Micro and Nano-Technologies for opical instrumentation

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TEC-MMO, *EOP-PIO, esa-estec

MNT Roundtable 2012

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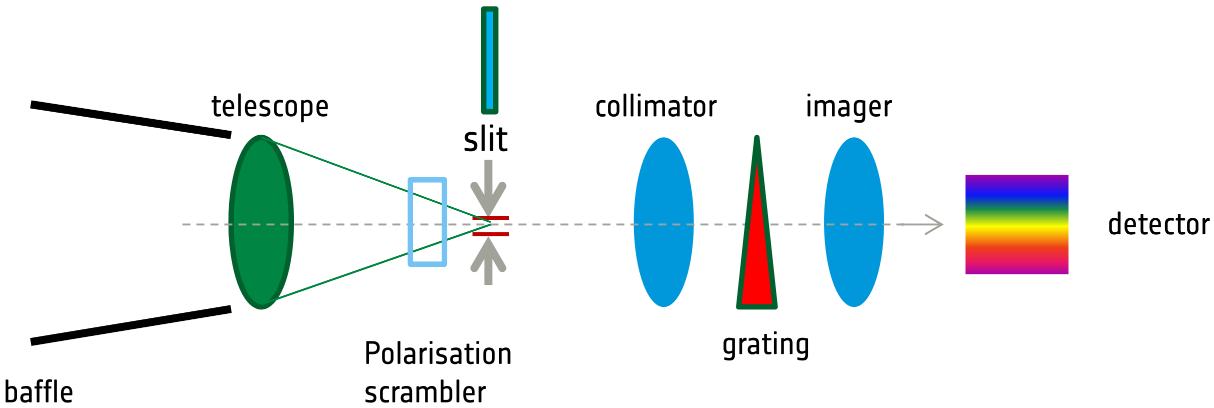
MNT in optical spectrometers



How can MNT improve spectrometers?

Optical MEMS

<u>2 parallel studies on “optical MEMS for Earth observation applications”</u>

Consortium 1: Luso Space, SSTL
Contract#: 100810

- Selected Applications:

1) De-clouded spectrometer
2) Variable slit spectrometer

Consortium 2: Thales, LAM, EPFL
Contract#: 101991

- Selected Applications:

1) De-clouded spectrometer
2) Programmable spectrometer

<u>De-clouded spectrometer</u>:

Goal

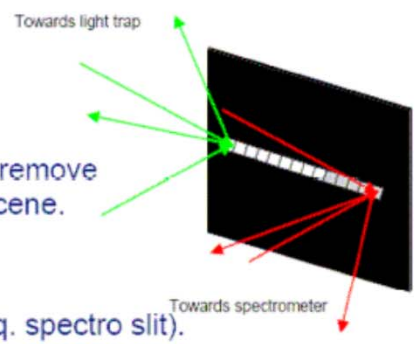
- The sea observed in infrared wavelength is very dark,
- But very bright signal reflected by clouds or the sun-glint
- prevent from the CCD saturation
- Very high dynamic required for the detector.

Working principle

- By opening or closing the shutter/mirror, we could remove the sun-glint or clouds reflection of the observed scene.

Component

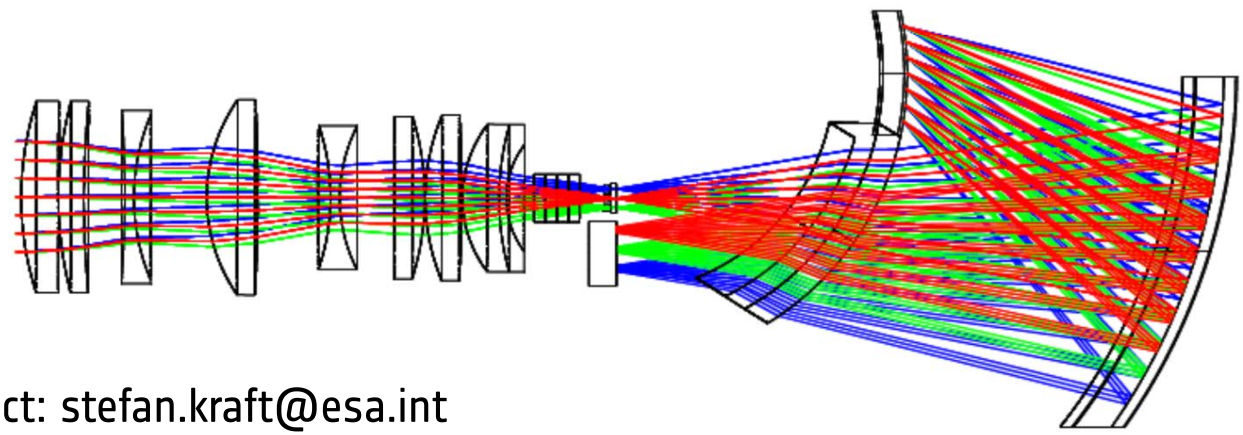
- DMA or a MSA into an intermediate focal plane (eq. spectro slit).



