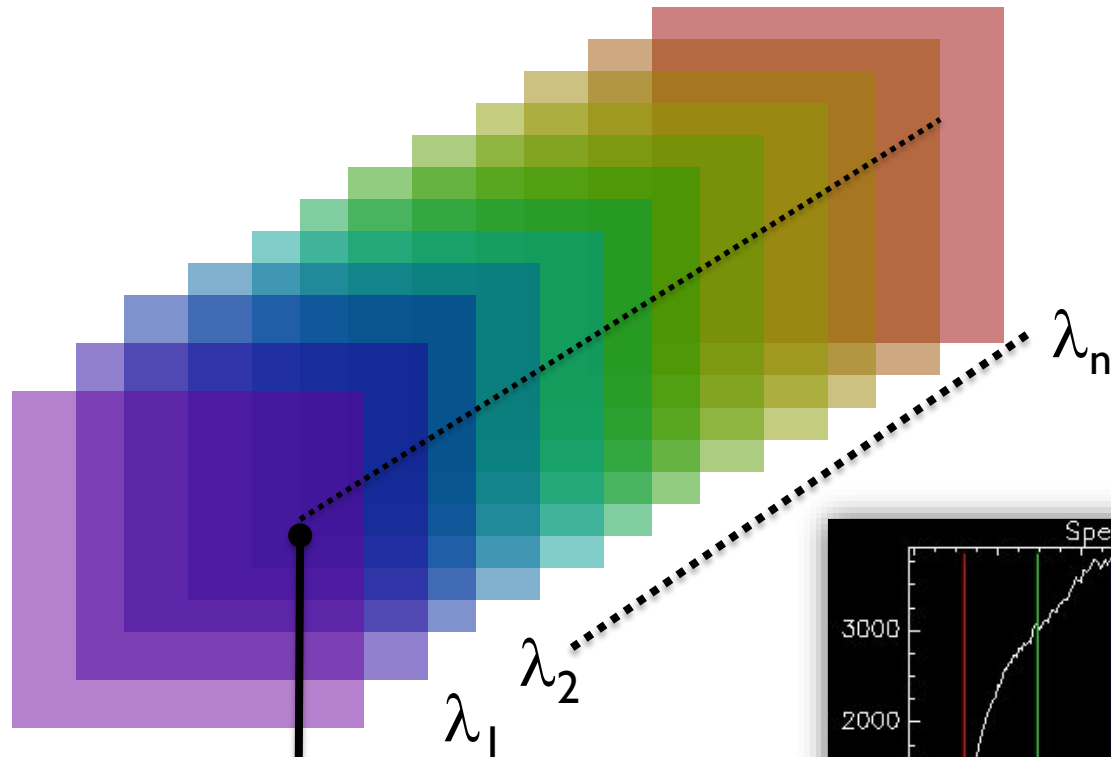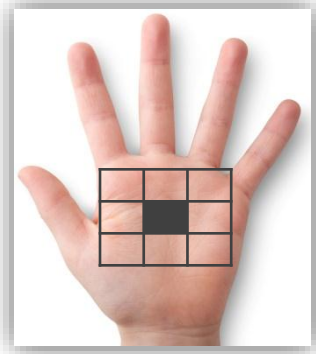# HYPER SPECTRAL IMAGING
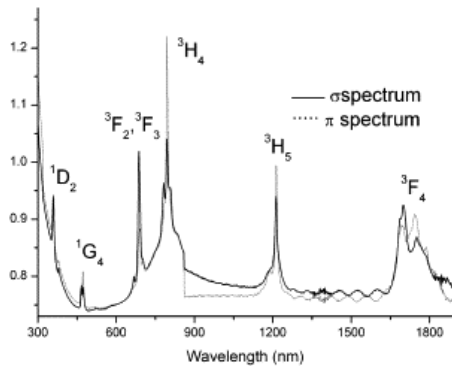
Improves vision and discrimination power by using spectral signature information of surface material / object being captured
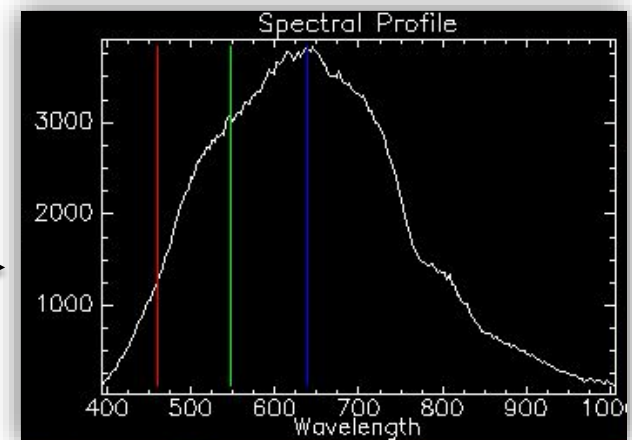
SPECTRAL IMAGING OPEN ONE NEW DIMENSION

