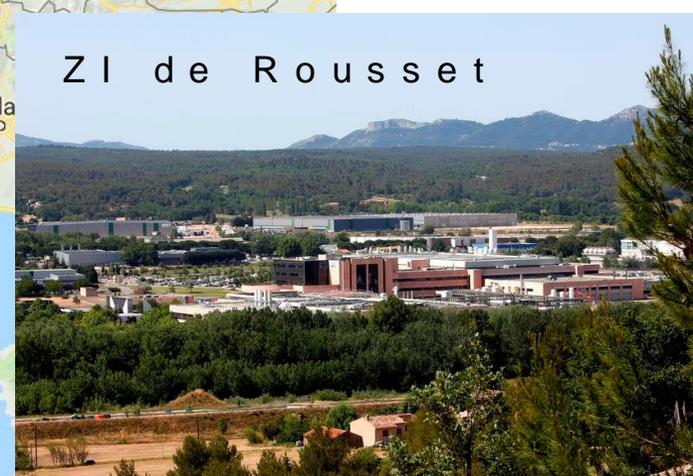
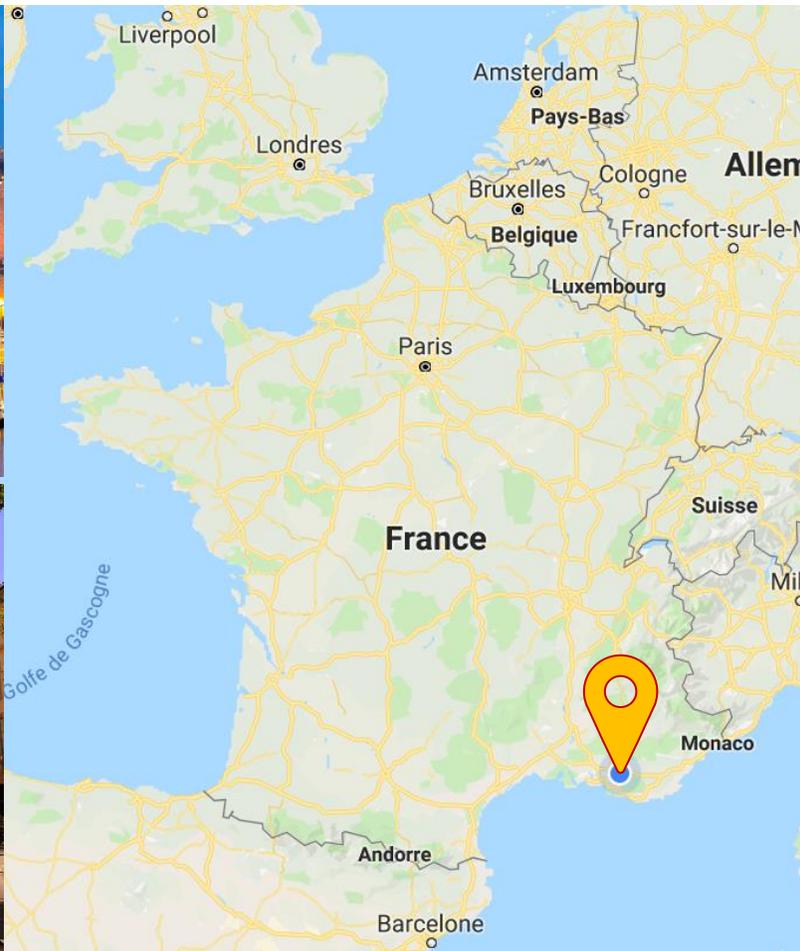
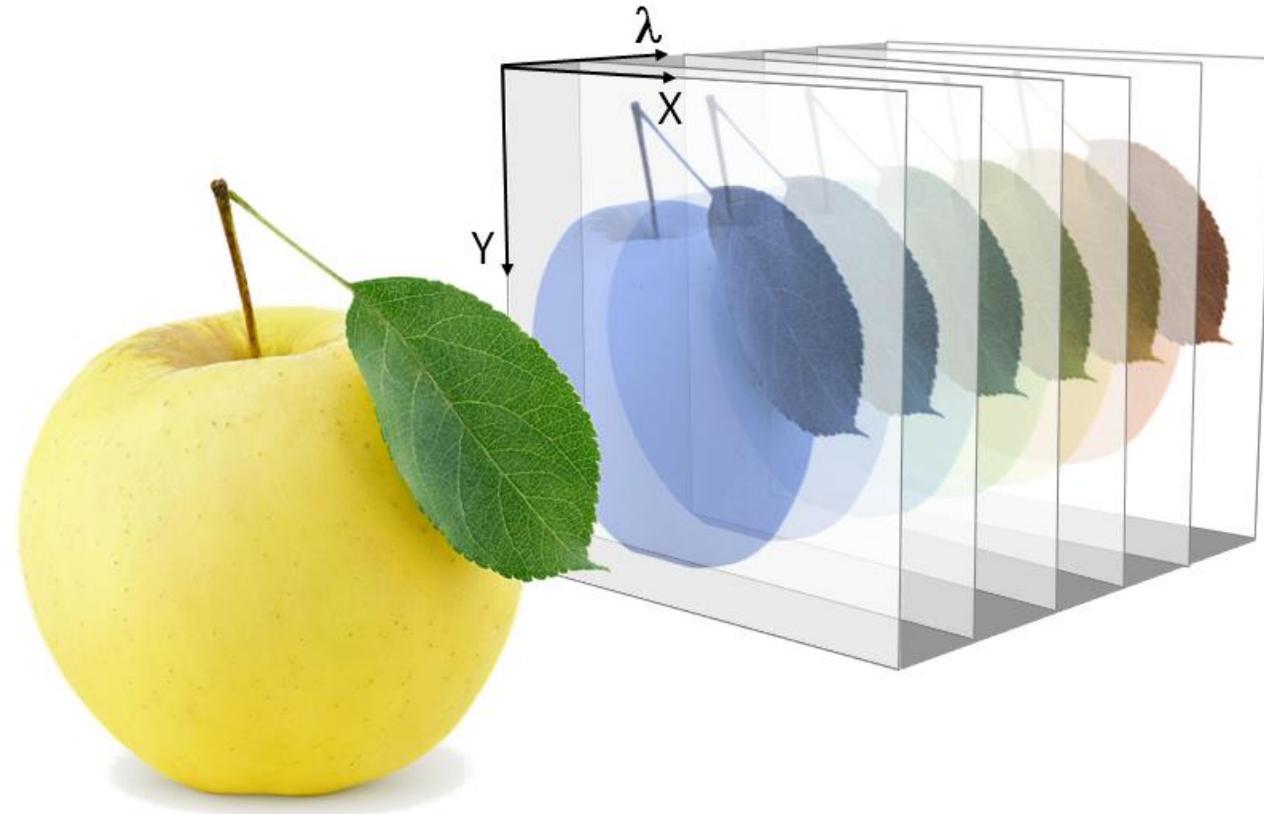


