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

FWHM ~ 5-20nm
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)

⇒ All tunable: results in high speed, compact & cost-effective HSI solution!
DIFFERENT HSI CAPTURE APPROACHES

**Line-Scan design**

- 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!

**Snapshot design**

- 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 32 points each!
OUTDOOR DEMO OF IMEC SNAPSHOT HSI CAMERA

Solution equivalent to
256x256 = 65,000 ‘spectroscopes-on-chip’
scanning @ video-rate with 32 points
spectral point resolution each

DEMO video available on  http://vimeo.com/77218620
WHERE RELIES KEY SPECTRAL INFORMATION?

- **Color measurements**
  - 380-720nm

- **Fluorescence imaging peaks**
  - 450-720nm

- **Chlorophyll absorption / vegetation reflectance**
  - 510-970nm

- **Oxygenation in blood**
  - 500-900nm

- **Water absorption**
  - 970nm +1450nm +1850nm

- **Fluorescence imaging peaks**
  - 450-720nm

- **Skin tones / tissue chromophores**
  - 450-700nm

- **Hydrocarbon organic compounds**
  - (Ethanol, Benzene, Aromatics, ETBE, MTBE, Toluene...)
  - 750-950nm

- **Oxygenation in blood**
  - 500-900nm

- **CO2**
  - 2100nm +3500nm + 4800nm

- **Minerals mapping**
  - 2300nm -2400nm

- **CH4**
  - 2300nm +2400nm

- **PVC / plastic recycling**
  - 1700nm -1900nm

- **Minerals mapping**
  - 2300nm -2400nm

- **Skin tones / tissue chromophores**
  - 450-700nm
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

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)
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)
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)