microstructural measurement for SEMs

### Key Words

Electron backscatter diffraction, EBSD, CMOS, texture analysis, orientation mapping, strain analysis, grain reconstruction, boundary analysis

The Thermo Scientific™ Lumis™ Electron Backscatter Diffraction (EBSD) detector incorporates the latest CMOS sensor technology, advanced optics, and uses new indexing algorithms for the analysis of electron backscatter patterns (EBSPs) at beam currents of 10 pA and below.

Developments in sensor technology have led to a new generation of imaging devices with improved performance characteristics. The latest CMOS sensors now provide exceptional sensitivity even at high frame rates due to a high dynamic range, increased quantum efficiency and improved noise management

The Lumis EBSD detector incorporates a large format CMOS sensor and proprietary reverse zoom optics to complement and extend the built-in CMOS sensor binning. A high-efficiency, octagonal scintillator converts the electron backscatter electrons into light, which is focused on to a user-controlled region of the sensor by the high-quality reverse zoom optics. This allows a continuous choice of “binned” electron backscatter pattern (EBSP) size and gives full flexibility over EBSP speed, quality and sensitivity.

Driving the optics in the opposite direction and applying sensor binning allows high speed EBSD – at several thousand frames per second for reduced collection times and higher sample throughputs. With > 2.2 million pixels, the detector is ideally suited to high-resolution EBSD applications, such as strain measurement and phase identification.

The advanced optics and high sensor sensitivity allow electron backscatter patterns to be acquired at ultra-low probe currents (10 pA). This is particularly important for beam sensitive or dose restricted materials, or where higher probe current may introduce contamination / drift.

An integrated 5-diode forescatter detector allows rapid surveying of a specimen to identify areas of interest.



Thermo Scientific Lumis Electron Backscatter Diffraction (EBSD) detector

### Features

- High DQE CMOS sensor, >2.2 megapixels
- High speed, above 1000 indexed EBSP per second
- Optical binning using reverse zoom optics
- Lens auto-focus
- Very high sensitivity, down to 5 pA
- High vacuum, bellows design
- Extra wide phosphor
- Integrated 5-diode forescatter detector
- No external support boxes

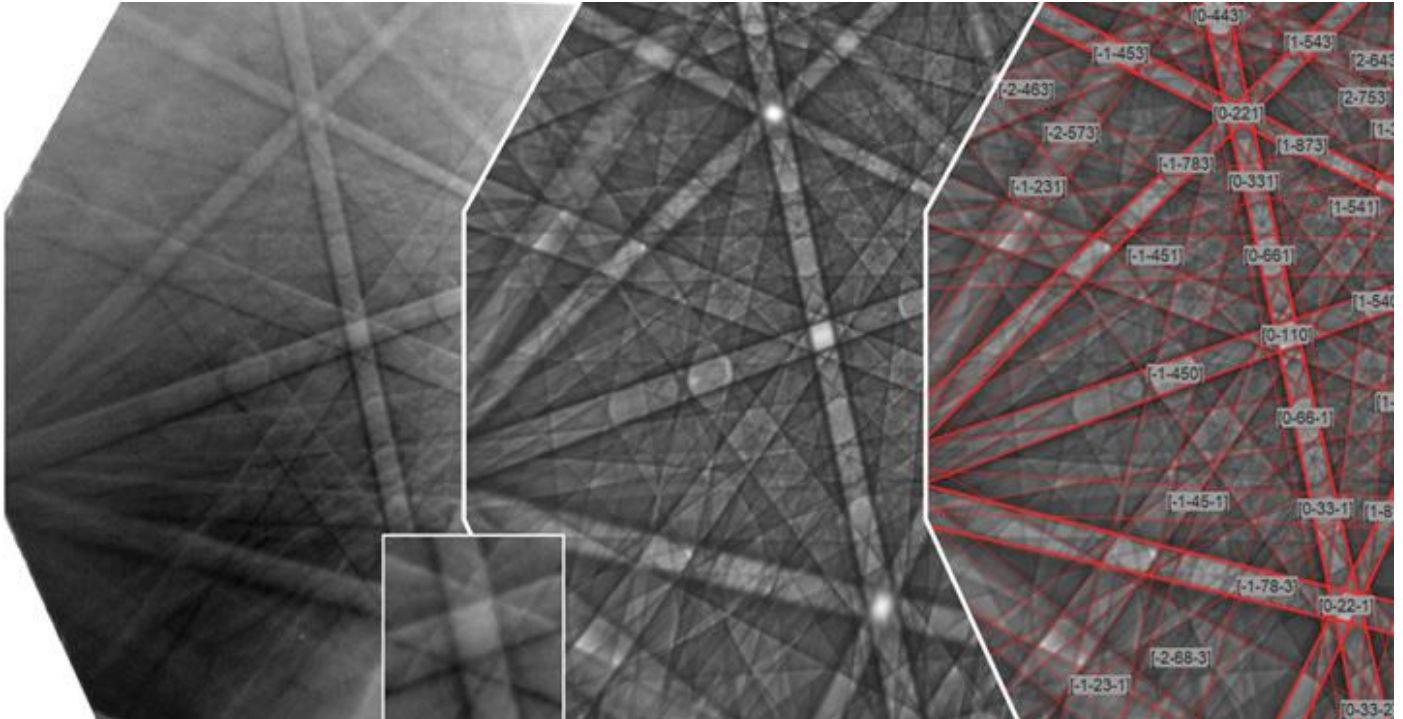
## Advanced reverse zoom optics

The Lumis EBSD detector has novel, proprietary reverse zoom optics to provide continuous zooming.