COLOR SHADES®: a versatile Snapshot Multispectral Imaging Technology for a wide range of applications

Thierry BERTHOU
SILIOS Technologies

Delft, the Netherlands
21 June 2023

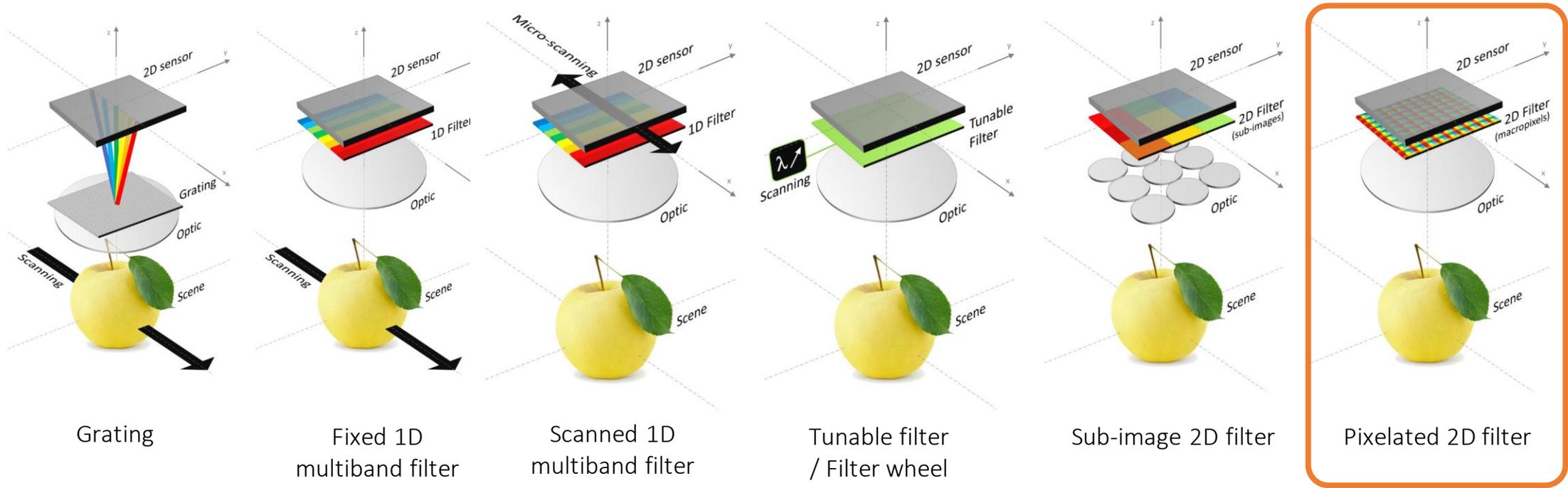




The hypercube includes N sub-images of the scene each at a different wavelength.