Spectrometer

Color camera

Hyperspectral camera
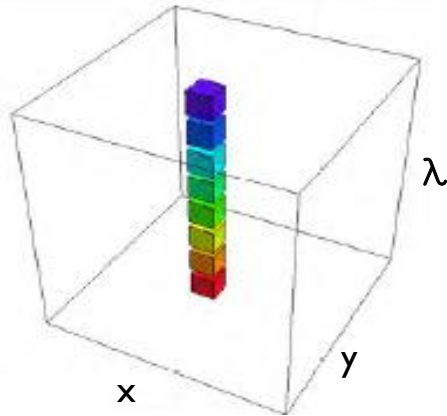
→ Accurate **spectral analysis** of **one spatial pixel** only
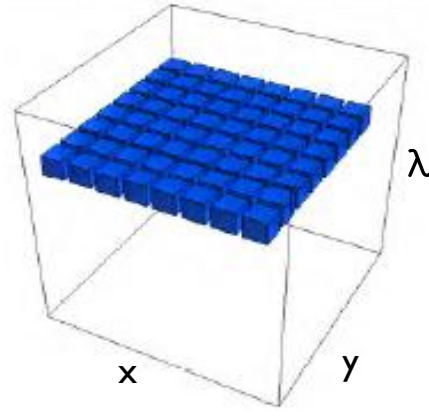
→ Seeing **RGB colors** of **one image** only
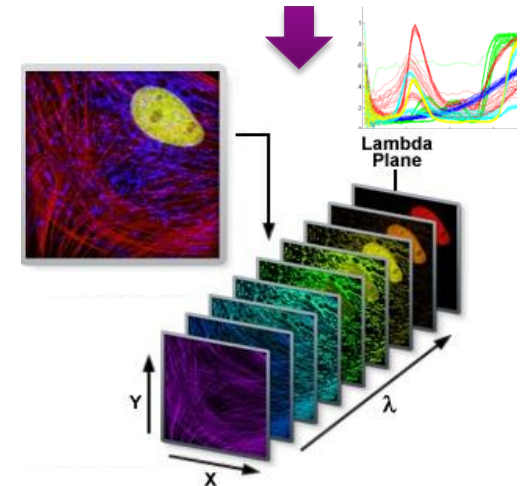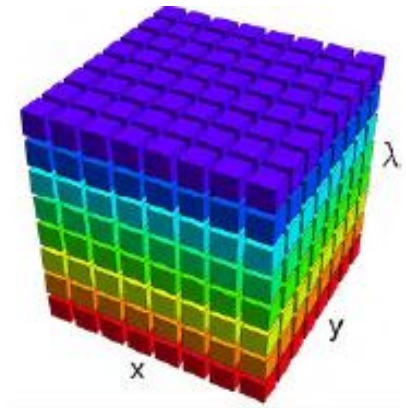
→ **spectral signature** images revealing **objects chemical composition**

IMEC APPROACH FABRY-PEROT SPECTRAL FILTERS
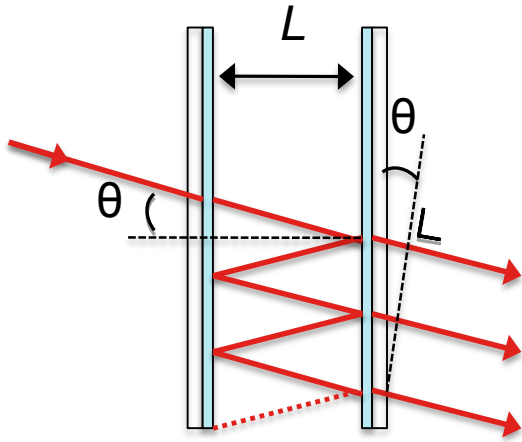
Wavelength selection depends on cavity length L

$$k\lambda = 2nL\cos\theta$$

Different cavity heights = different spectral wavelengths captured!

