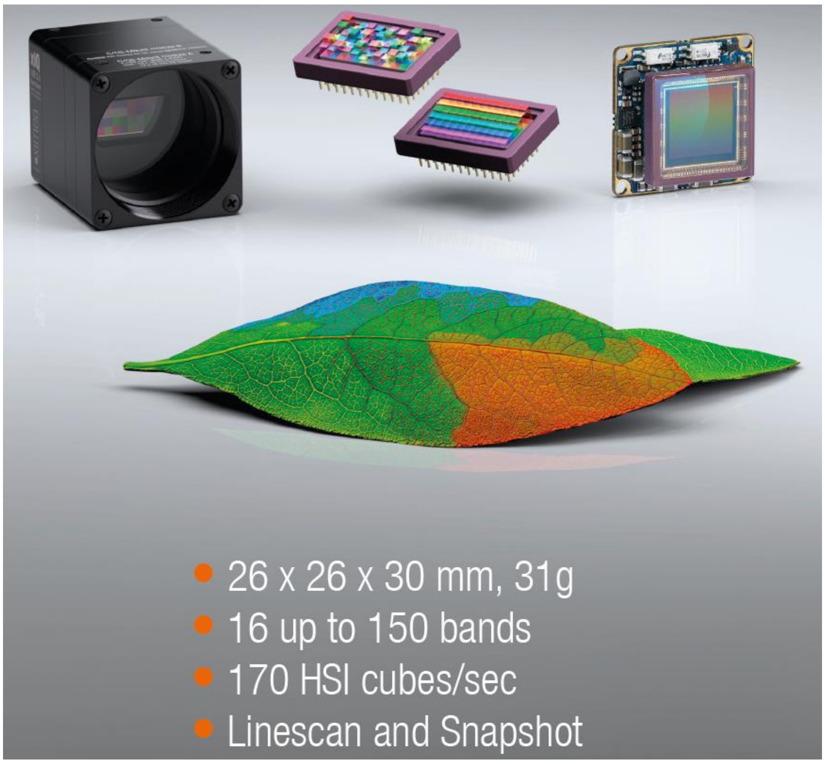
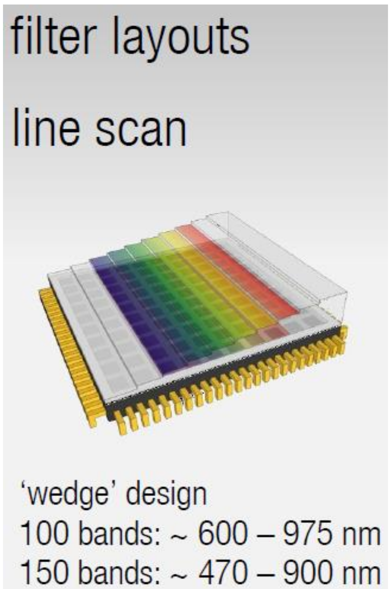
xiSpec