Optical MEMS

Variable slit spectrometer: Multiple entrance slits have been suggested for the FIMAS grating spectrometer:

- Each slit is filtered to a 14nm band:
  - O_2A band limited to 758nm-772nm
  - O_2B band limited to 686nm-700nm
- O_2A band is imaged at 0.1nm and 0.3nm resolution
- O_2B band only at 0.3nm
- With only one slit, the range could be increased to 650nm-800nm



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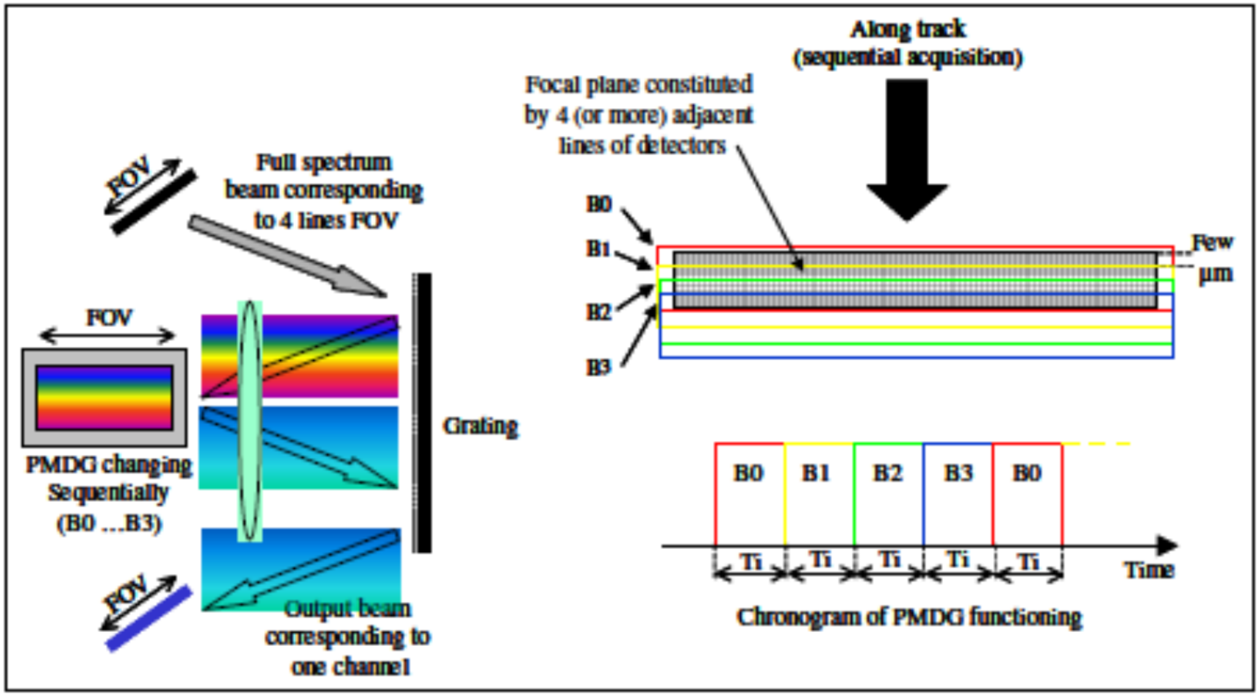
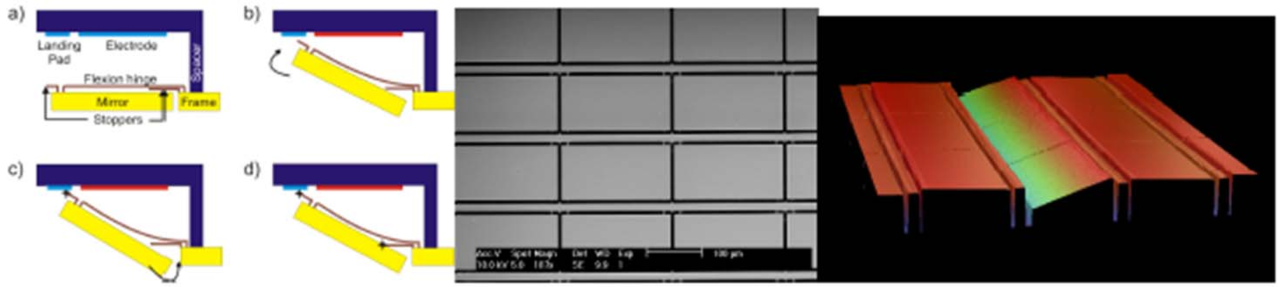
Optical MEMS