Narrow-band & high transmission efficiencies spectral filters

Tx (%)

FWHM ~ 5-20nm

740   760   780   800   820   840
Wavelength (nm)
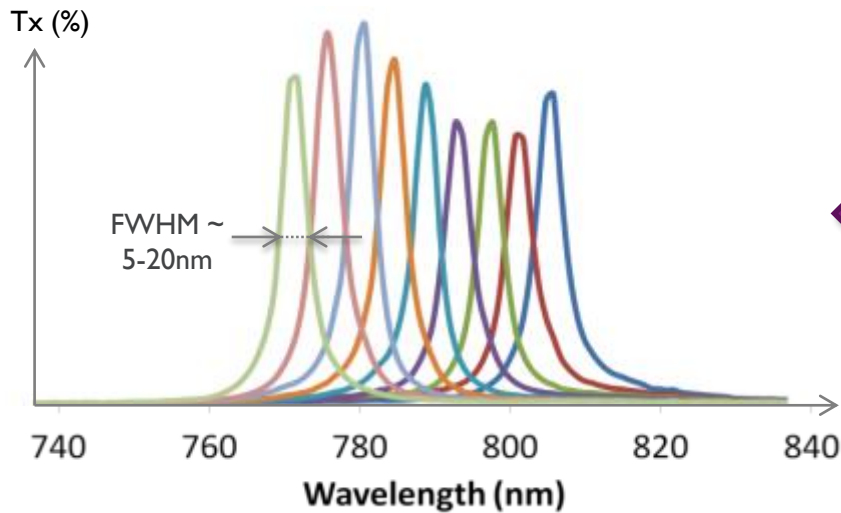
IMEC HYPERSPECTRAL TECHNOLOGY USP

- **Filters fully integrated on pixels and CMOS compatible**
  - Extra post-processing step in standard image sensor production
  - No assembly, no alignment nor stray light issues
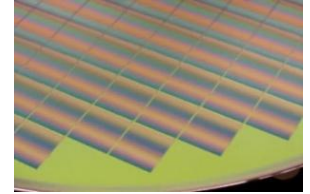
- **Optical filters & imager can be customized to match with final application requirements**

  - Number of filters, central wavelength, FWHM
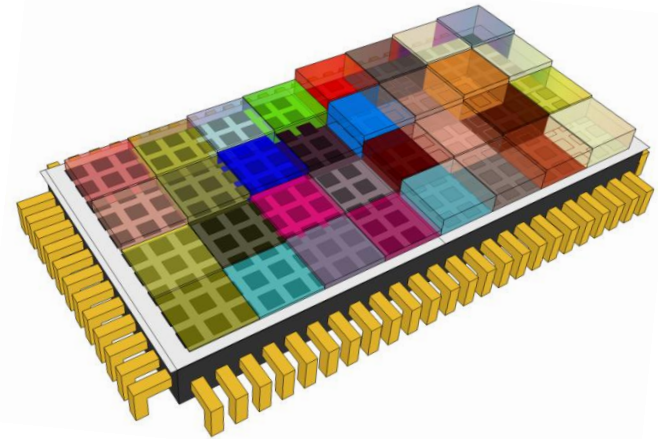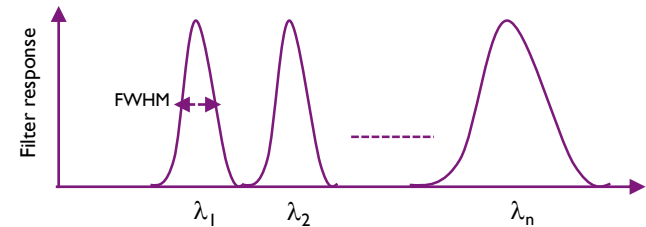

  - Possibility to fill sensor with ONLY selected bands of interest (not restricted to continuous wavelength, or range or specific line arrangement)
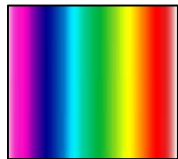
| Continuous Line-scan | Custom Line-scan | Snapshot Tiled | Snapshot Bayer Mosaic |
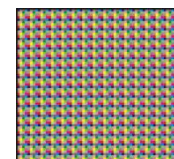
➔ **All tunable: results in high speed, compact & cost-effective HSI solution!**