linescan cameras

sensor info and data processing





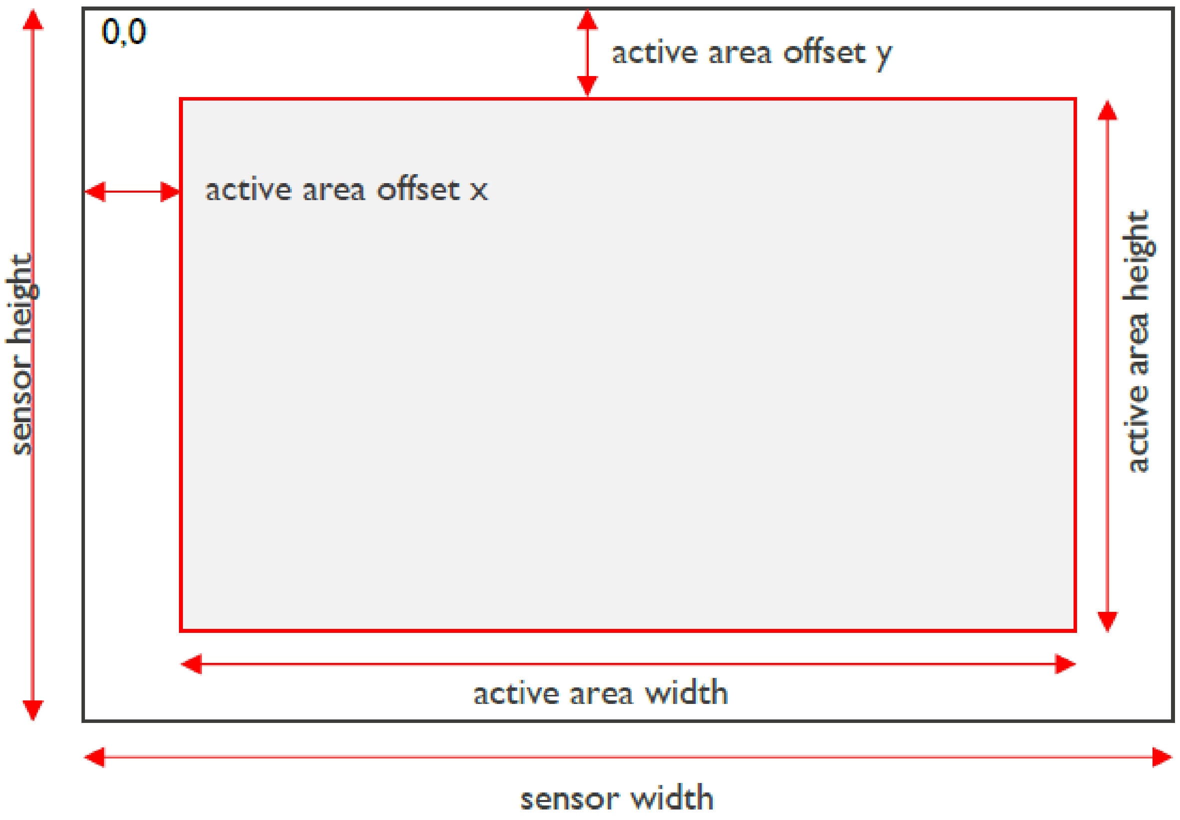
Two line scan hyperspectral imaging sensors are available:

LS100 with 100+ spectral bands between 600 and 975 nm in approx. 4nm steps

LS150 with 150+ spectral bands between 470 and 900 nm in approx. 3mm steps

The basic structure is similar.

The filter layout describes the pattern in which the filters are deposited on the sensor. Typically, the filters do not cover the entire surface of the sensor. The area on the sensor covered with filters is called the active area. The positioning of the active area on the sensor is illustrated below:



The linescan filter layout has a wedge design. The n filters in the linescan layout are organized in n bands of a fixed height over the full width of the active area. Typically, the width of the active area equals the width of the sensor. The height of the active area equals n times the height of the bands in pixels (e.g., 8 pixels). The band at the top of the active area has position index 0. The position index is incremented to the bottom of the active area, with the band at the bottom of the active area has position index n−1. The linescan wedge layout is summarized below:

Because of the organization of the filters in bands over the whole width of the sensor, this filter layout is best suited for linescan applications.

The filter layout is denoted by LS followed by the number of bands available. E.g., LS100 denotes the linescan layout with 100 spectral bands available. Note that the number of available bands does not necessarily coincide with the actual number of bands on the sensor. This is because some bands are used for production quality checks and future product development.

(Source: imec, "hyperspectral sensors, technology review", V1.1, 2017-10-25)

LS100 NIR sensor

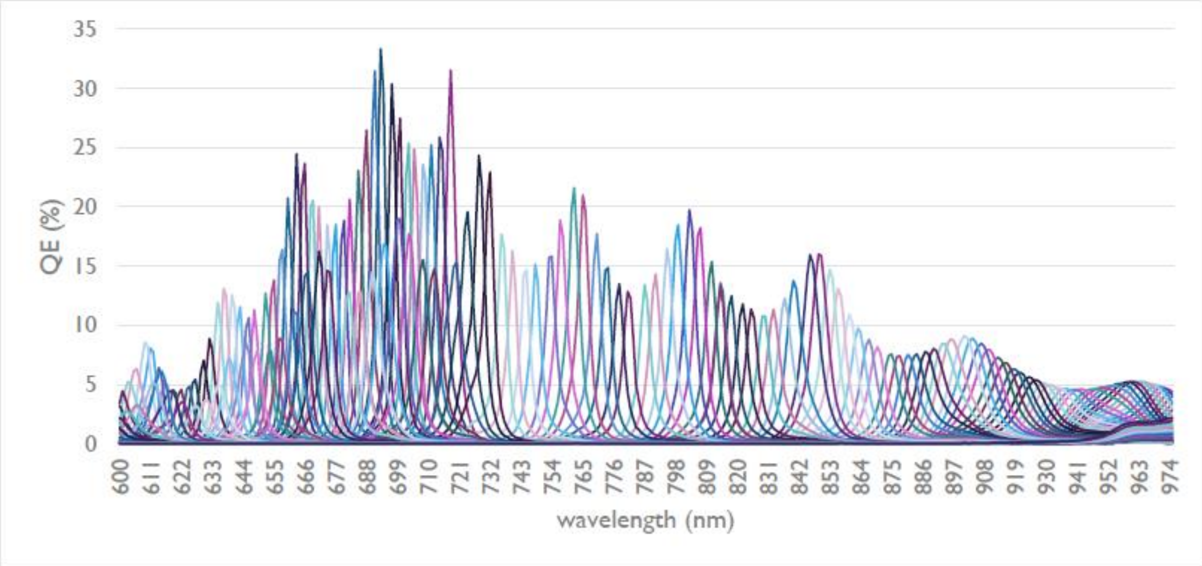
Wavelength range	600 – 975 nm
# bands	100+ (max. 128)
Calibration file names	CMV2K-LS100-600_1000-x.x.x.x.xml

