



MICRO-OPTICS for SPACE INDUSTRY

Earth Monitoring, Moon and Space exploration

Thierry BERTHOU

EPIC Meeting on Photonics for Space
September 21-23 2023

About us



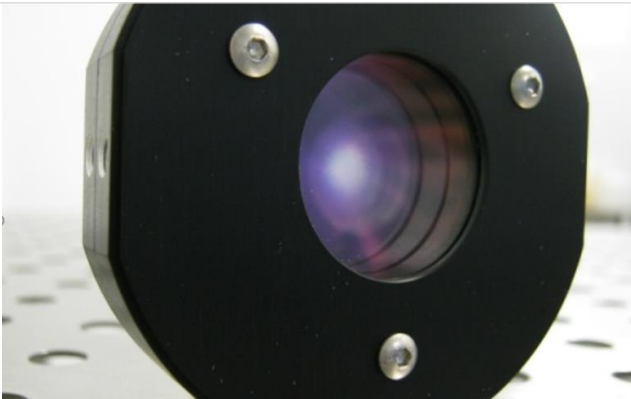
SILIOS TECHNOLOGIES

Funded in 2001

Located In Provence close to Aix-en-Provence

WE ARE EXPERTS IN *MICRO-OPTICS*





DIFFRACTIVE OPTICAL COMPONENTS (2001)
SCIENTIFIC & INDUSTRIAL LASERS, ASTRONOMY & SPACE



MULTISPECTRAL CAMERAS & SENSORS (2009)
MULTISPECTRAL IMAGING

COLOR SHADES® MULTISPECTRAL TECHNOLOGY



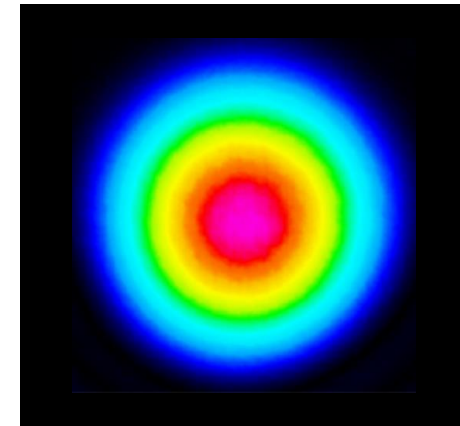
PHASE PLATES / DIFFRACTIVE OPTICS FOR SPACE INDUSTRY

Diffractive Optics: Beam Shapers



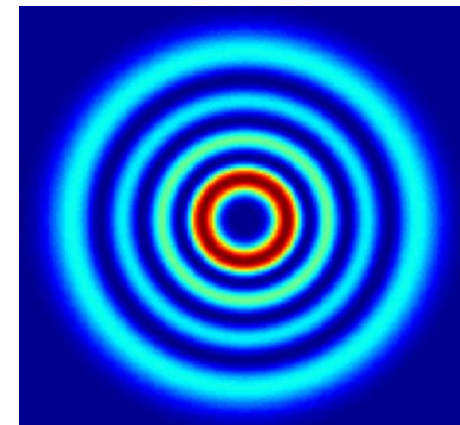
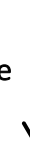
VIRGO (European LIGO)

TEM00 beam conversion into a Laguerre-Gauss LG33 propagation mode.



TEM00

Mise en forme



LG33

Static Aberrations Generator

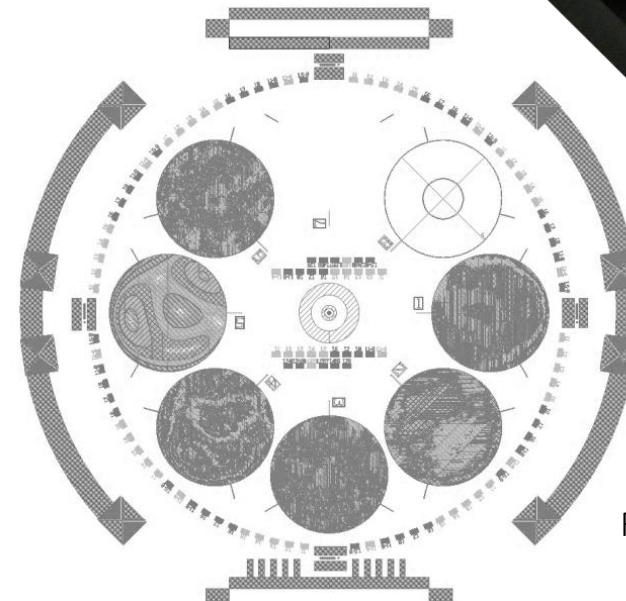
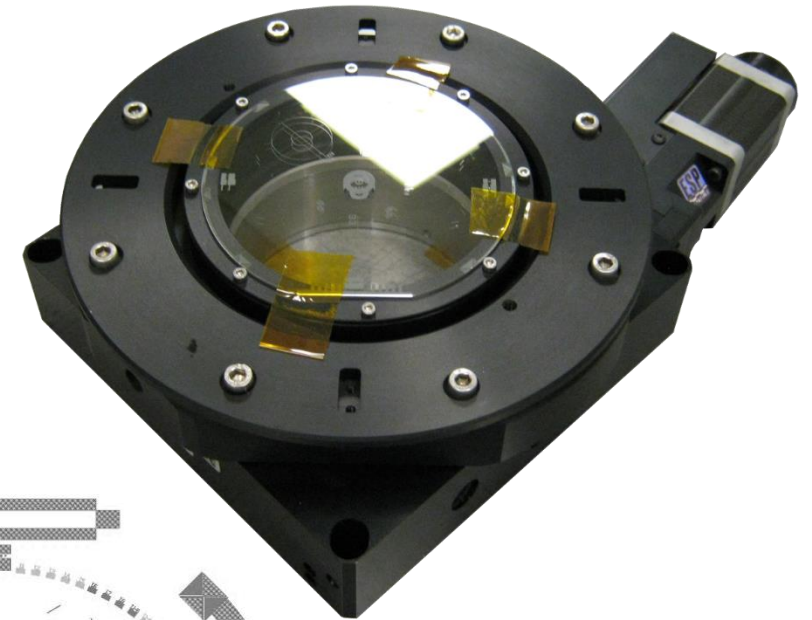
RASCASSE project : SILIOS manufactured a wheel of static phase plates and integrated the wheel onto a rotating mechanics for a positioning of the phase maps into the beam at a micron-scale.