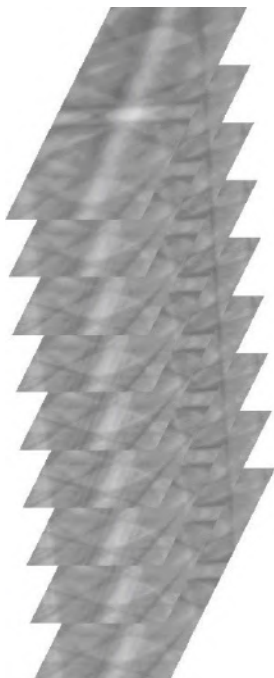
Good quality DSLR cameras (and even some mobile phones) have an optical zoom lens to provide optimal images. Digital zoom (i.e., binning) is used for lower performance and resolution systems.

Reverse zoom optics features:

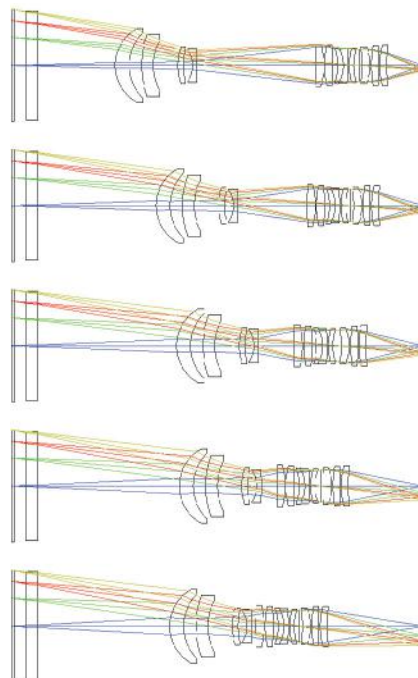
- Continuous zoom range
- High efficiency light transfer
- optimized MTF
- Low optical distortion
- *In-situ* focusing of the EBSD phosphor



Hexagonal iron (II) sulphide, FeS, EBSD 30 kV; (lower left) detail of [0-110] zone; (middle) dynamical diffraction simulation, (right) indexed and labelled.



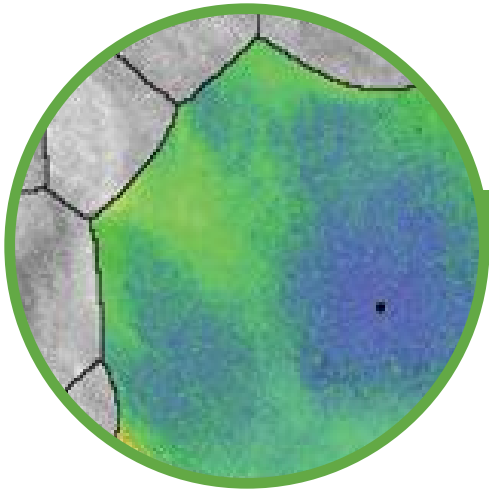
Silicon [112] zone details from a through-focus set of EBSPs, showing automatic focusing of the lens.



Intelligent, reverse zoom optic incorporating a high sensitivity CMOS sensor

The Lumis EBSD detector incorporates a unique octagonal phosphor design that achieves optimal light throughput and solid angle balance between the circular lenses and the rectangular CMOS sensor.

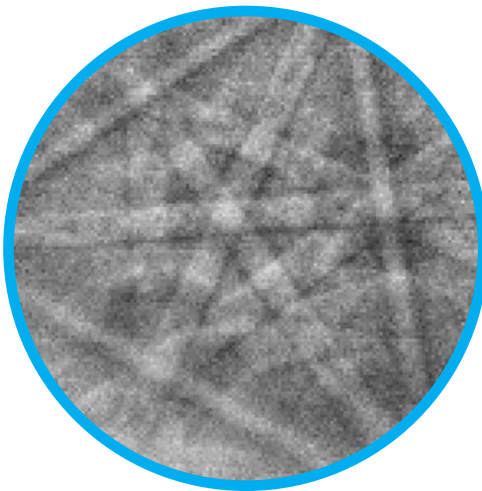
A circular phosphor does not match the rectangular sensor and collisions with the specimen and SEM pole-piece are much more likely.



## Resolution

The Lumis EBSD detector has a > 2.2 megapixel sensor combined with a high Modulation Transfer Function (MTF) optical assembly to provide the highest resolution of any EBSD detector on the market. Cross-correlative strain analysis and complex phase ID can now be achieved as a matter of routine.