Programmable spectrometer:



Optical MEMS

¾ of the most interesting concepts are based on DMA type of components:



According to the study DMA would help to reduce stray-light, leading to:

>higher measurement accuracy

>more usable pixels and therefore more and new scientific results possible

More applications for the DMA are:

>scene brightness equalisation (1D array)

>read-out smear elimination (1D array)

>multiobject spectroscopy (2D array)

¼ of the most interesting concepts is based on variable slit type of component:

Variable slit would help to:

>increase spectral range

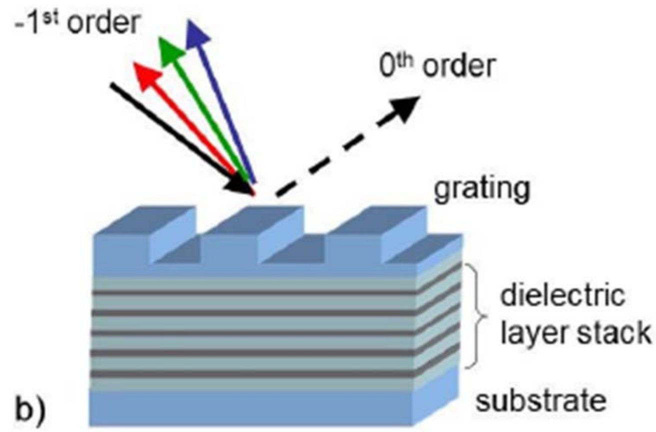
>flexibility

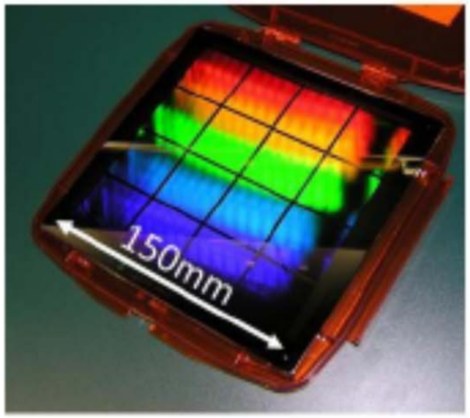
Optical gratings

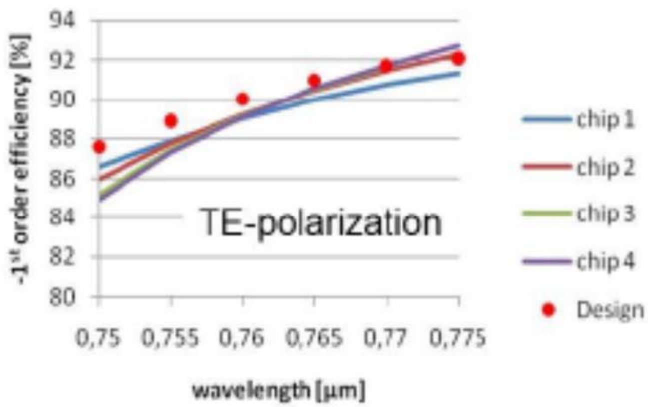
<u>IOF, Jena contracted by Astrium for grating development for Sentinel 4 (ESA) mission</u>