Phase Screen

- Pixel size: 39.2 x 39.2 micron²
- Op. wavelength: 750 nm
- PTV OPD: 1 000 nm (etch depth: 2 202 nm)
- Number of phase levels: 256
- Smallest OPD step: 3.9 nm (etch depth: 8.6 nm)

Rotative Mechanics

- Angular absolute accuracy: 0.030° ou +/-0.015°
- Unidirectional reproducibility: 0.01°
- Smallest Increment: 0.0002°
- Phase maps positioning: better than 5 microns

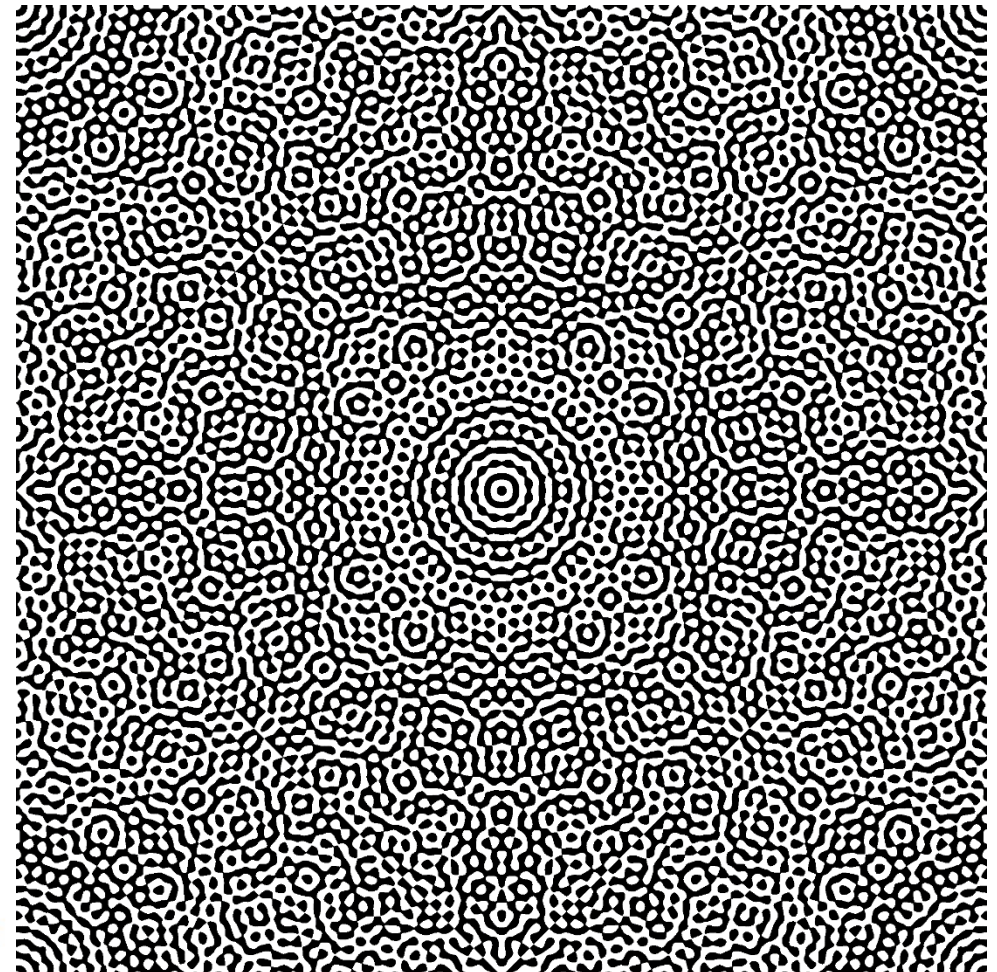
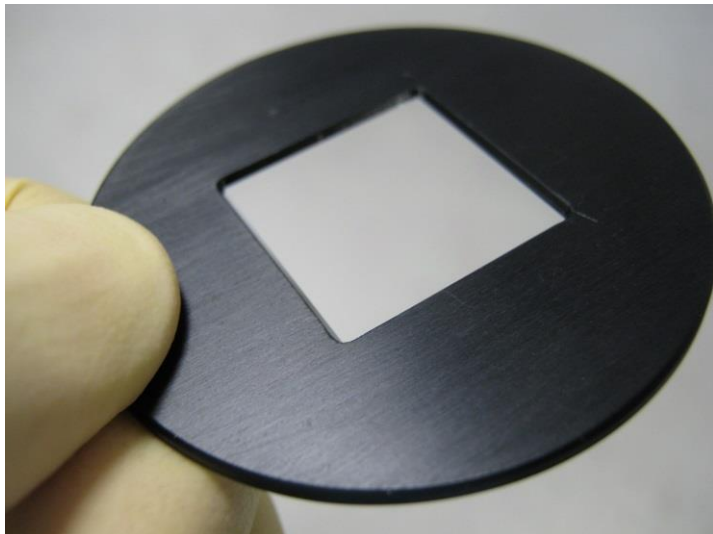