DIFFERENT HSI CAPTURE APPROACHES

Line-Scan design

Snapshot design

OR
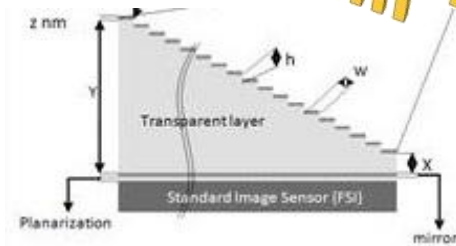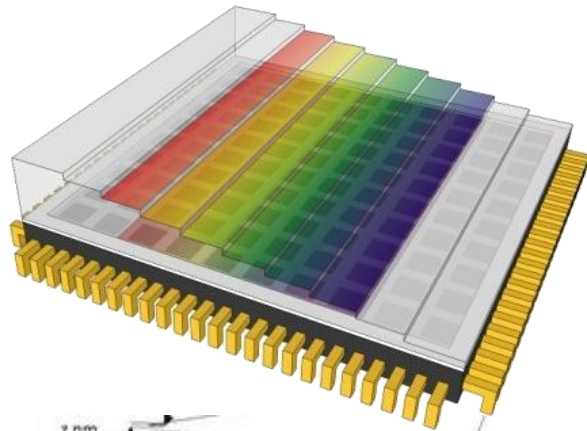
SCANNING movement needed

highest spatial and spectral resolution possible
(100 band images of 4MPx resolution each)

→ "on-chip" integration of **2048 parallel**
'low-end' spectroscopes having spectral
resolution of **100 points** each!
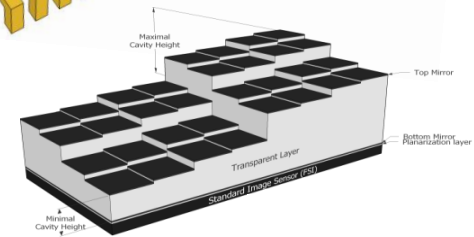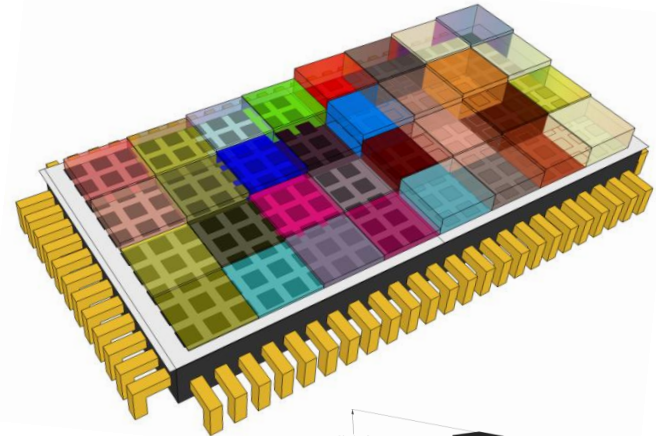
NO SCAN = real-time HSI cubes acquisition

spatial versus spectral resolution trade-off
(32 band images of 256x256 resolution today)

→ "on-chip" integration of **65 000**
'low-end' spectroscopes having spectral
resolution of **32points** each!

OUTDOOR DEMO OF IMEC SNAPSHOT HSI CAMERA

PIXEL # 2: LEAF

PIXEL # 1: LEAF

PIXEL # 3: VARIABLE

PIXEL # 4: CONCRETE
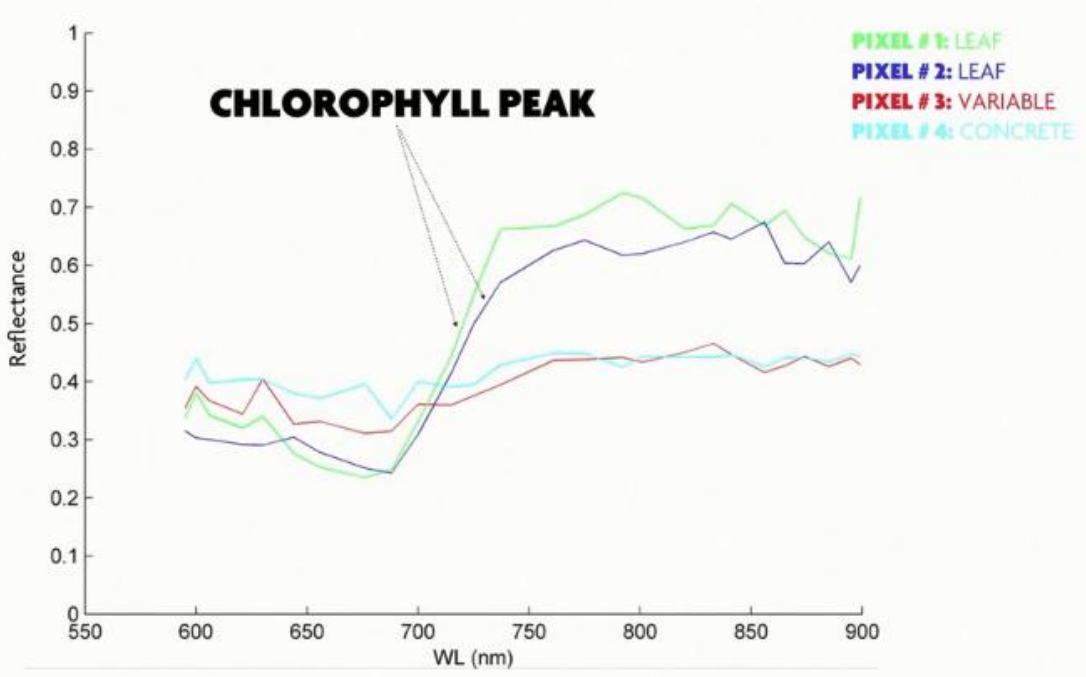
Solution equivalent to
256x256 = 65 000 'spectroscopes-on-chip'
scanning @ video-rate with 32points
spectral point resolution each