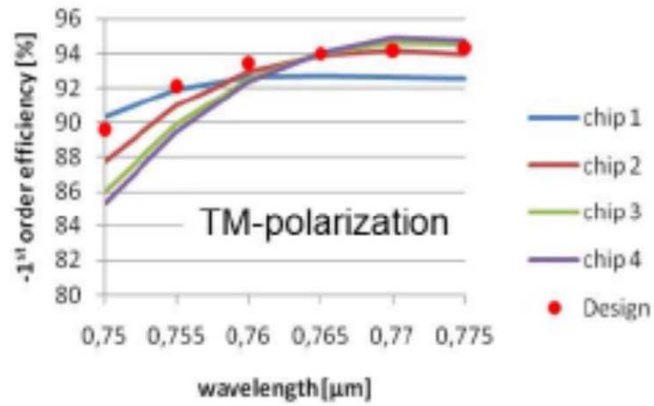
Parameter	Value
grating type	reflection grating
grating period	667nm
wavelength range	750nm … 775nm
diffraction efficiency +1st order	> 70%
polarization sensitivity $\frac{\lvert\eta_{TE}-\eta_{TM}\rvert}{\eta_{TE}+\eta_{TM}}$	< 2%
angle of incidence	38°
grating size	~80mm diameter

Table 1. Preliminary optical parameters of the NIR-spectrometer grating for the Sentinle-4 mission.









Optical gratings

<u>New grating developments for</u>:

Sentinel 4 (UV-VIS-NIR)
Sentinel 5 (UV-VIS-NIR-SWIR)
FLEX (NIR)
CarbonSat (NIR-SWIR)

Expected specifications:

- Highly dispersive
- Low straylight
- Low polarisation sensitivity
- Highly efficient
- Leading to compact instrument

>are the drivers for new grating designs

<u>Example of SWIR grating for Tropomi and Sentinel-5</u>:

Development of immersed diffraction grating for the TROPOMI-SWIR spectrometer

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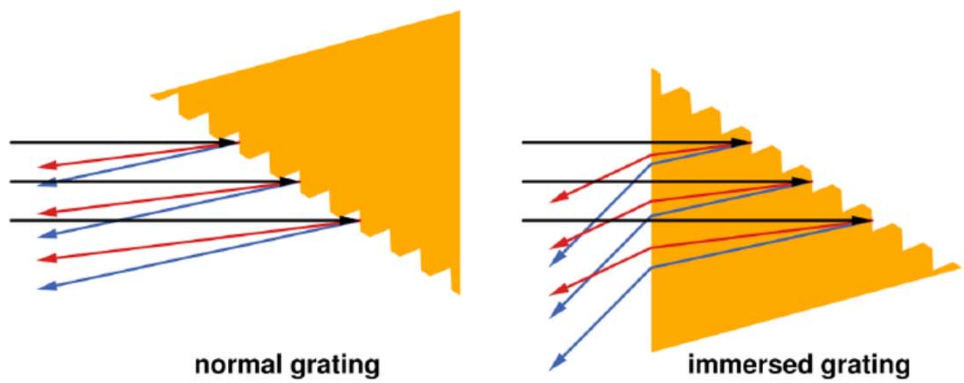
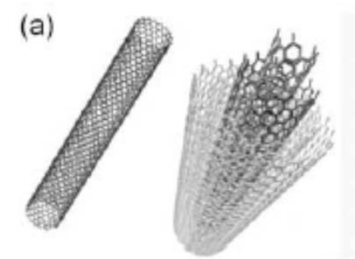


Figure 1. Sketch of the principle of a normal reflection grating (left) and an immersed grating (right), lithographically produced in silicon. The resolving power of the immersed grating is increased with a factor 3.4 of the refractive index as compared to the normal grating. In reality the grating surface is 60 mm in length and the line spacing is 2.5 µm.

Metamaterials

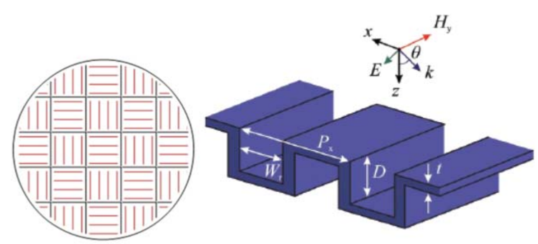
2 parallel studies on “metamaterials for optical and photonics applications”

> Results are summarized in: Luis Gaspar Venancio et al., Proc. of SPIE Vol. 8146 81460E-13

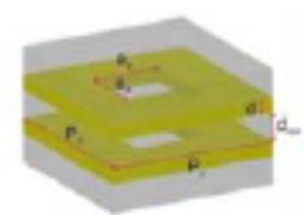


1. Survey
2. Classification and selection

Criterion	Description
Application range	This criterion addresses the versatility of the metamaterial.
Benefit	The metamaterial is judged beneficial if clear advantages are shown with respect to available standard technologies.
Feasibility and manufacturability	With this criterion only metamaterials which have been already manufactured and tested can be retained.
Maturity	With this criterion the manufacturing process maturity is assessed.