RASCASSE Phase screen

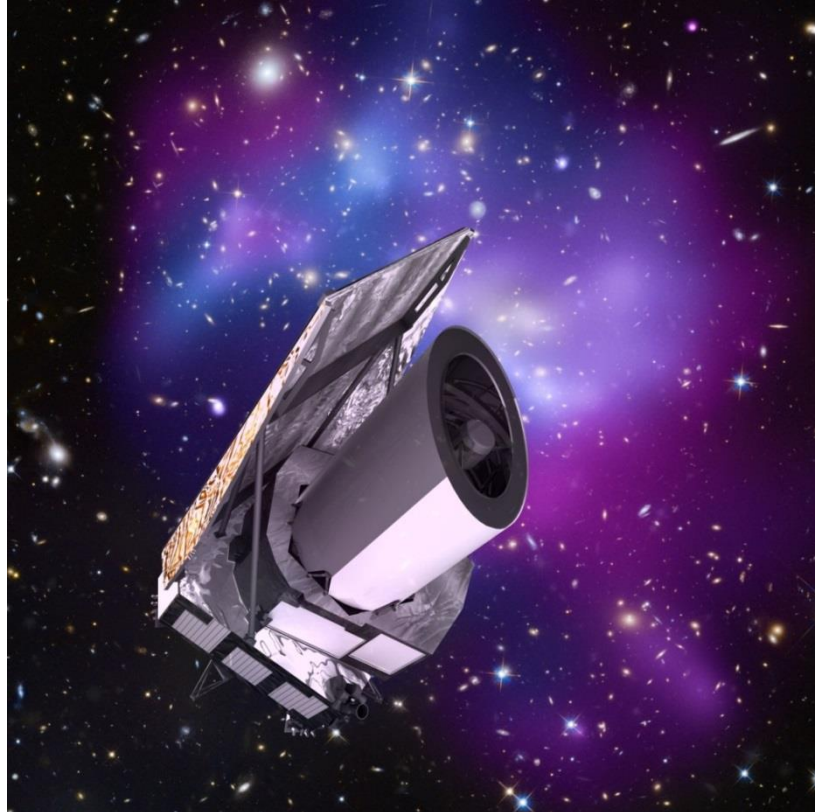
CSIG

CSIG Targets (Continuously-Self Imaging Grating) for characterisation of space imager.

(ex : test of EUCLID imagers at CEA IRFU)



Mire CSIG – ONERA – N.Guerineau



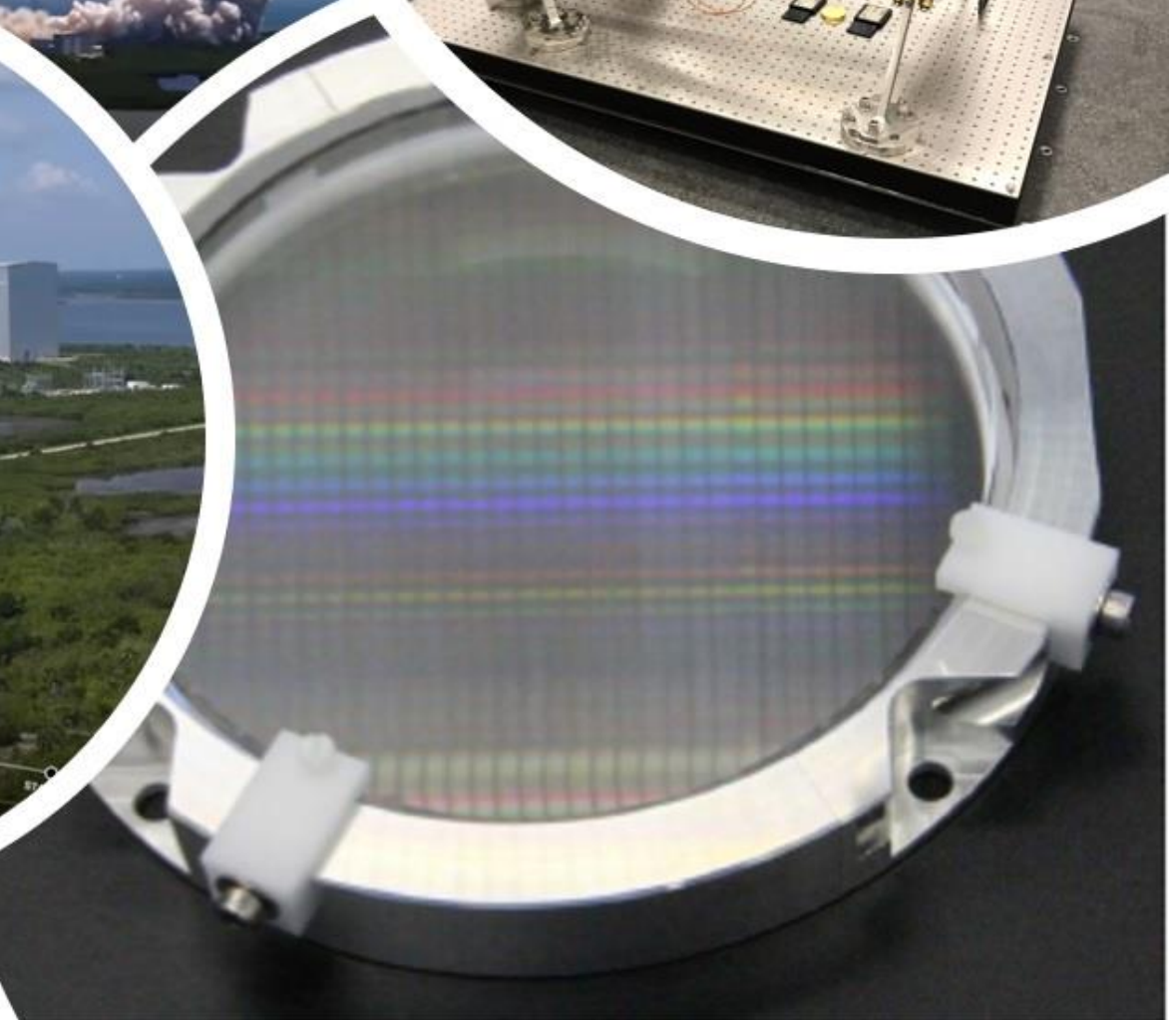
EUCLID

an ESA astrophysics space mission.

The Euclid mission aims at understanding **why the expansion of the Universe is accelerating** and what is the nature of the source responsible for this acceleration which physicists refer to as dark energy.

Launched July 1st, 2023 for a 6 years mission.