Sequential

Synchronous

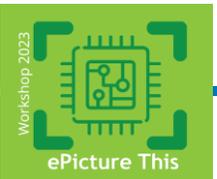


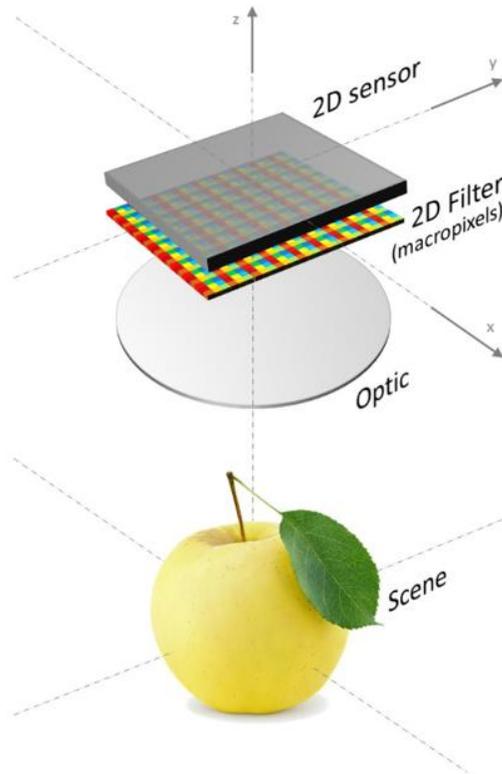
COLOR SHADES® Technology

SILIOS

Push broom

Snapshot



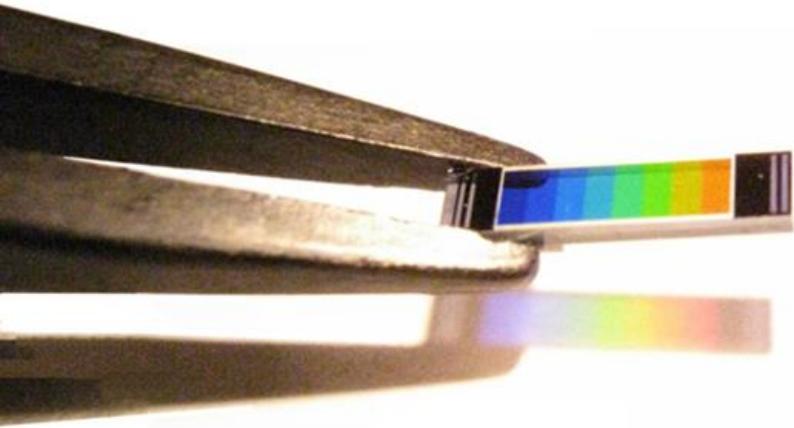


- ✓ Synchronous (all the spatial/spectral information captured in a single picture).
- ✓ Small Footprint (same footprint than the corresponding standard imager).
- ✓ Same field of view for all the sub-spectral bands.
- ✓ Light hypercube (compared to hyperspectral systems).
- ✓ Easy to use (like a standard camera)
- ✓ Low cost (even for low volume)

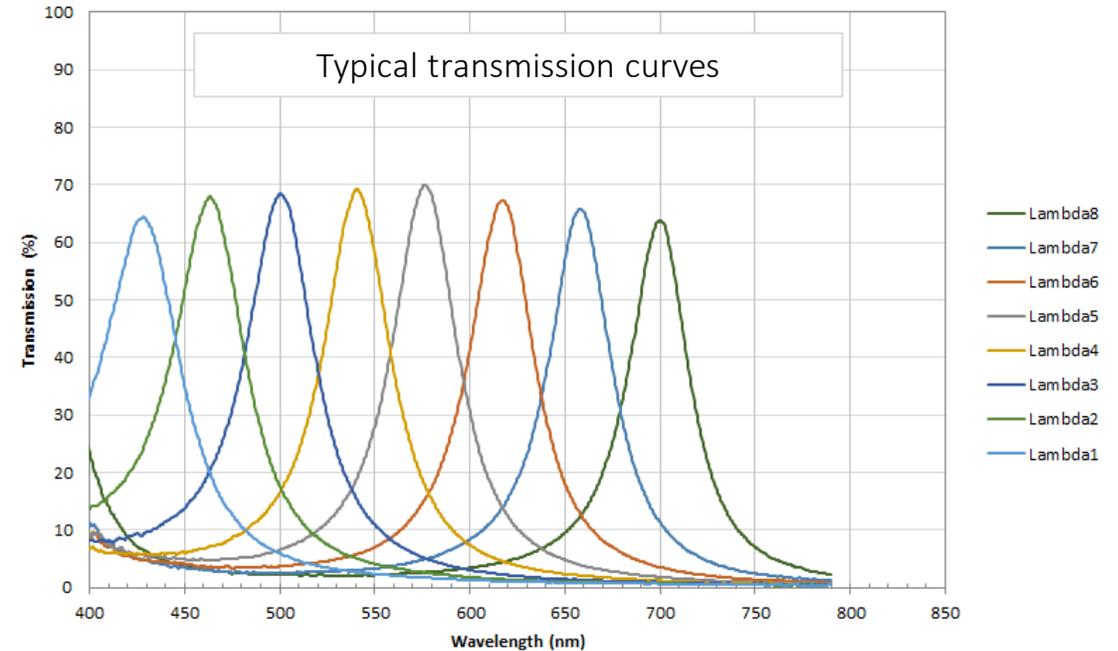
The COLOR SHADES® Technology : Principle

Typical specifications in VIS/NIR :

Tmax : 40% to 70%
FWHM : 15nm to 60nm (Avg 40nm) (VIS/NIR)
Max Spectral Range : 300nm (VIS/NIR) / 500nm for TOUCAN

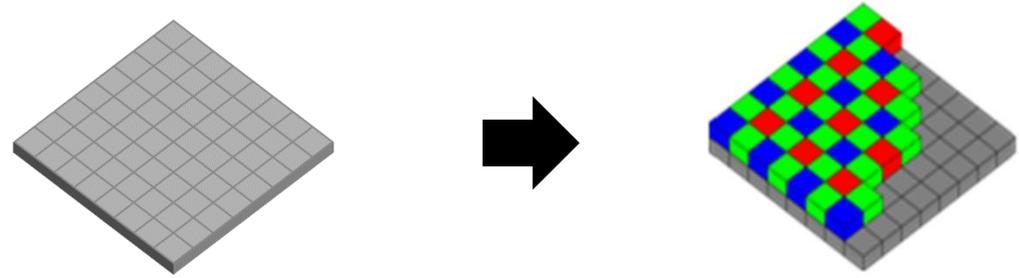


The *COLOR SHADES*® filters show low resonance level (low Q factor).



- ✓ **Low sensitivity to the incident angle.**
Only slight spectral band changes up to 15°. The filters can be used with optical apertures up to F/2.
- ✓ **High sensitivity.**
Due to a high integrated transmission.