CHLOROPHYLL PEAK

PIXEL # 1: LEAF
PIXEL # 2: LEAF
PIXEL # 3: VARIABLE
PIXEL # 4: CONCRETE
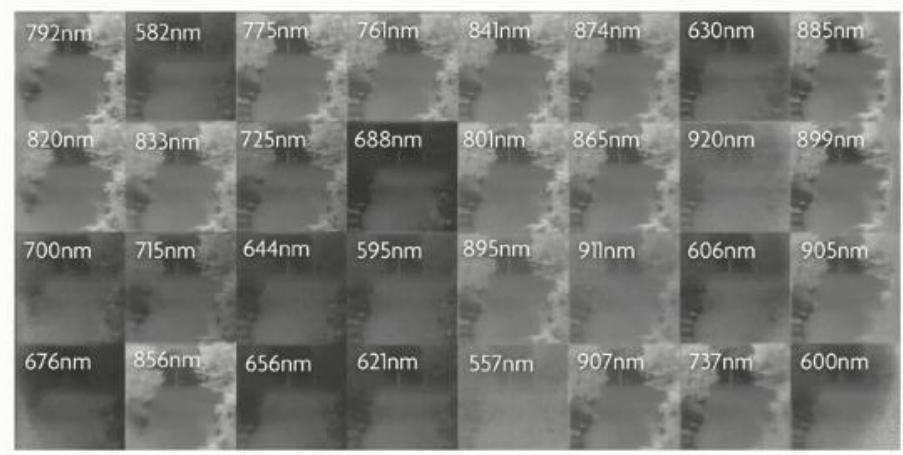
DEMO video available on http://vimeo.com/77218620

WHERE RELIES KEY SPECTRAL INFORMATIONS?

Color measurements
380-720m

Fluorescence imaging peaks
450-720m

Chlorophyll absorption / vegetation reflectance
510-970nm

Oxygenation in blood
500-900m

Water absorption
970nm
+1450nm
+1850nm

CH4
2300nm

CO2
2100nm
+3500nm
+ 4800nm

λ (nm)

350 400 450 500 550 600 650 700 750 800 850 900 950 1000 1500 3500 5000

450-700m

Skin tones / tissue chromophores

750-950m

Hydrocarbon organic compounds
(Ethanol, Benzene, Aromatics, ETBE, MTBE, Toluene...)

2300nm -2400nm

Minerals mapping

1700nm -1900nm

PVC / plastic recycling

KEY DRIVING APPLICATIONS **FOR IMEC HSI**

Remote sensing

UAV/drones & nano-sattelites for:
→ Precision agriculture
→ Environment monitoring
→ Terrestrial / maritime earth observation

Life-science / spectroscopy instrumentation

→ Imaging spectroscopy analyzers
→ DNA sequencers / flow cytometers
→ Water monitoring analyzers
→ Blood / urine analyzers

Machine vision / Optical sorting

→ Food sorting / quality grading
→ Pharmaceutical defect inspection
→ Industrial inspection (plastic, ceramic, glass, etc...)
→ Robotic machine vision
→ Mining / Mineralogy
→ Print quality inspection

Automotive & Transport

→ Night vision systems
→ Fuel monitoring systems

Medical imaging

→ Surgery-guided imaging
→ Fluorescence microscopy
→ Endoscopy
→ Ophthalmology / retina imaging
→ Wounds imaging

Security / Surveillance

→ Industrial gas leaks monitoring
→ Intrusion detection / authentication
→ Rescue
→ Forensics