EUCLID's Launch
July 1st, 2023

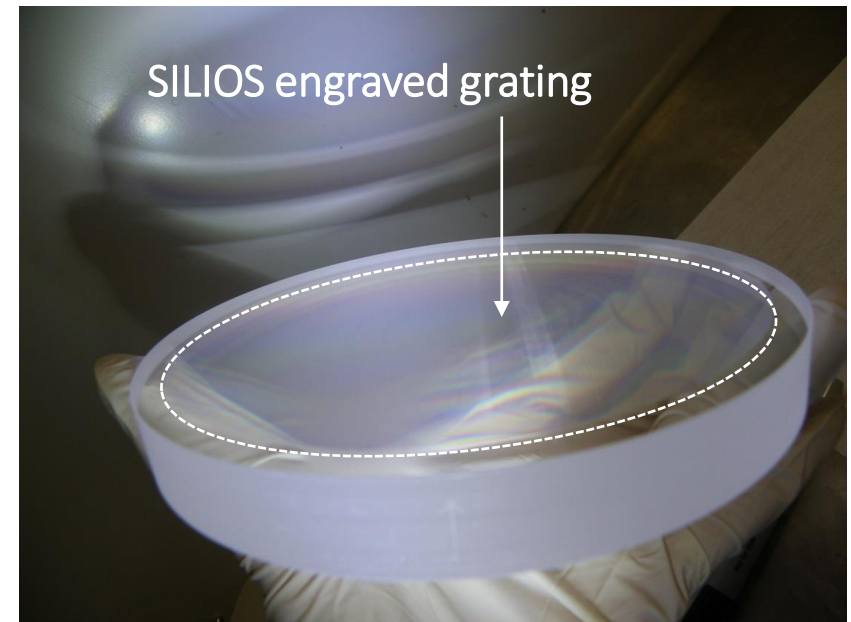
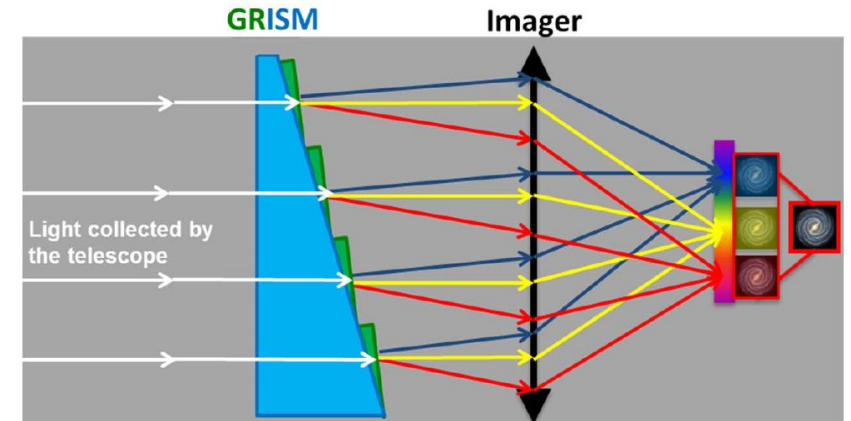
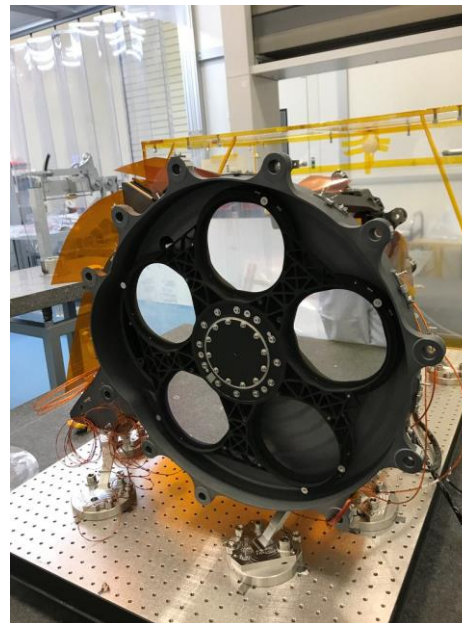
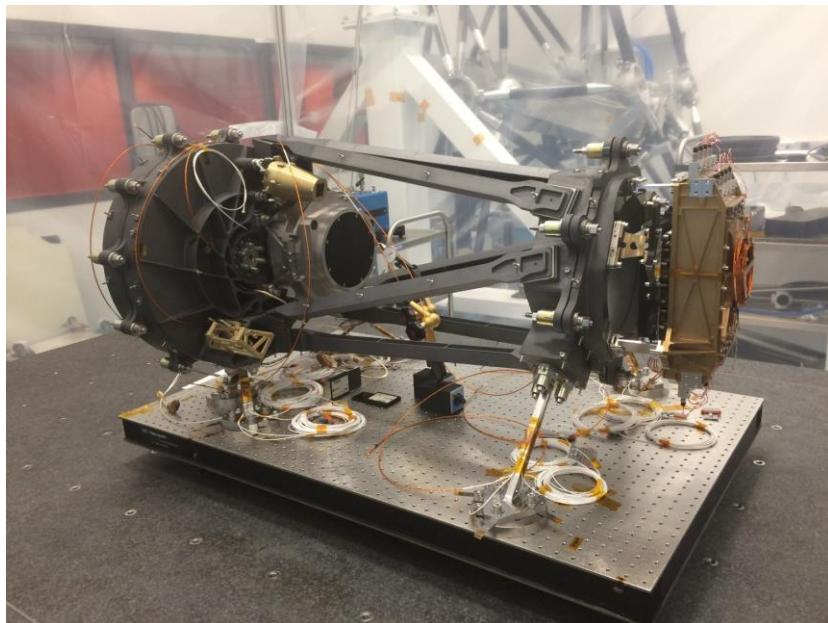


Gratings on Prism : GRISM

SILIOS manufactured the gratings of the GRISMs for LAM to be integrated in the GRIMs' wheel of the NISP instrument of ESA's EUCLID Telescope.