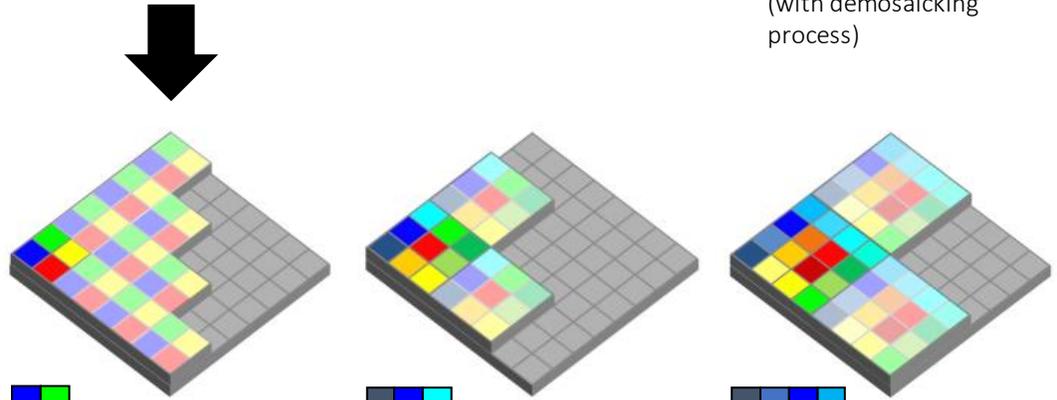
The COLOR SHADES® Technology : Principle



Standard Monochrome Sensor
Resolution : $N \times M$

Standard Color sensor
Resolution : $N \times M$
(with demosaïcking process)

Standard Color Imaging (RGB).



4 interleaved images
Resolution : $N/2 \times M/2$

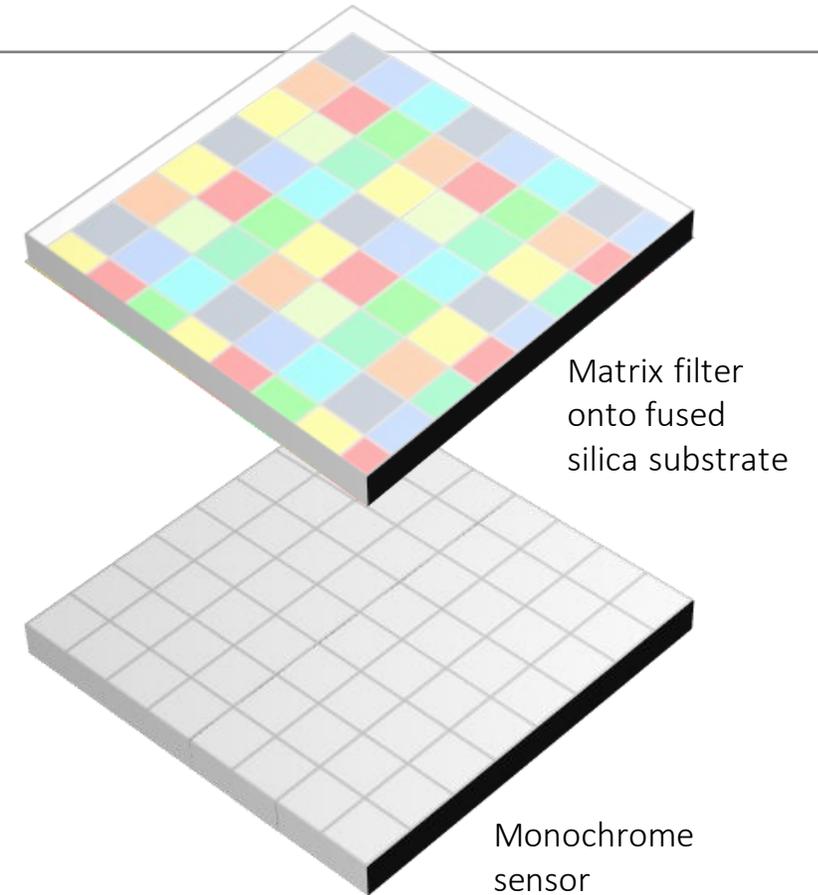
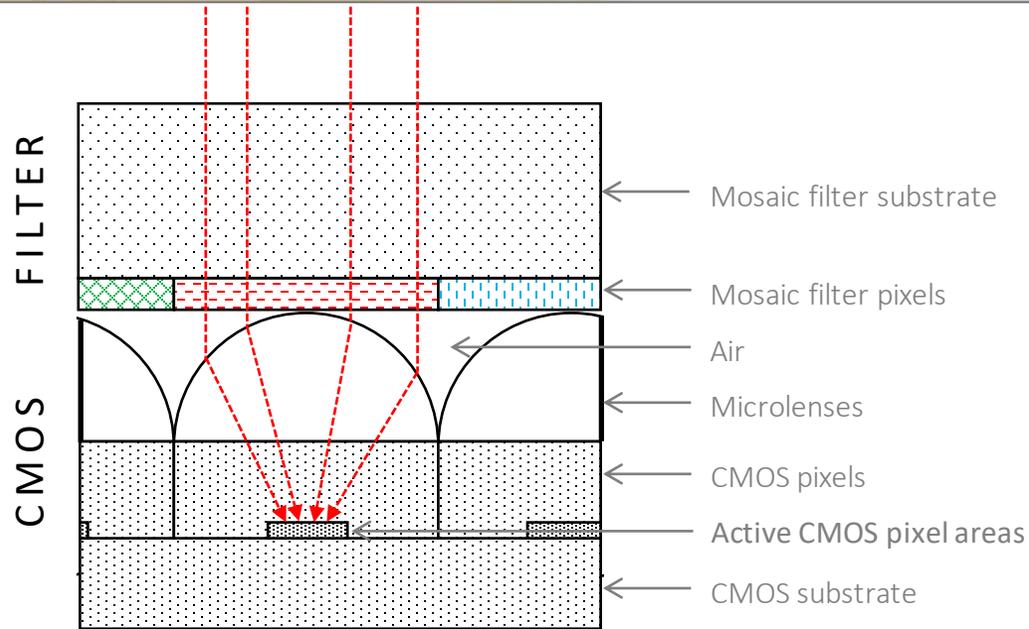
9 interleaved images
Resolution : $N/3 \times M/3$