LINE-SCAN HSI Sensor design, XIMEA camera MQ022HG-IM-LS100-600-1000
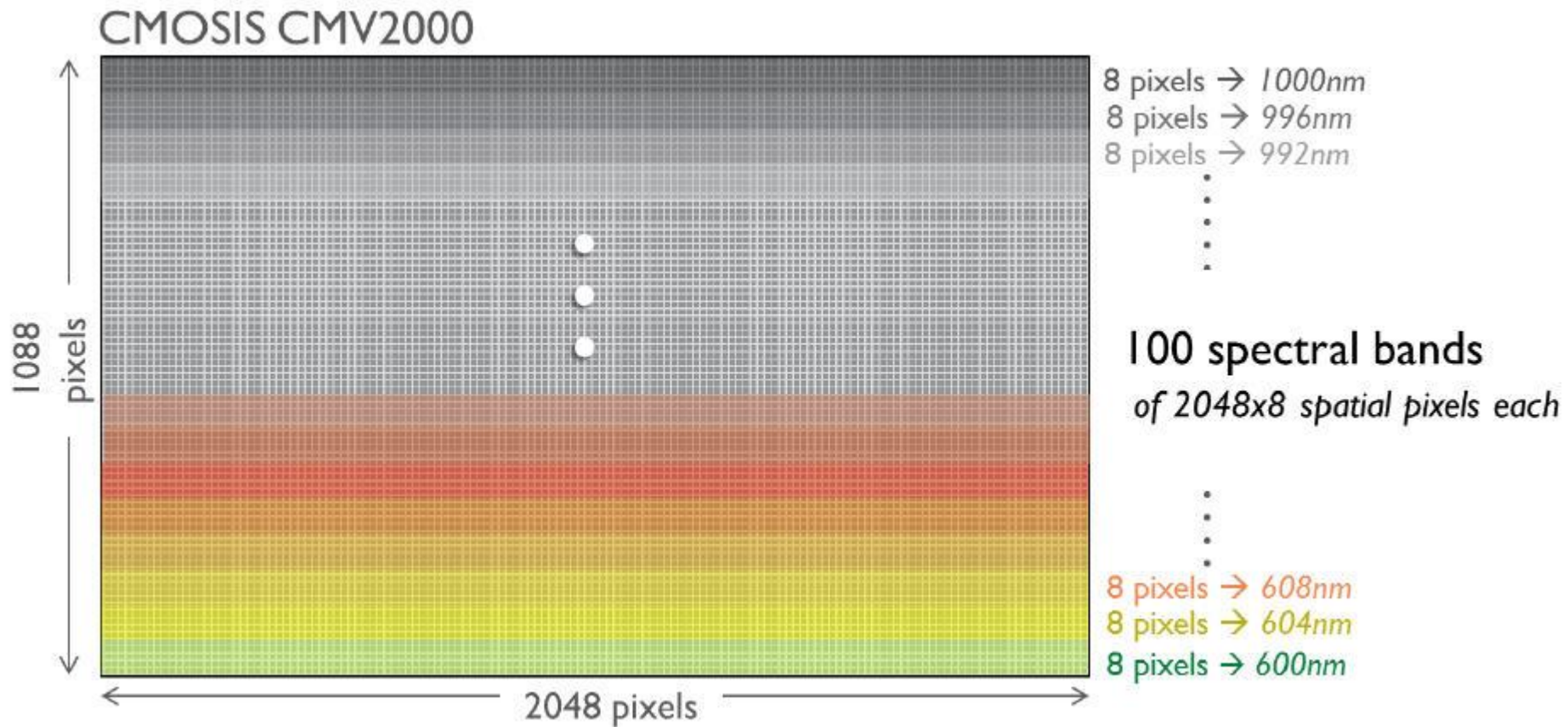
©imec

Key specification

Spectral resolution:	100 bands in 600-1000nm with 4nm incremental steps
FWHM:	~ 15nm
Spatial resolution:	2048 pixels x length of scan
Speed:	up to 170 fps (full sensor frame)