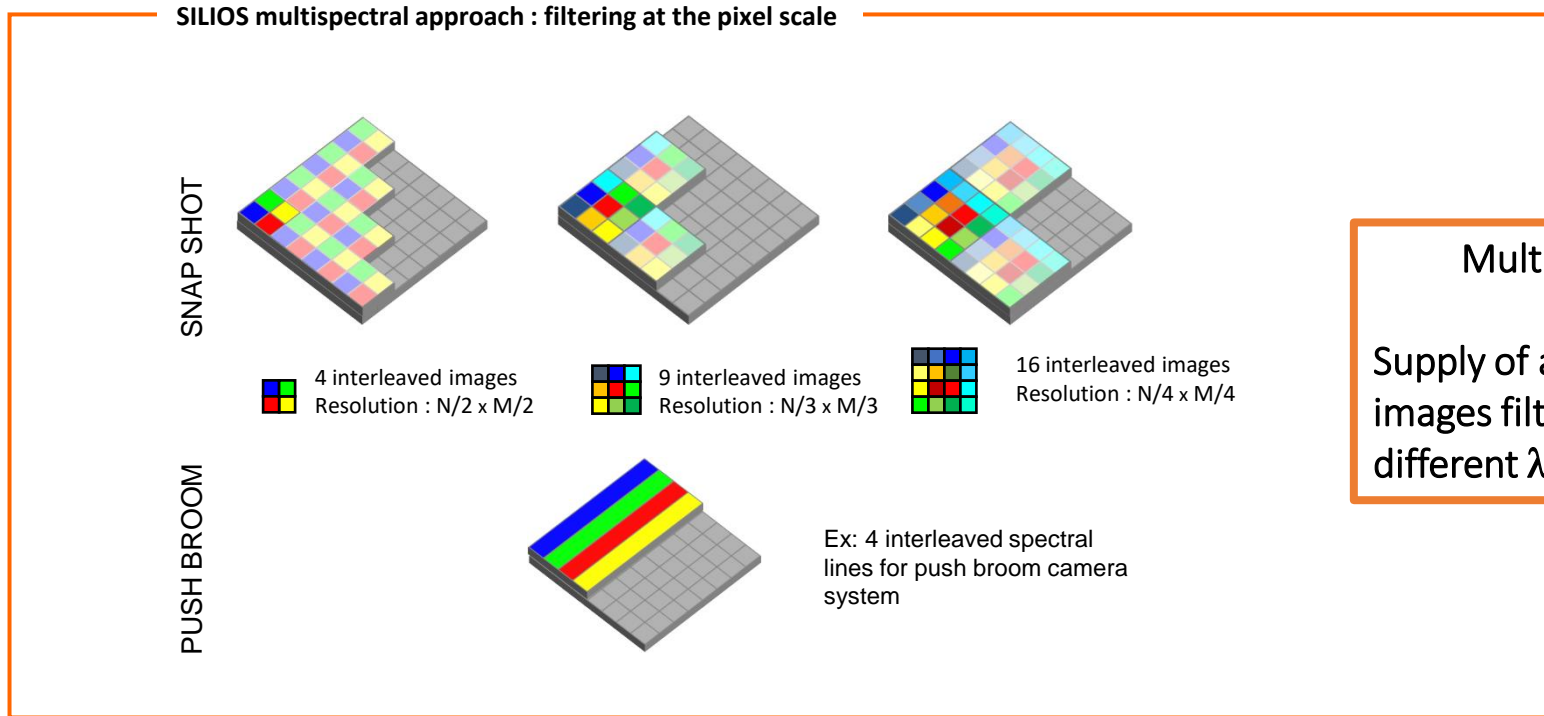
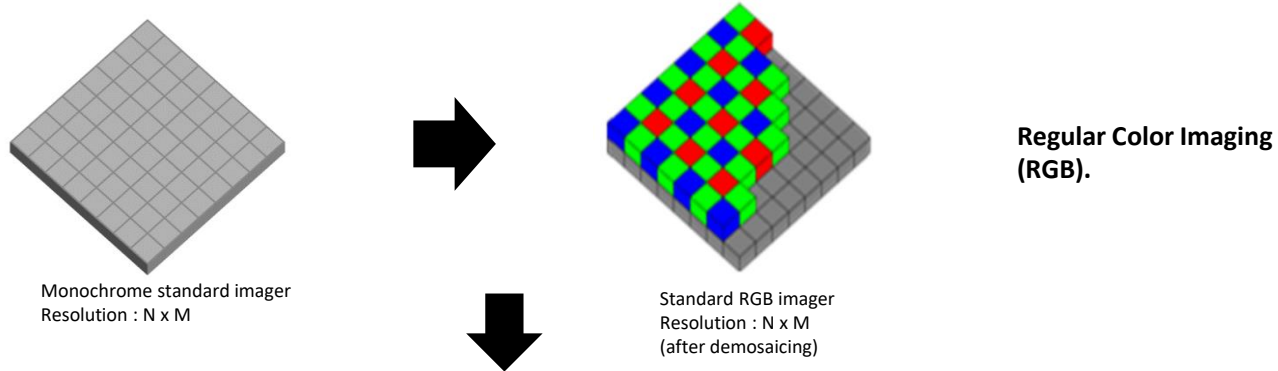
NISP : Near Infrared Spectro-Photometer





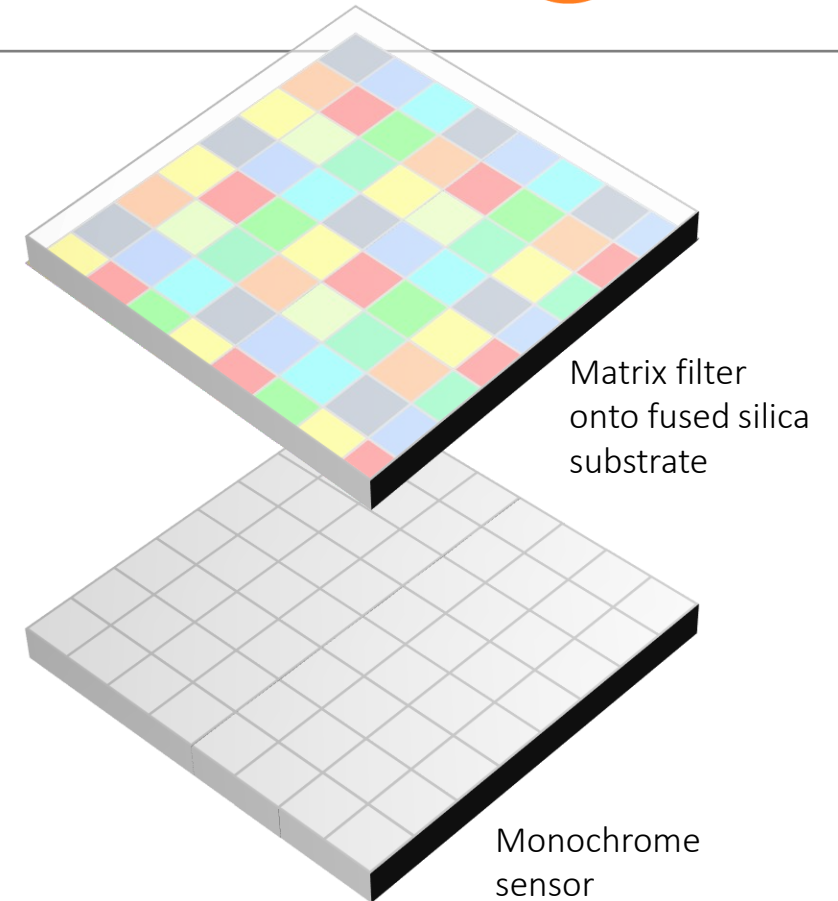
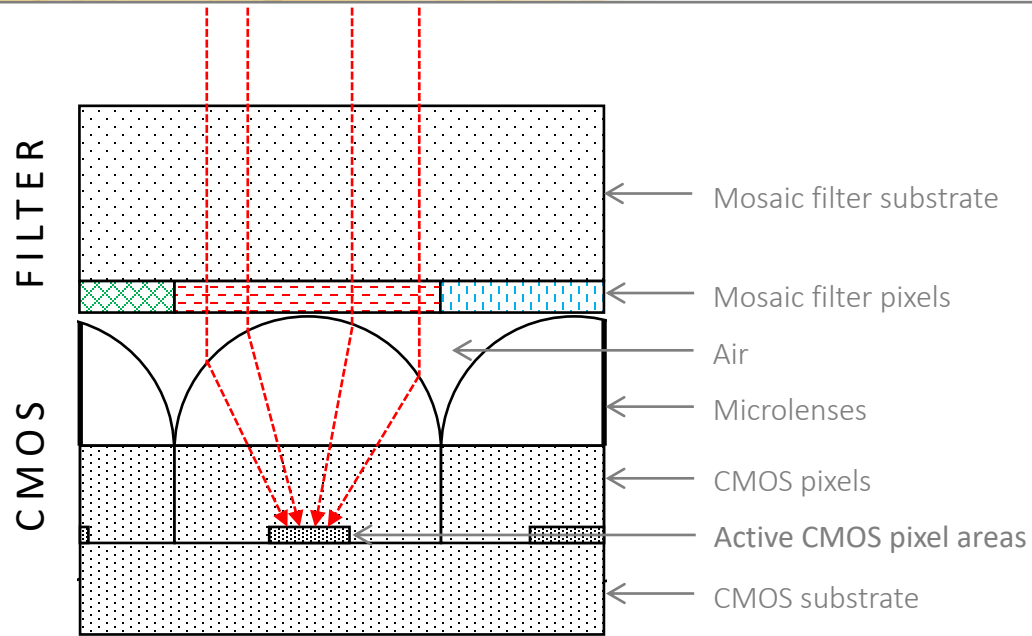
COLOR SHADES[®]
MULTISPECTRAL TECHNOLOGY
FOR SPACE INDUSTRY