16 interleaved images
Resolution : $N/4 \times M/4$

SILIOS Multispectral Imaging.
(filtering at the pixel scale)

Set of 4, 9 or 16 spectral sub-images.

The COLOR SHADES® Technology : Principle

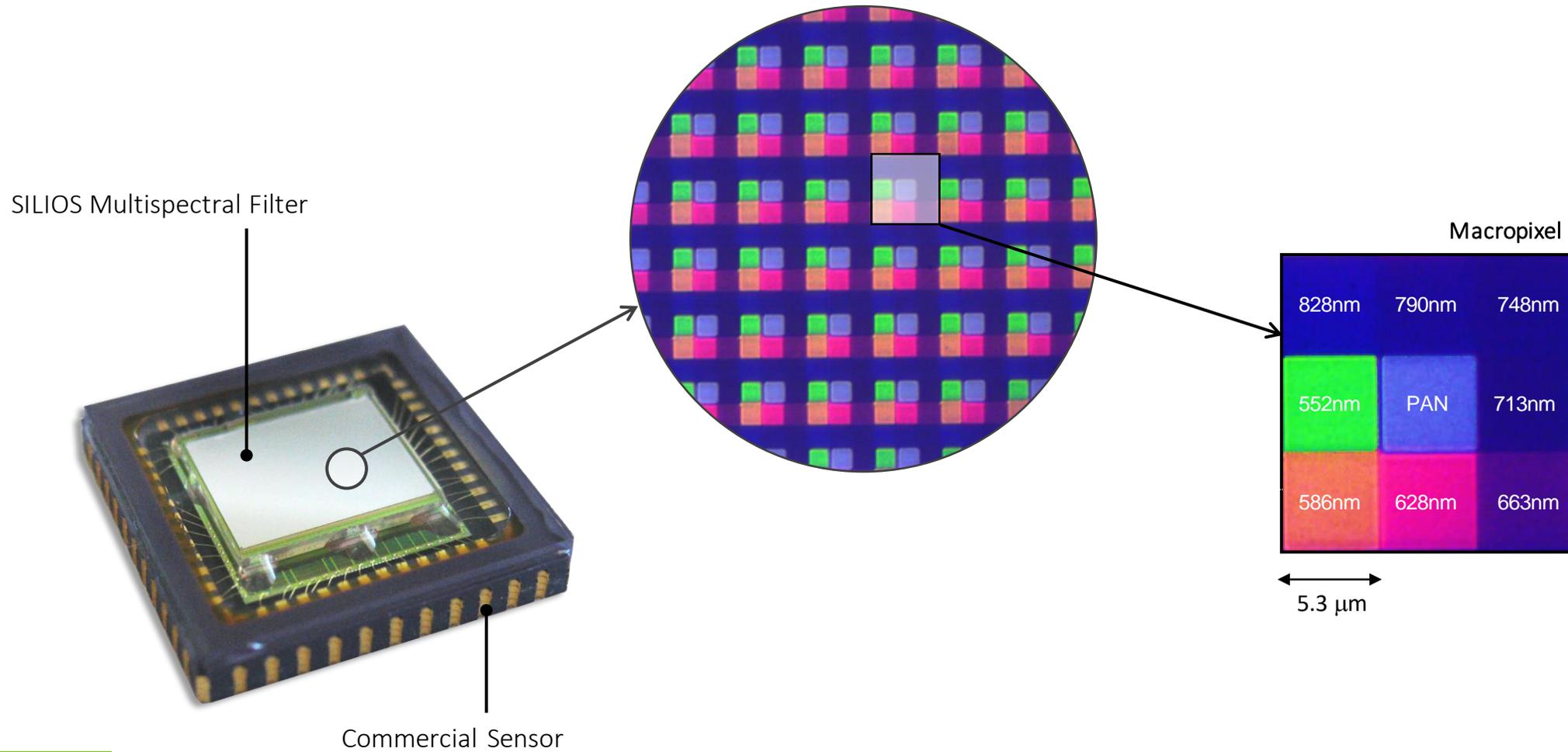


The pixelated multispectral filter is aligned onto the imaging array and assembled.

Advantages compared to the Monolithic approach:

- ✓ Applicable to (almost) all commercial imagers (CMOS, InGaAs).
- ✓ The multispectral filter is placed above the microlenses, thus avoiding strong incidences of light rays.
- ✓ The microlenses can be kept (hence a gain of +50% on the collection of photons).
- ✓ Scalable technology in terms of production volume (low volumes to medium volumes).