SNAPSHOT MOSAIC HSI Sensor design, XIMEA camera MQ022HG-IM-SM4X4-470-620

4x4 mosaic = 16 bands

CMOSIS CMV2000

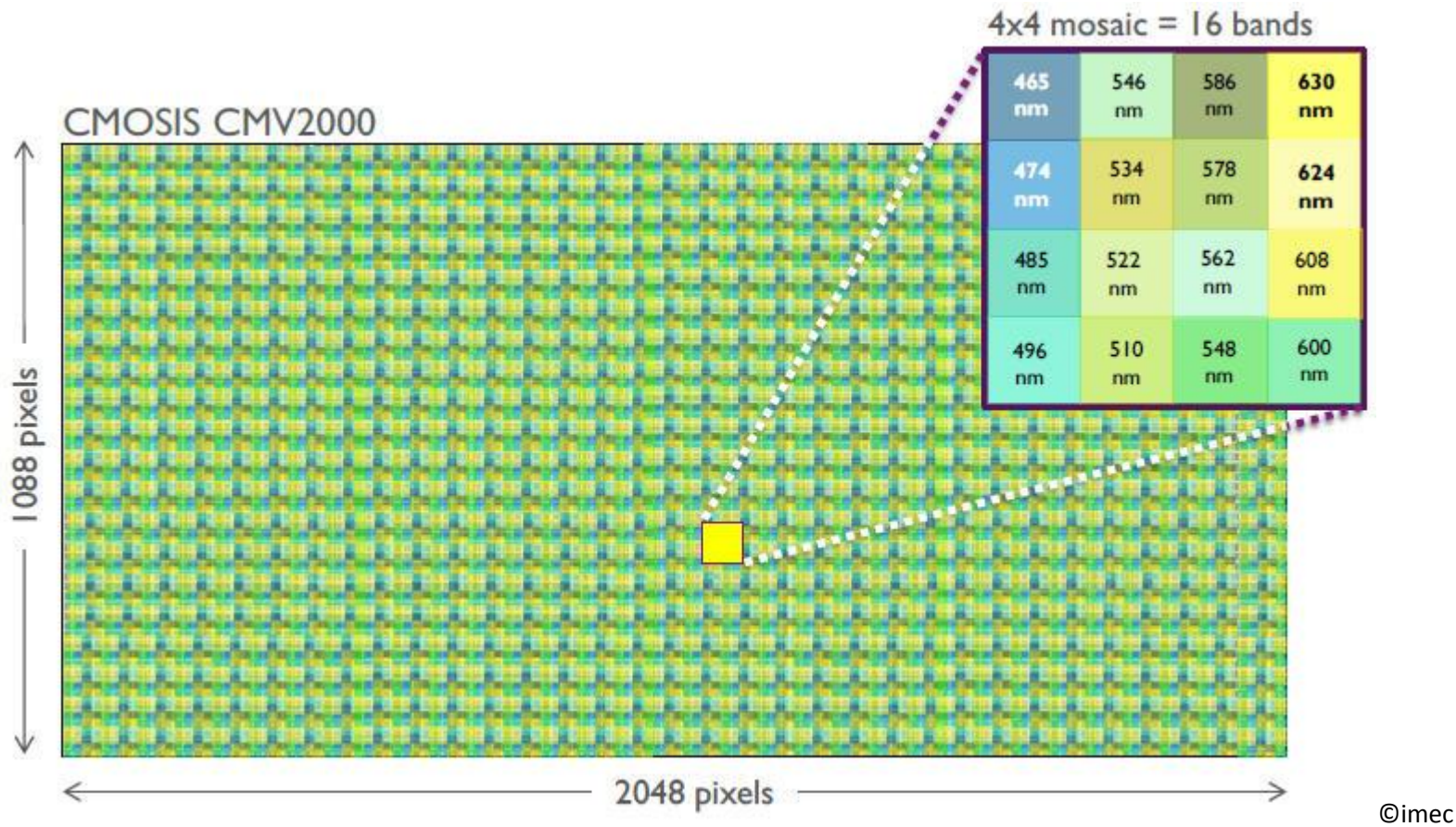| 465 nm | 546 nm | 586 nm | 630 nm |
474 nm	534 nm	578 nm	624 nm
485 nm	522 nm	562 nm	608 nm
496 nm	510 nm	548 nm	600 nm

1088 pixels

2048 pixels

©imec

Key specification

Spectral resolution:	4x4 mosaic = 16 bands in 465-630nm
FWHM:	~ 15nm
Spatial resolution:	from 512x272 (per band) ⯈ up to 2Mpx (per band) depending on demosaicing algorithm
Speed:	up to 170 data-cubes / s (full sensor frame)

SNAPSHOT MOSAIC HSI Sensor design, XIMEA camera MQ022HG-IM-SM5X5-600-1000

5x5 mosaic = 25 bands

915 nm	930 nm	945 nm	960 nm	975 nm
835 nm	850 nm	875 nm	890 nm	900 nm
760 nm	775 nm	790 nm	805 nm	820 nm
675 nm	700 nm	715 nm	730 nm	745 nm
600 nm	615 nm	630 nm	645 nm	660 nm