MULTISPECTRAL IMAGING (Custom Bayer Matrix)



Multispectral Imaging.
Supply of a set of 4, 9 or 16 sub-images filtered or lines @ different λ

The COLOR SHADES® Technology : Principle

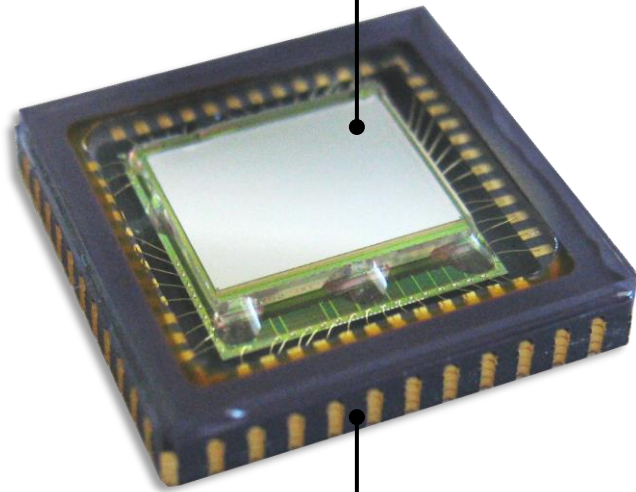


The pixelated multispectral filter is aligned onto the imaging array and assembled.

Advantages compared to the Monolithic approach:

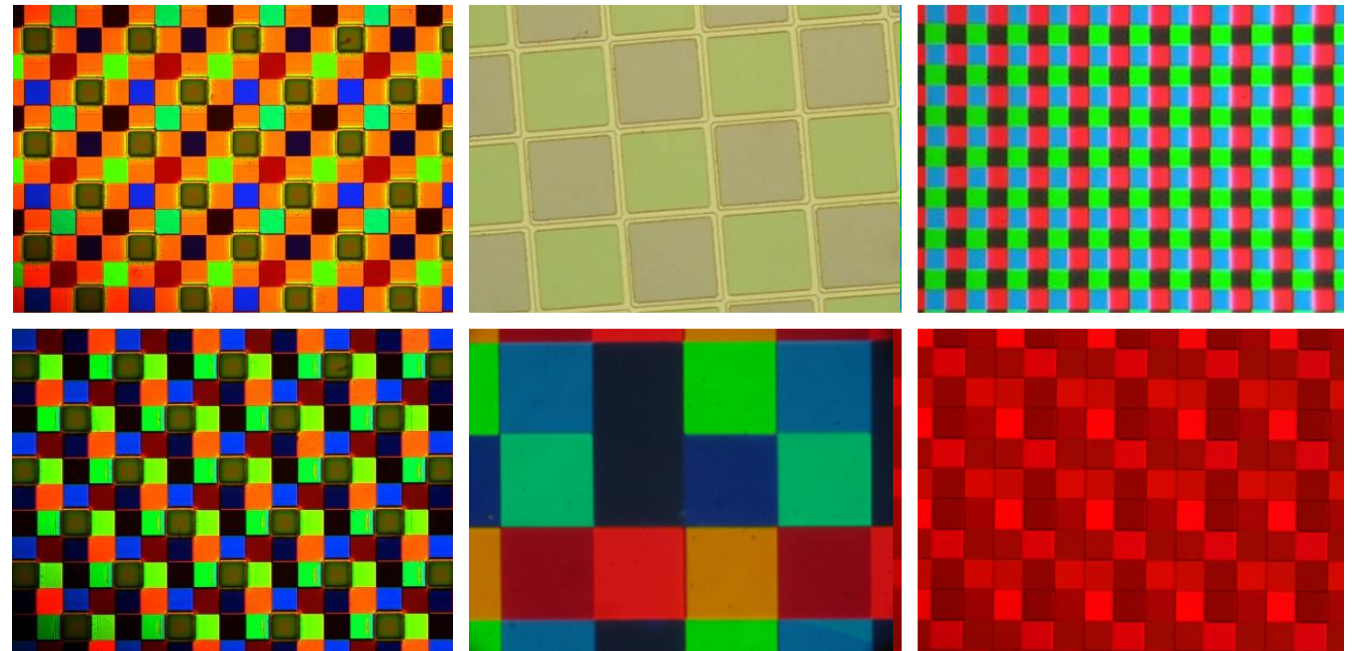
- ✓ Applicable to (almost) all commercial imagers (CMOS, InGaAs).
- ✓ The multispectral filter is placed above the microlenses, thus avoiding strong incidences of light rays.
- ✓ The microlenses can be kept (hence a gain of +50% on the collection of photons).
- ✓ Scalable technology in terms of production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

