


Thermal and Multispectral Imaging

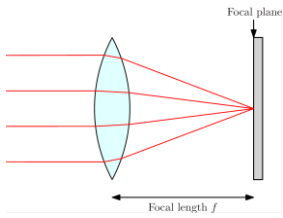
Lecture 3: Sensors and Cameras
Jörgen Ahlberg



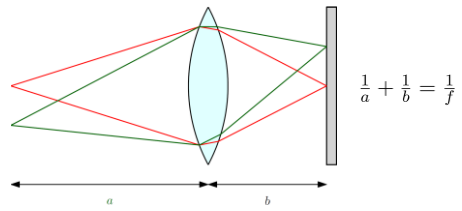
Optics



Lens, focal plane, focal length



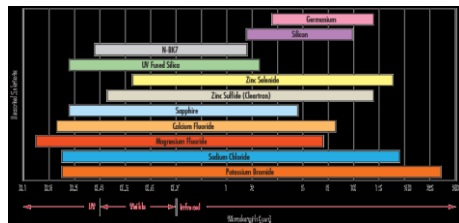
Lens, focal plane, focal length



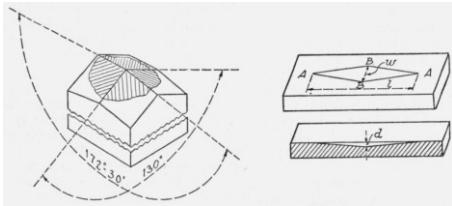
Lens materials

- Transmittance
- Durability
- Refractive index
- Dispersion
- Thermal sensitivity
- Cost
- Weight

Transmittance



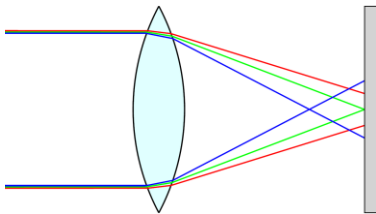
Durability: Knoop Hardness



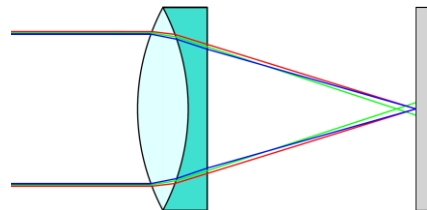
Refractive index

- High n_d -> Thin lens.
- VNIR: <2.
- TIR: 2-4.

Dispersion -> chromatic aberrations



Achromatic duplet

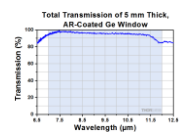
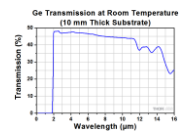


Thermal sensitivity

- Expansion
- Transmittance

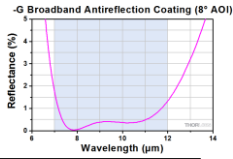
Lens materials: Germanium

- Good for MWIR and LWIR (with AR coating)
- Durable (KH 780)
- High refractive index (4.0)
- Transmittance drops with temperature!



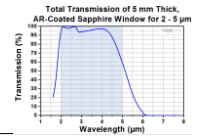
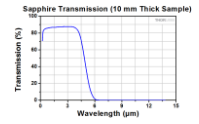
Lens materials: Zinc Selenide

- Transmits even better than Germanium!
- KH 120 ☺
- Toxic



Lens materials: Sapphire

- Durable (KH 2200).
- Good transmittance in VIS-MWIR.

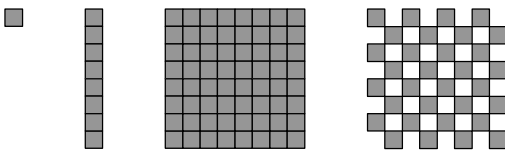


Sensors

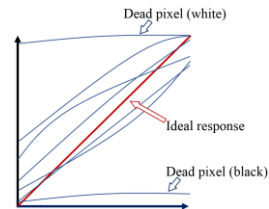
Sensor materials

Sensor type / material	Used for
Cooled	
Mercury cadmium telluride	MCT SWIR – LWIR
Indium antimonide	InSb NIR – LWIR
Strained Layer Superlattice	SLS MWIR, LWIR
Un-cooled	
Charged-coupled device	CCD VNIR
Active-pixel sensor	APS / CMOS VNIR
Indium gallium arsenide	InGaAs NIR, SWIR
Microbolometer	LWIR

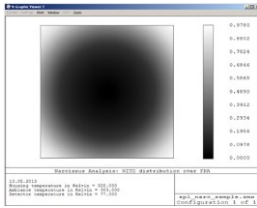
Image sensor – focal plane array (FPA)



Calibration and NUC

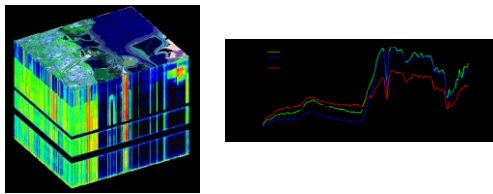


Narcissus



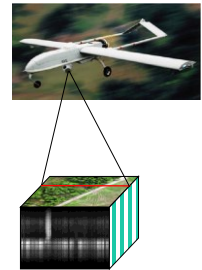
Multi/hyperspectral cameras

The data cube



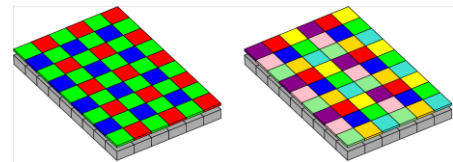
Acquiring the data cube

- Push-broom
- Wisk-broom
- Staring
- Scanning

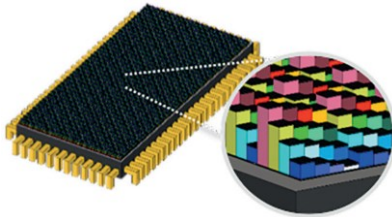


Multispectral cameras

Filter mosaics



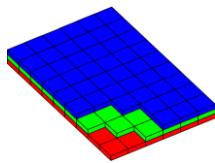
16-band sensor from IMEC



Filter wheels



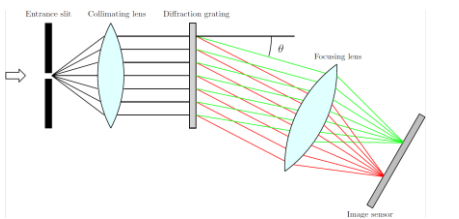
Multi-layer sensors



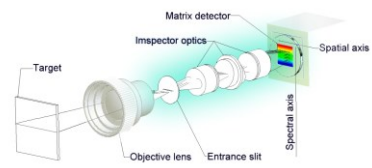
Hyperspectral cameras



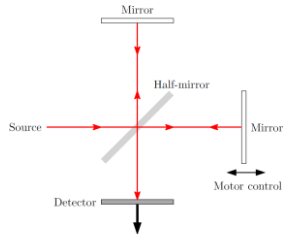
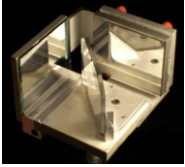
Diffraction grating



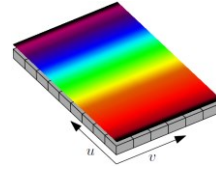
Specim



Interferometer



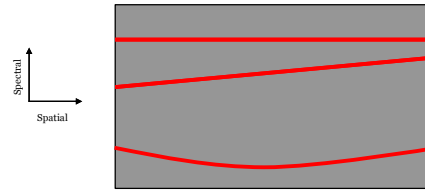
Linear variable optical band-pass filter



Limitations



Misalignment & smile



Misalignment & keystone