Item	Description	Function
Ab6	Low-density array of long nanotubes	Absorber for straylight baffling
P2	1D meander structure	Polarisation scrambling
P4	Double mesh structure	Polarisation scrambling



3. Study

Metamaterials

Title of activity:	Metamaterials for optical and photonics applications for space
Contract numbers:	4200022943/10/NL/AF and 4200022944/10/NL/AF
Primes:	cosine Research and Fraunhofer Institute (INT)
Start date:	22/06/2010
End date:	19/01/2012
TRL:	2
Contact person	Luis M. Gaspar Venancio
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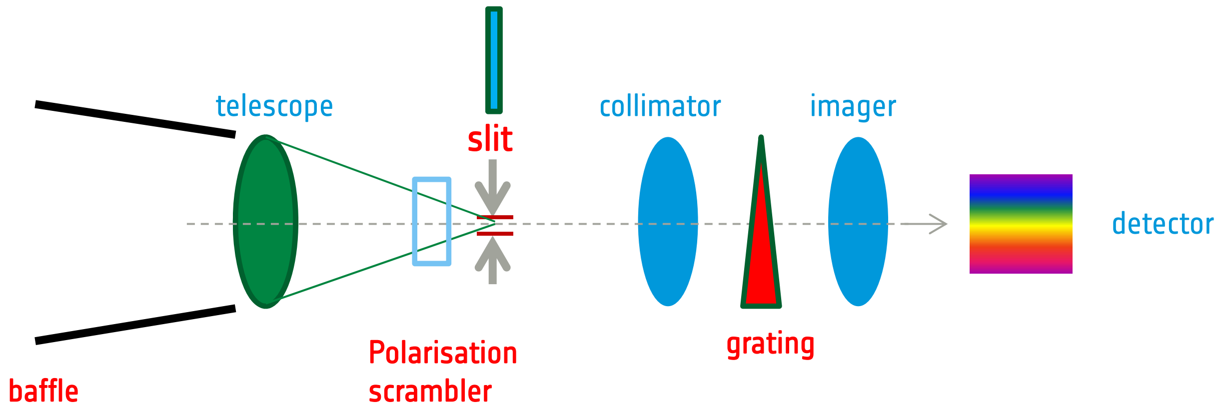
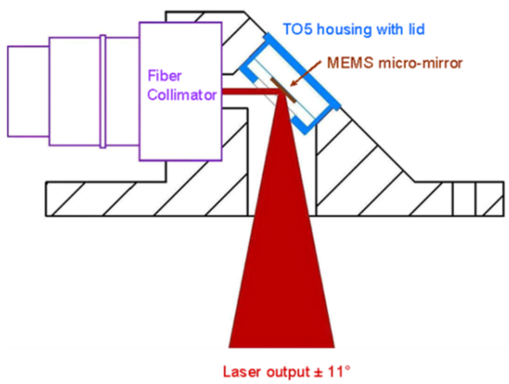
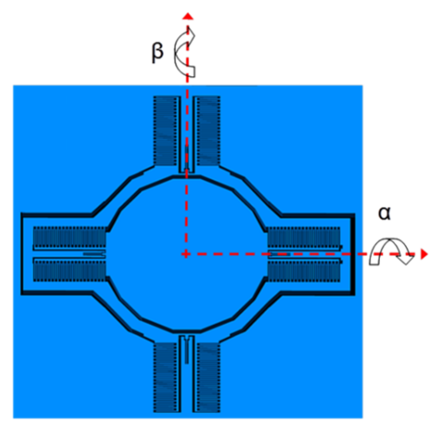
MNT in optical spectrometers



Optical MEMS development for rover navigation applications

Title of activity:	Micro Laser Beam Scanner
Prime contractor:	Sercalo
Contract number:	4000103902/11/NL/CP
Start date :	Q3 2011
End date:	Q3 2013
TRL level step:	3 to 5