Multispectral filter
COLOR SHADES® Technology



Commercial
packaged sensor

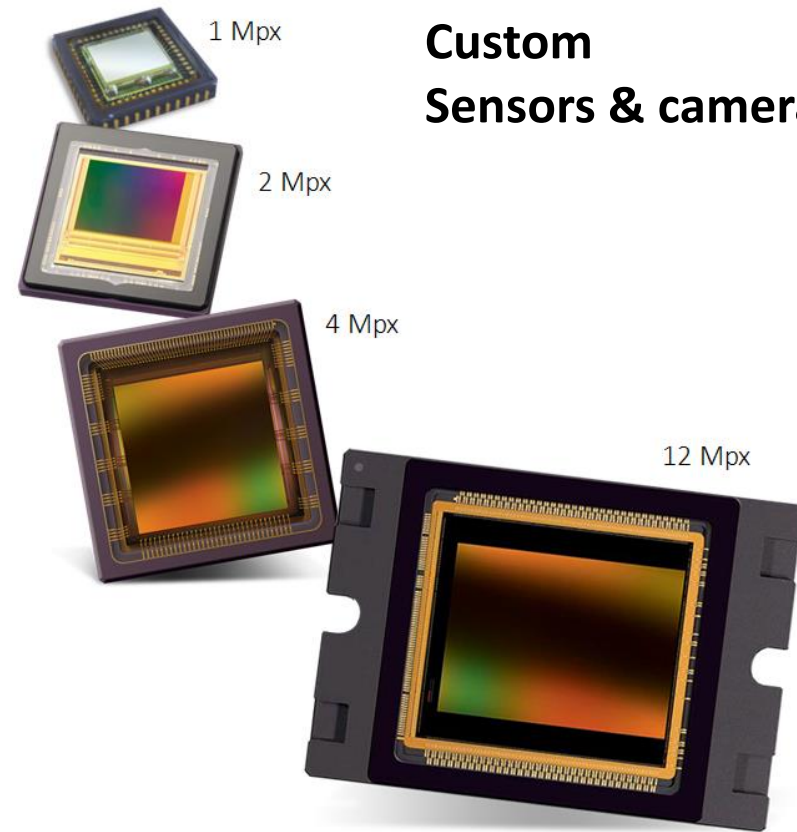
Custom macropixels and spectral ranges



Off-the-Shelf Sensors & cameras



Custom Sensors & cameras



NEW SPACE

Earth & Planets Observation



VIS/NIR & SWIR MULTISPCTRAL SENSORS

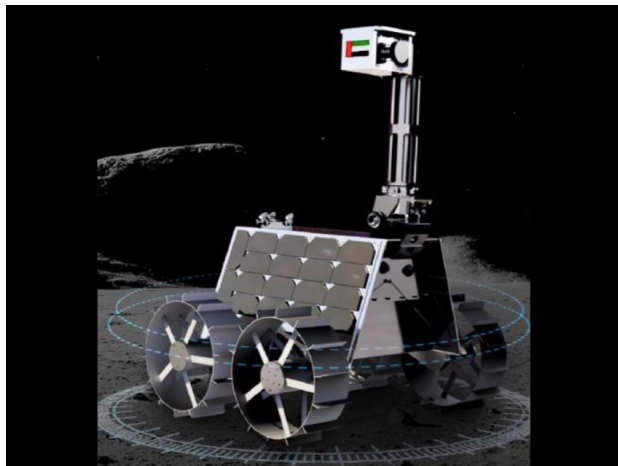
Rovers



Nano-/Micro-Satellites



Destination Moon : RASHID-2 mission

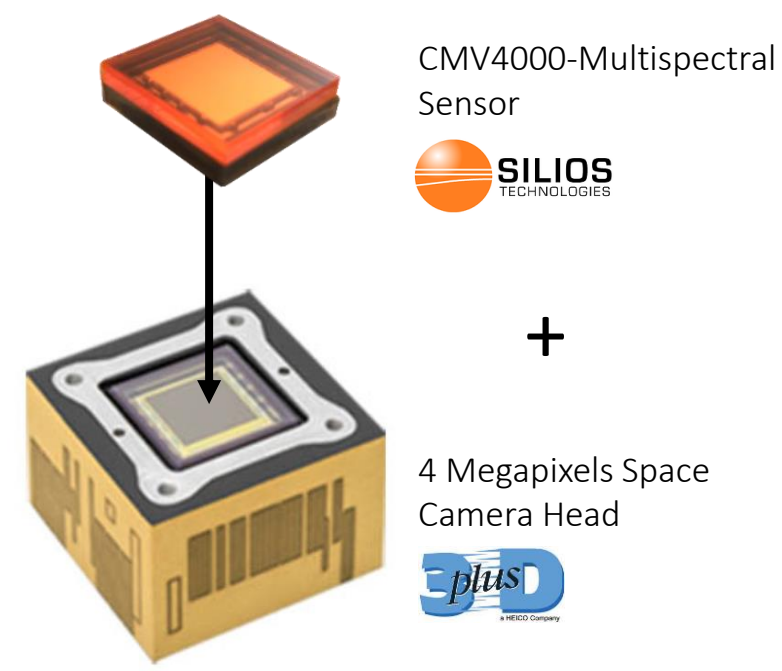
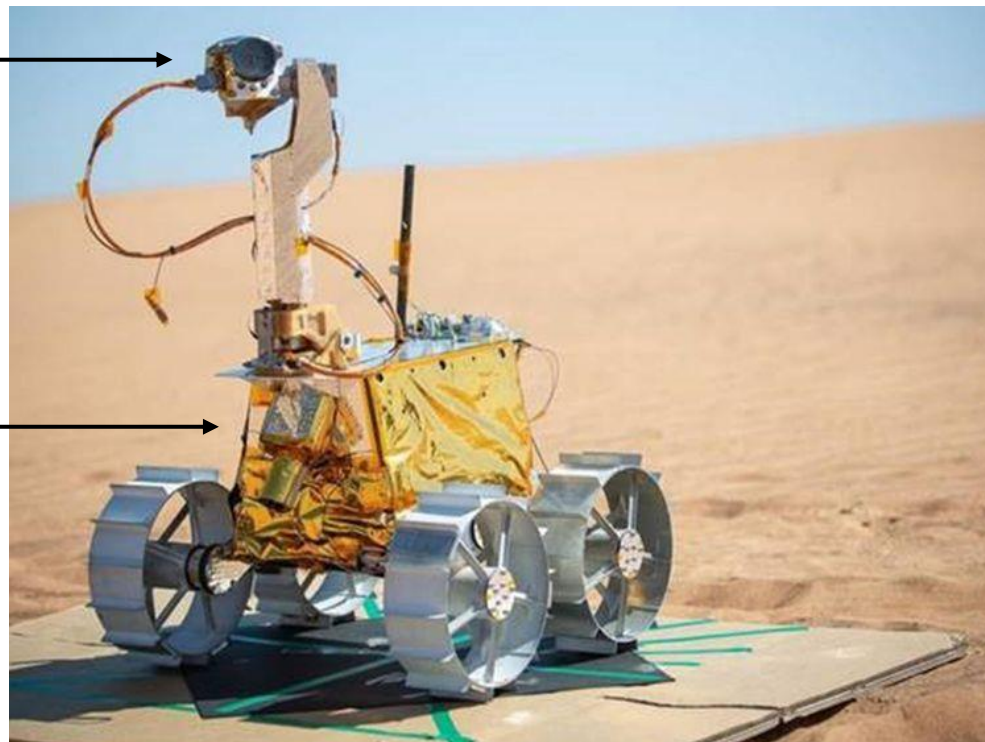