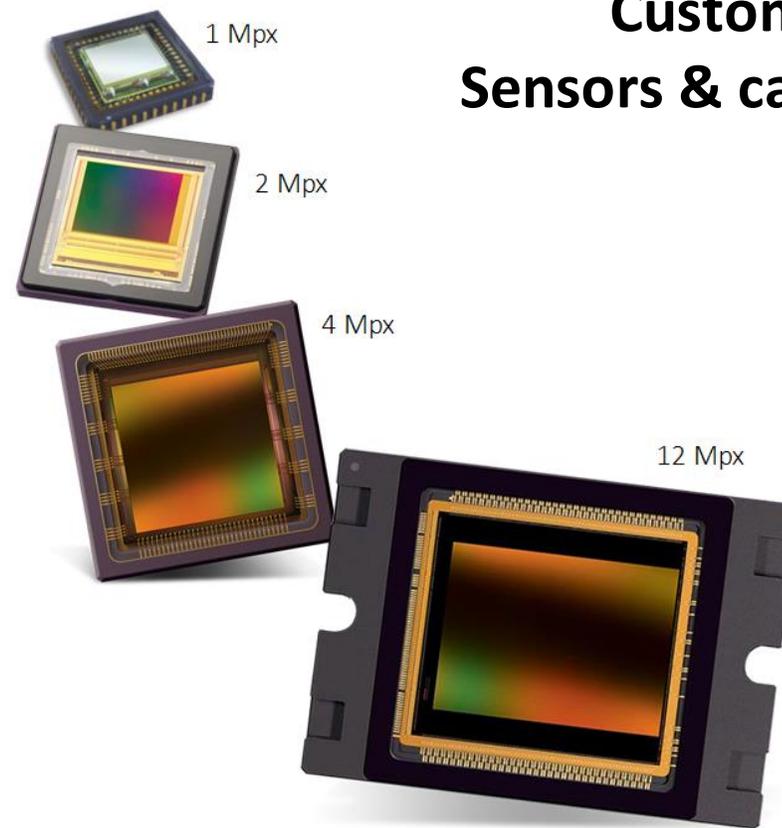
The COLOR SHADES[®] Technology : Principle



Off-the-Shelf Sensors & cameras



Custom Sensors & cameras

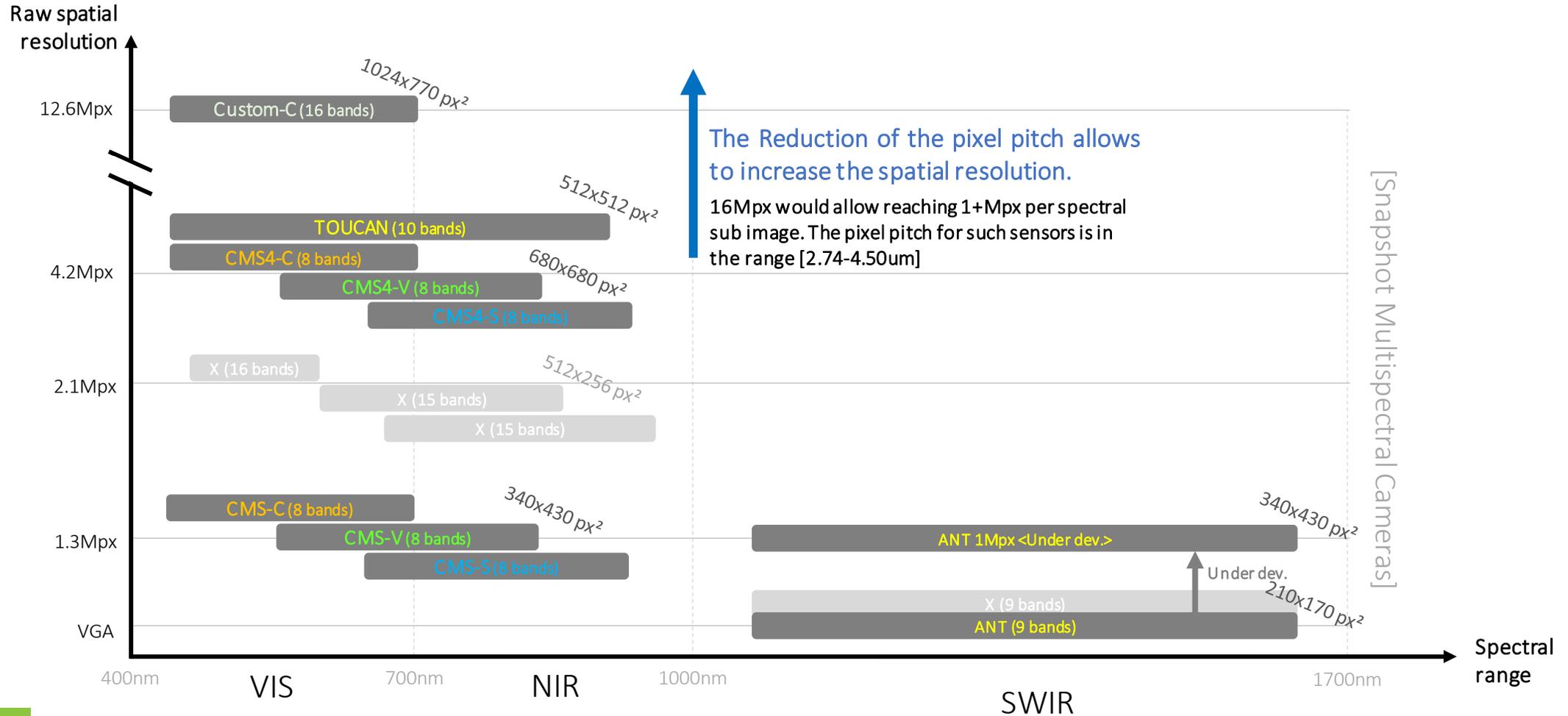


Main advantage :
HIGH FLEXIBILITY to address a segmented Hyper/multispectral imaging market.