The CMV2K LS100 NIR sensor is a CMOSIS CMV2K sensor with 128 filters in a wedge pattern, active in the near infrared (600-975 nm). Each band is 8 rows high, covering in total 1024 rows of the sensor. An example of the filter responses in the active range is given in Figure 15.

> **Note**: At least 100 of the 128 bands are available for use on the sensor. The remaining bands are used for production quality checks and future product development. Typically, the available bands are band 13 to band 114.

In the evaluation kits a custom made 600-975 nm band pass filter is built into the Ximea camera.

Example filter responses of the LS100+ NIR sensor in the active range of 600-1000nm:



(Source: imec, “hyperspectral sensors, technology review”, V1.1, 2017-10-25)

LS150 NIR sensor

Wavelength range	470 – 900 nm
# bands	150+ (max. 192)
Calibration file names	CMV2K-LS150-470_900-x.x.x.x.xml

The CMV2K LS150 VIS-NIR sensor is a CMOSIS CMV2K sensor with 64 filters active in the visual range (470-600 nm) and 128 filters active in the near infrared (600-900 nm). The filters are distributed over two separate active areas. Within each active area, the filters are organized in a wedge pattern in which each band covers 5 rows. The active areas are separated from each other by an empty interface zone of 120 rows. An overview of the filter layout is given in the figure below.

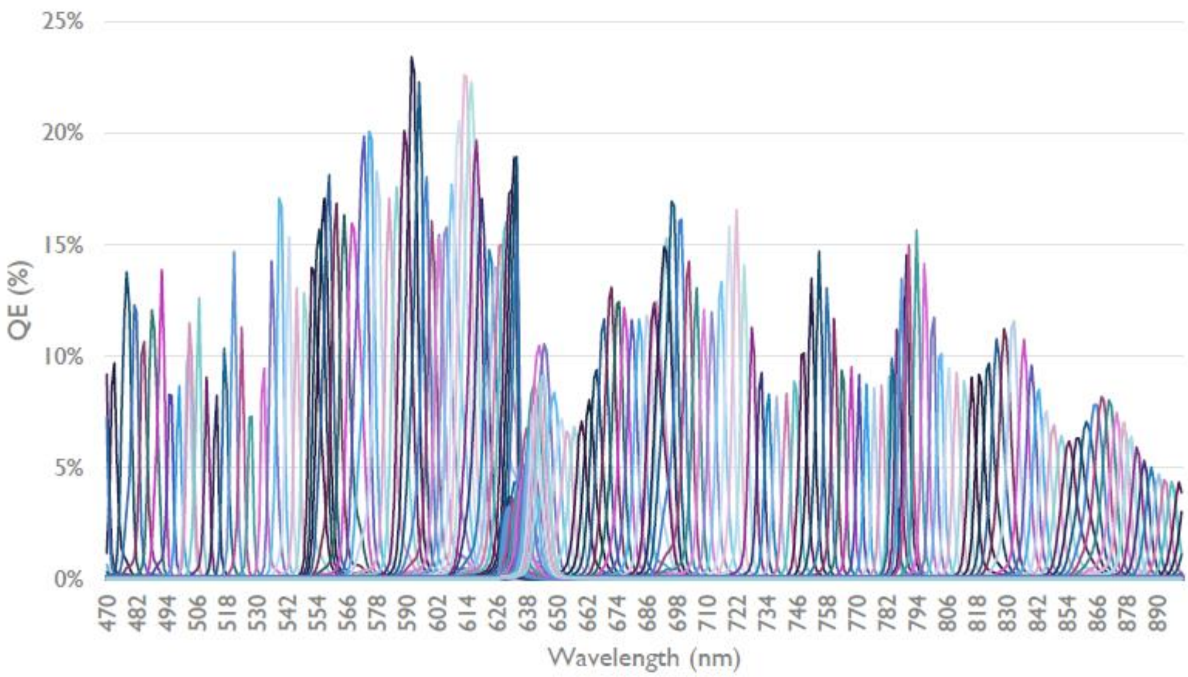
0	VIS
1	VIS
	...
62	VIS
63	VIS
	empty interface zone
64	NIR
65	NIR
	...
190	NIR
191	NIR

Note: At least 150 of the 192 bands are available for use on the sensor. The remaining bands are used for production quality checks and future product development.