SILIOS has developed with CNES a multispectral imager to equip the Lunar Rover RASHID-2 of the United Arab Emirates (launch between 2024 and 2026). This imager is mounted on a 3DPLUS camera.



SILIOS/3D+ MS cam1
(large field of view)

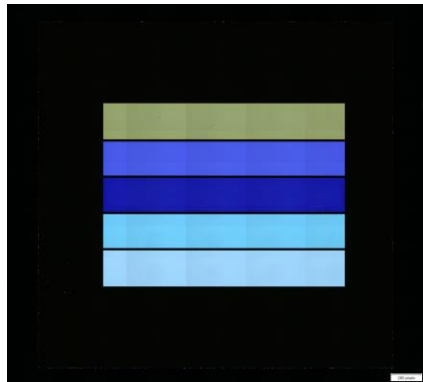
SILIOS/3D+ MS cam2
(small field of view)



= Multispectral CAmera for SPace EXploration

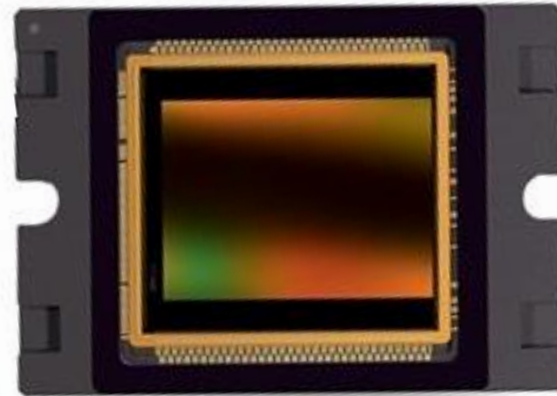
For a National Space Agency (in Europe), SILIOS is currently assembling **Stripe Multispectral filters** onto **12 Mpix CMOS sensors** to achieve a series of compact and high performance Cameras for Small Earth Observation Satellites.

Ground Sampling Distance (GSD) = 5.5 m with multispectral images at a nominal altitude of 600 Km.



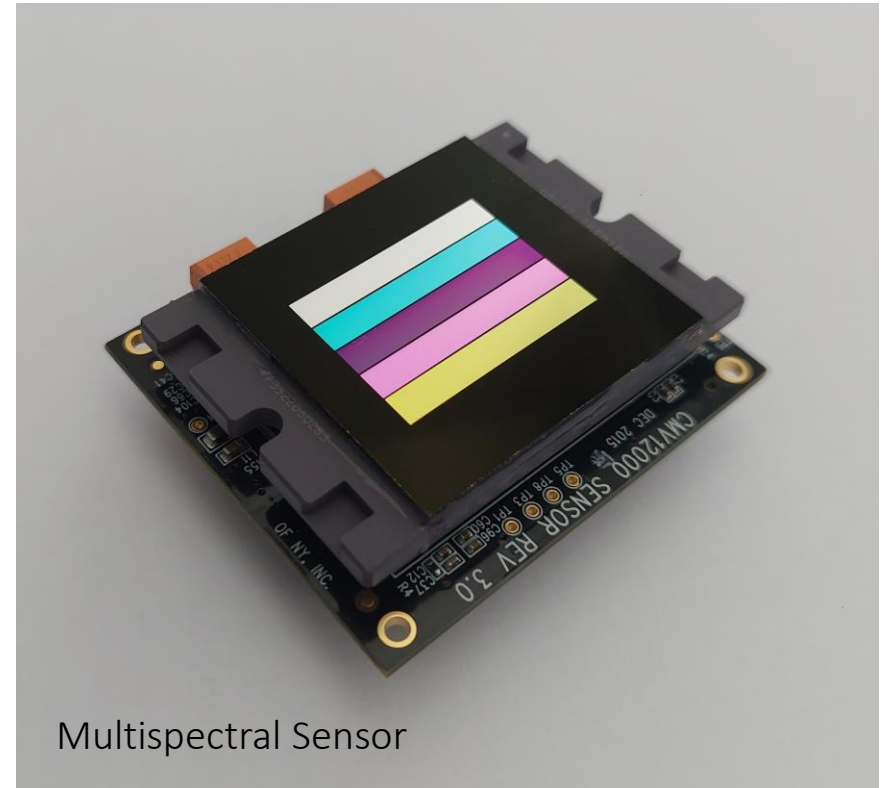
5 channels VIS + NIR
High Transmission
Band-Pass Filters

+



12 Mpix CMOS Sensor

=



Multispectral Sensor

Thank you for you attention

www.silios.com



We are on the same wavelength

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