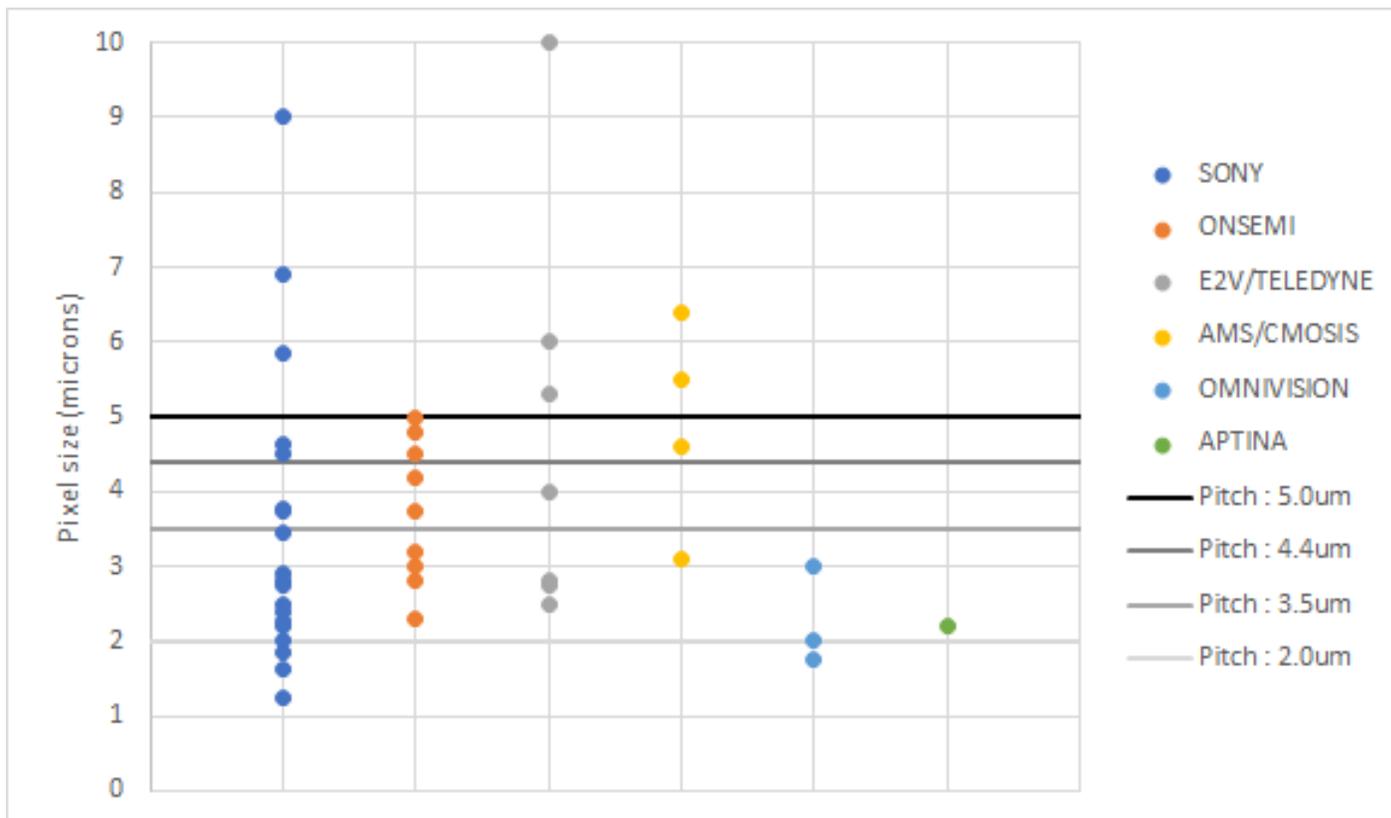
DEV1 : pixel size reduction

Improvement of the spatial resolution

Improvement of the spatial resolution



Improvement of the spatial resolution



Data extracted from the FLIR « Sensor Periodic Table 2022 »