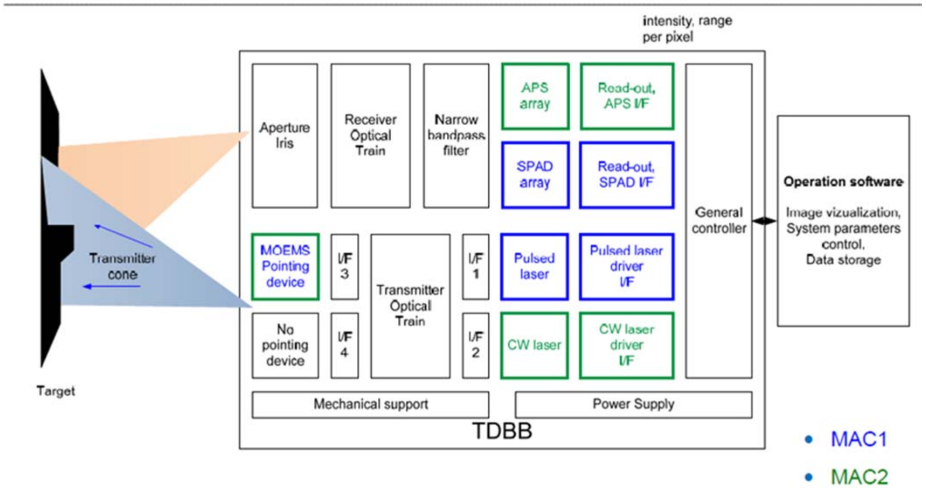


contact: Joao.Pereira.Do.Carmo@esa.int, ext.# 56169

Hardware development for miniaturized imaging LIDAR System

Title of activity:	Miniaturized Imaging LIDAR System (Phase 1)
Contract number:	4000103730/11/NL/EM
Prime contractor:	CSEM
Start date :	Q2 2011
End date:	Q1 2013
TRL level step:	2 to 3

Baseline approach for the demonstrator breadboard



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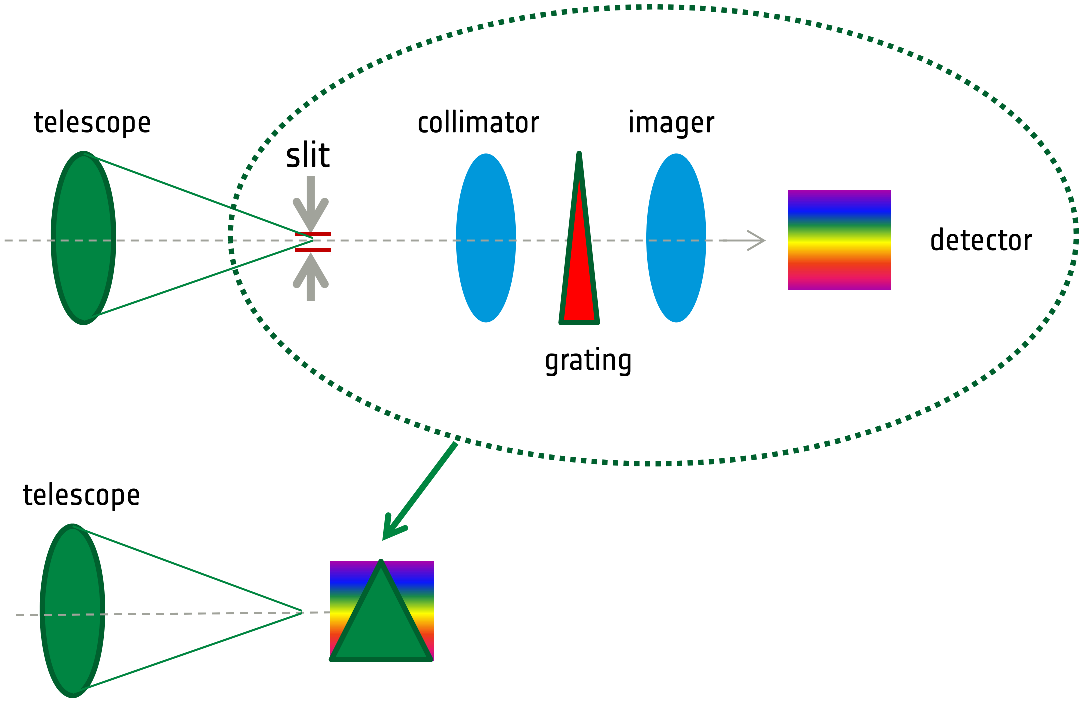
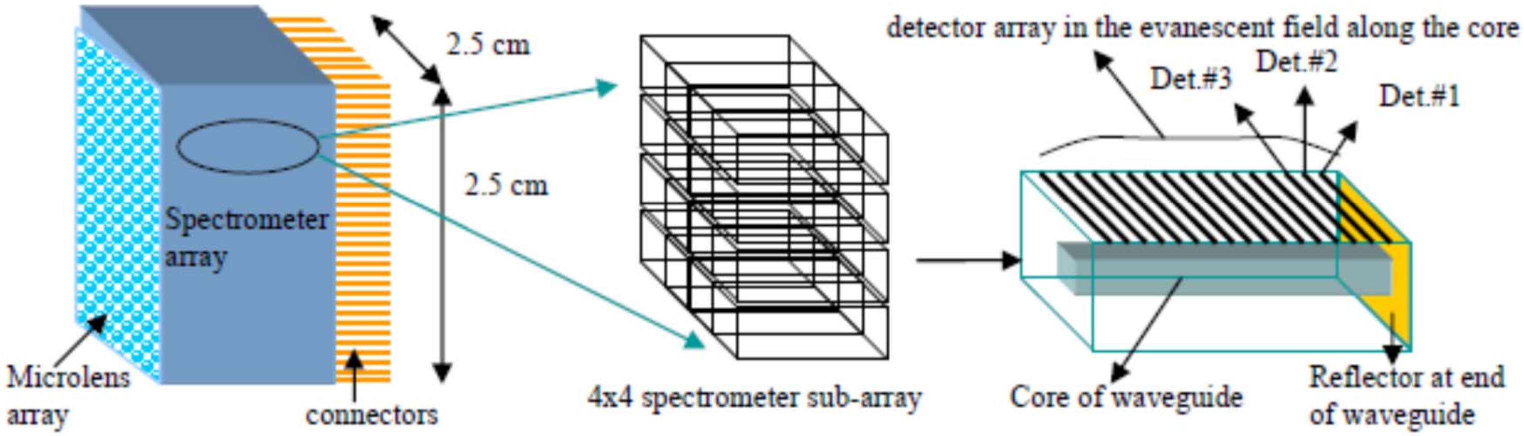
Fully integrated imaging spectrometer