Note: The pixel response in the empty interface zone is not defined. These pixels are often fully saturated.

In the evaluation kits a custom made 460-910 nm band pass filter is built into the Ximea camera.

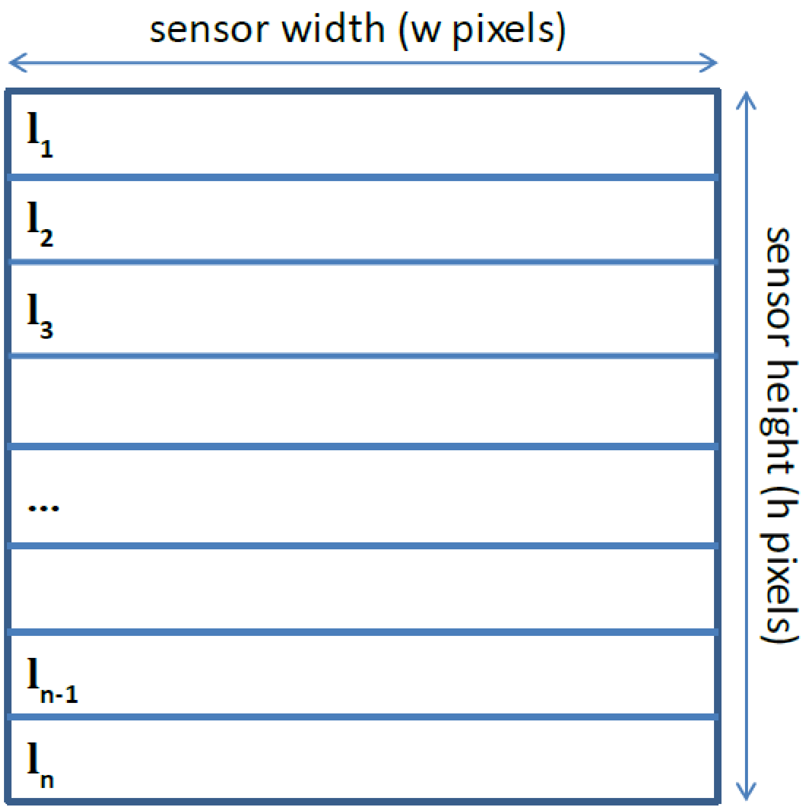
An example of the responses of the filters is given in the figure below for wavelengths in the range of 400 to 1000 nm. The sensor is designed for an active range of 470-900 nm. All filters have one response peak in the active range.



(Source: imec, “hyperspectral sensors, technology review”, V1.1, 2017-10-25)

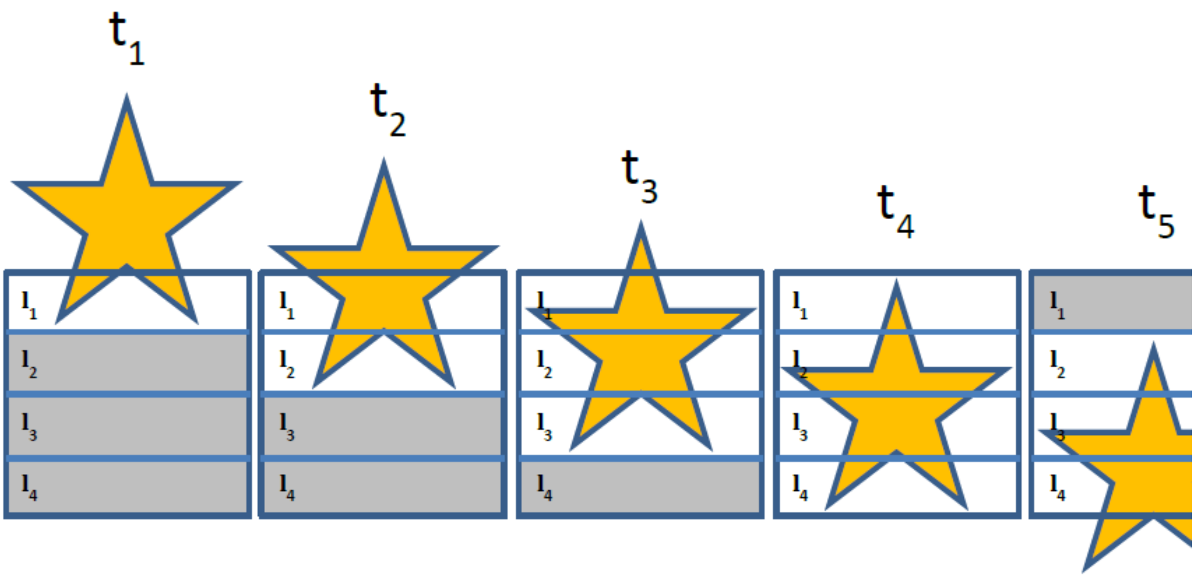
Data acquisition, date cube and spectrum calculation