The Lumis EBSD detector uses the latest in CMOS technology developments to bring unprecedented low light sensitivity. A large format, high detective quantum efficiency (DQE) sensor is combined with advanced noise management strategies to enable operation below 10 pA.

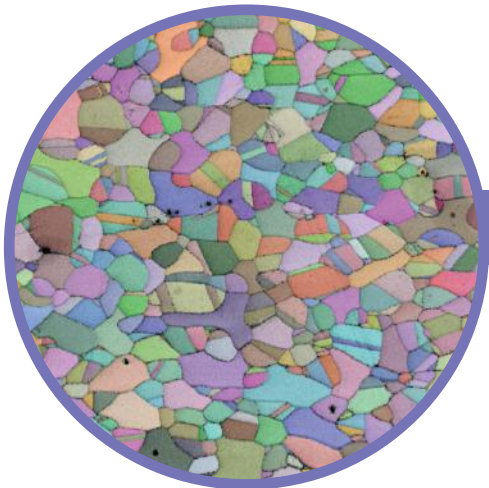


## Sensitivity

Electron backscatter pattern from nickel, 20 kV acquired at 0.006 nA,

The Lumis EBSD detector combines both optical and electronic binning to achieve high speed while maintaining resolution and sensitivity.

The highly optimized, threaded EBSD acquisition software & advanced CMOS camera readout allows speeds beyond 1000 fps to be reached.



## Speed

Part of a 1024 x 768 pixel Duplex stainless steel map acquired at 3 nA, 20 kV. Dwell time 1 ms, total acquisition time 13 minutes



## Lumis specifications

### Camera specifications

- High sensitivity CMOS
- Optimized reverse zoom optics lens
- Sensor 1920 x 1200 pixels
- Quantum efficiency 70% (typical)
- Dark noise  $\sim 7e^-$
- Dynamic range  $\sim 74$  dB
- S/N ratio 45 dB (typical)
- Dwell time from 0.1 ms to 5 s
- Collection speed above 1000 fps
- Binning down to 4x4 + optical zoom

### Detector mechanical specifications

- Software controlled insertion / retraction,  $< 100 \mu\text{m}$  accuracy
- Fits on most SEMs via an interface plate
- Replaceable phosphor

### SEM image acquisition specifications

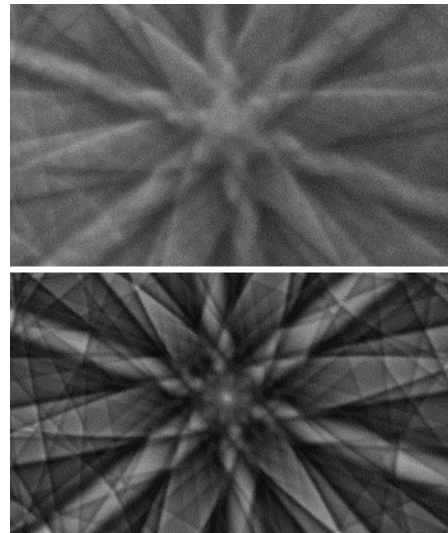
- Electron Image acquisition up to 4096 x 4096 pixels at 1 ms dwell time
- Tilt corrected imaging
- Simultaneous EBSD and EDS

### Software features

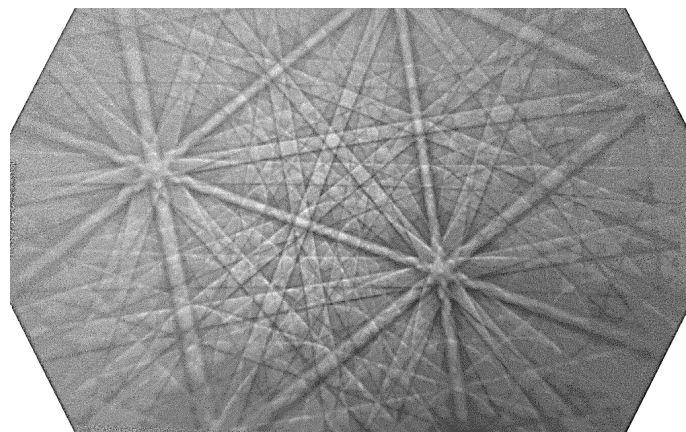
- Automatic EBSP analysis with advanced settings
- Searchable phase databases & CIF import of crystallographic data
- Pattern Center auto calibration
- Mapping – display of EBSP quality, phase, orientation, grain boundaries, special boundaries (e.g. CSL), texture.
- Grain reconstruction – grain size, shape, morphology
- Pole figure, Inverse pole figure, ODF
- Re-analysis of saved projects
- Single click reporting to Microsoft Word
- Export / import map as \*.ang or \*.csv file

### Operating system compatibility

- Windows 10, Windows 7 compatible
- 64-bit software & drivers



Nickel EBSP [110] detail and dynamical simulation



Nickel EBSP – in the [110] detail (above), higher order bands are clearly visible

Find out more at [thermofisher.com/lumis](http://thermofisher.com/lumis)

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