Improvement of the spatial resolution

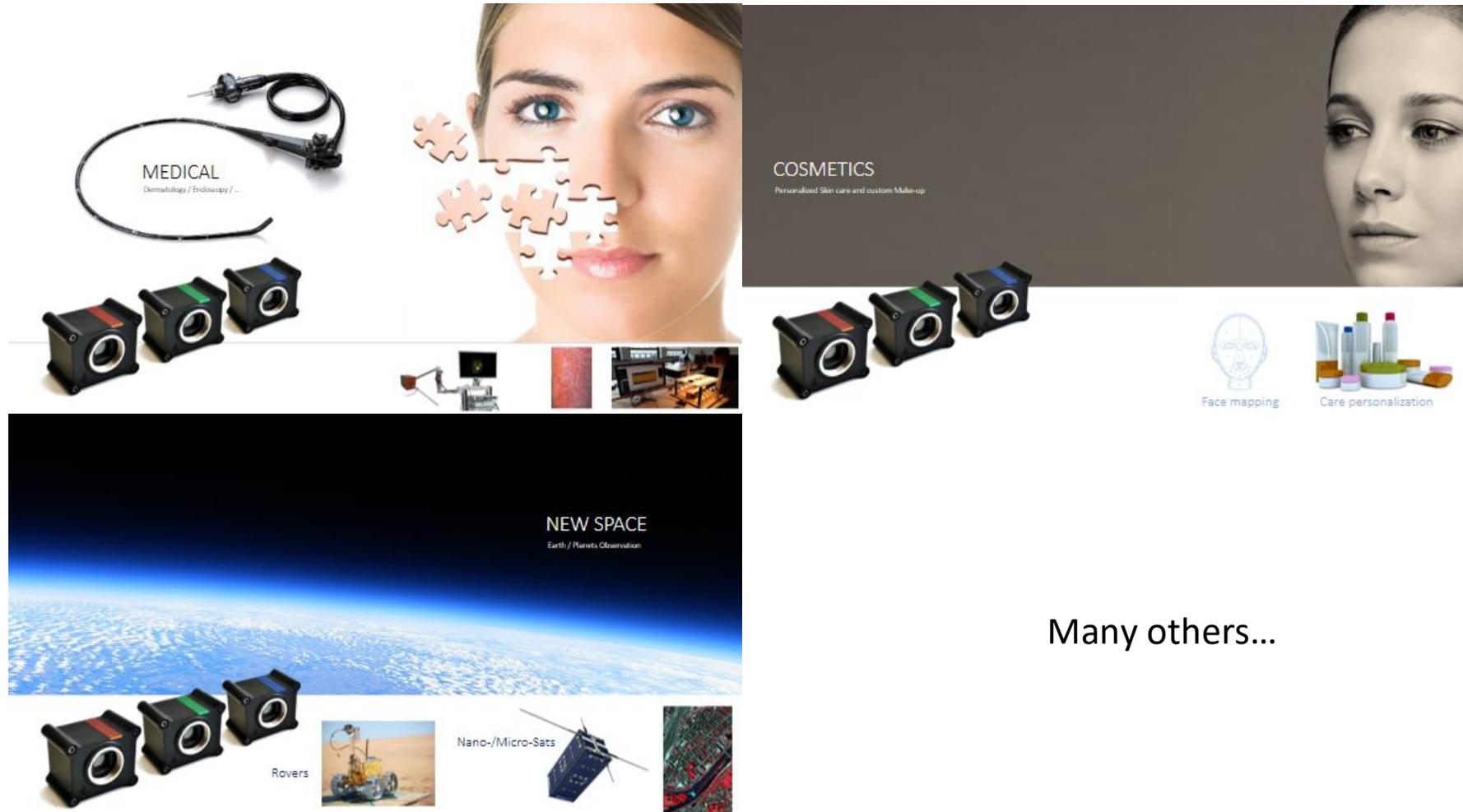
Pixel pitch	Manufacturing Steps		
	R&D filter	R&D Assembly	Production
>100um	✓	✓	✓
15um	✓	✓	✓
5um	✓	✓	✓
4.4um	Under dev.	Under dev.	✗
3.5um	Preliminary test	To be dev.	✗
2.0um	To be dev.	To be dev.	✗

DEV2 : use-case developments

The COLOR SHADES® Technology : applications



The COLOR SHADES® Technology : applications



MEDICAL
Dermatology / Endoscopy / ...

COSMETICS
Personalized Skin care and custom Make-up

NEW SPACE
Earth / Planets Observation

Face mapping

Care personalization

Rovers

Nano-/Micro-Sats

Many others...

Over the 12 past years, SILIOS mainly focused on the hardware development of its Snapshot Multispectral Cameras (filter manufacturing, filter assembly,...).

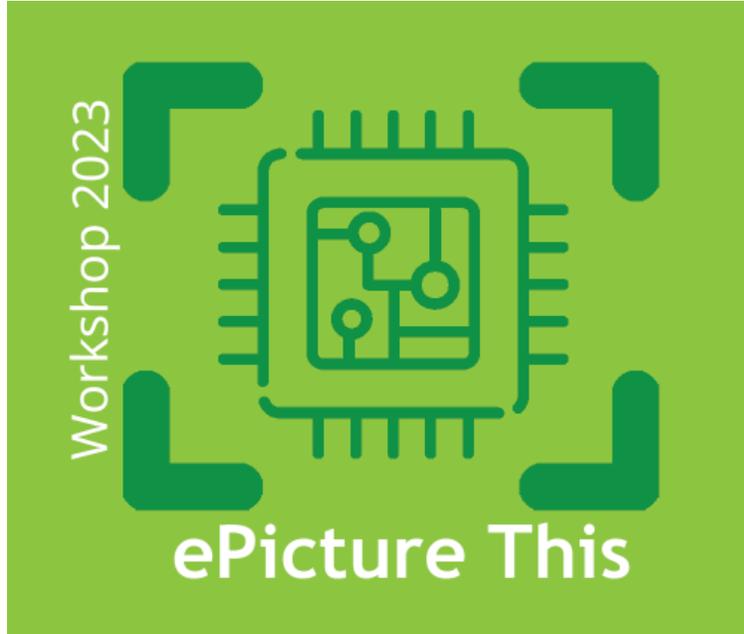
The hardware development will remain one of the main concerns in the future, but SILIOS would like to develop capabilities in the field of the hypercube data treatment (software treatment).

These software capabilities will be internally developed (for data correction mainly) and externally developed by mean of partnerships in the field of data treatment for specific applications and use-cases.

➔ SILIOS aims to develop new skills with partners for the use of the Snapshot Multispectral Cameras in different domains and for different use-cases.

Today SILIOS is looking for partners and projects to address :

1. The development of the pixel size reduction.
2. The development of new applications.



an initiative by PENTA label projects
MANTIS and IMAGINATION with AENEAS support

THANK YOU