The line-scan sensor that is used to acquire a hyperspectral representation of an object consists of a conventional sensor with specialized filters processed on top. Each filter only transmits a small portion of the complete spectrum reflected by the scene. All this information is then combined to create a hyperspectral representation of the scene: a hypercube.



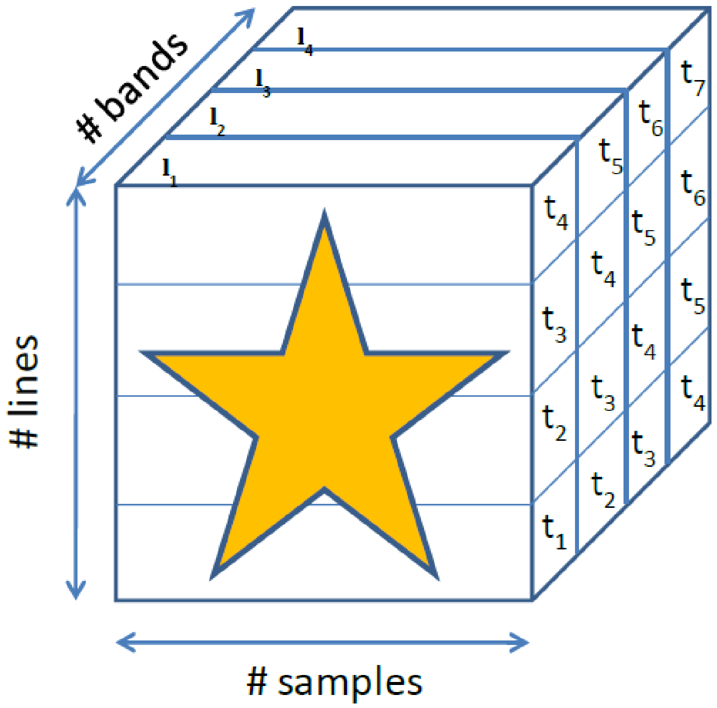
A representation of the wedge sensor is given above. It consists of a sensor with a resolution of w x h pixels, with n filter bands processed. Each band is h/n pixels in height, and w pixels in width.

As explained the frequency-specific regions on the sensor are organized in adjacent bands. In order to capture the spectra of every point of an object, we have to ensure that every point passes over each individual band. This is done by moving the object under the sensor, perpendicular to the orientation of the wedge bands. This is illustrated below:



A full scan of an object consists of a start-up phase, a steady-state phase, and a shutdown phase. During the start-up phase and the shutdown phase (t1/t2/t3 and t5/t6/t7, respectively), not all captured data will be used for hypercube construction. This unused data is shown in grey in the figure above. During steady-state (see t4), all captured data is used in the hypercube construction. The number of frames in steady-state depends on the length of the object.

The construction of a hypercube from these wedge images is done by re-organization of the individual bands, in such a way that all bands of a specific wavelength, taken over consecutive frames, are stitched together, and this for every wavelength. This is illustrated in the figure below. A spectrum of a specific point on the object can be obtained by taking the information for that position over all bands.



Stitching the individual bands of consecutive wedge frames together will only produce a good result if:

- The object moves under the sensor perpendicular to the orientation of the wedge bands. Any misalignment will result in incorrectly stitched images, both spatially and spectrally. The software provides a tool for the user to ensure that this requirement is met.
- The frame rate at which the camera captures images is in sync with the speed at which the object is moved under the camera.

(Source: imec, technical report, “Line scan processing pipeline”, 2013-11-18)

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