CMOSIS CMV2000

1088 pixels

2048 pixels

©imec
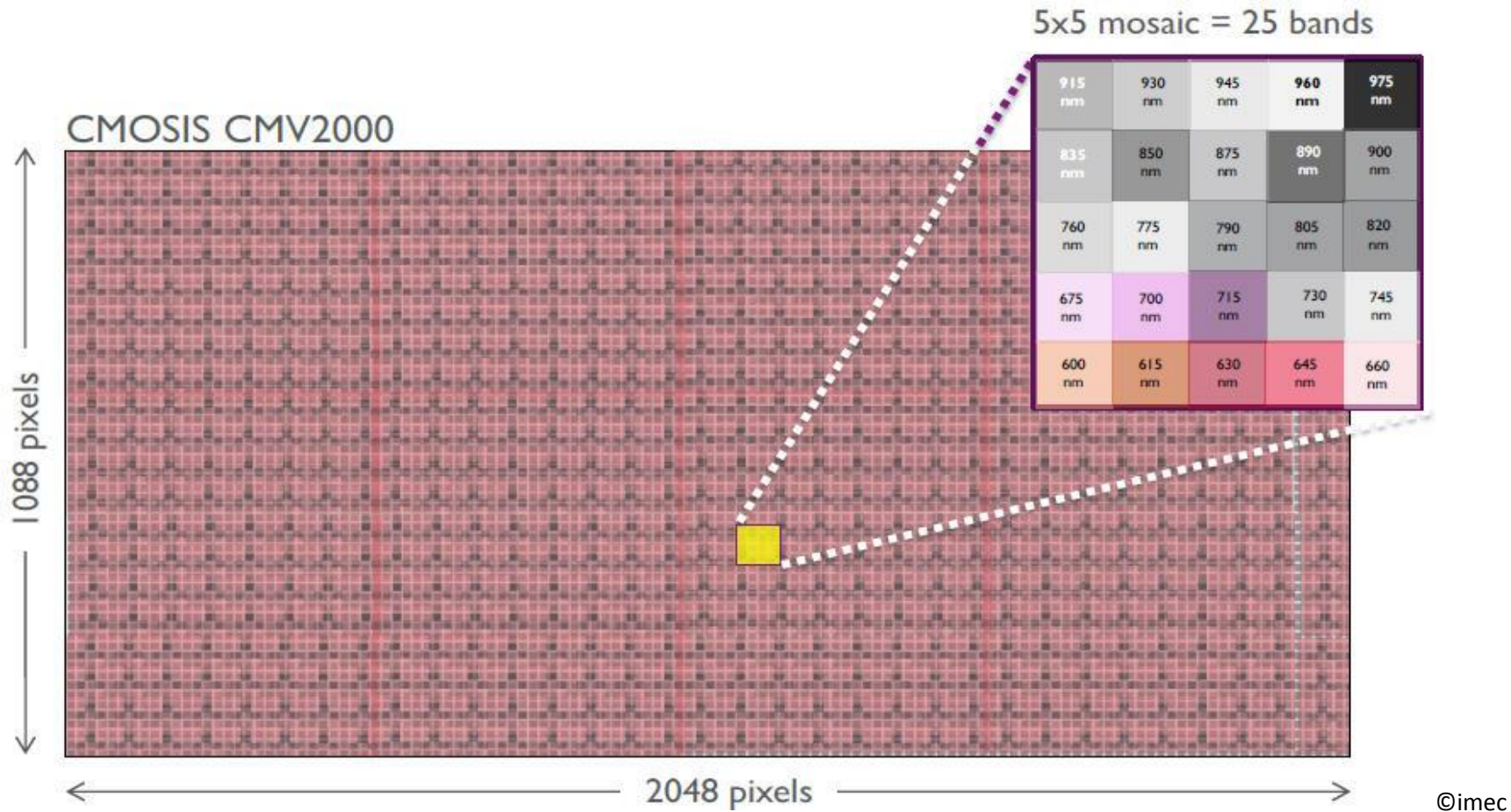
Key specification

Spectral resolution: 5x5 mosaic = 25 bands in 600-975nm
FWHM: ~ 16nm
Spatial resolution: from 409x217 (per band) ⮕ up to 2Mpx (per band) depending on demosaicing algorithm
Speed: up to 170 data-cubes / s (full sensor frame)