Fully integrated imaging spectrometer

Basic principle:



Published: B. Guldimann, Proc. of SPIE Vol. 7930 793000-5

Fully integrated imaging spectrometer

Feasibility study with hardware demonstrator

Title of activity:	Miniature high performance imaging spectrometer for remote sensing
Prime contractor:	MICOS
Contract number:	4000104975/11/NL/NA
Start date :	Q1 2012
End date:	Q1 2014
TRL level step:	1 to 3

contact: Benedikt.Guldimann@esa.int, ext.# 53592

Optical MEMS hardware development

Title of activity: Large optical MEMS switches architectures for broadband applications

Prime contractor: Sercalo

Contract number: 19531/06

End date: Q2 2011

Front View

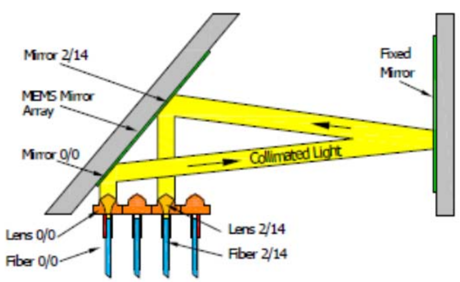


Figure 4 : One Chip Design (front view)

Top View

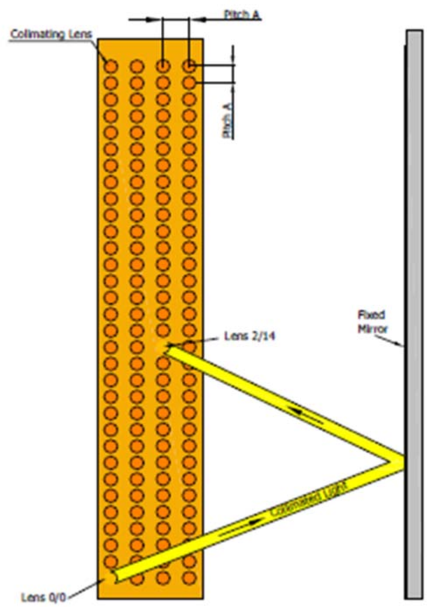


Figure 5 : 50x50 MEMS switch principle, One Chip Design (top view)

Telecom payload

Large optical MEMS switches architectures for broadband applications

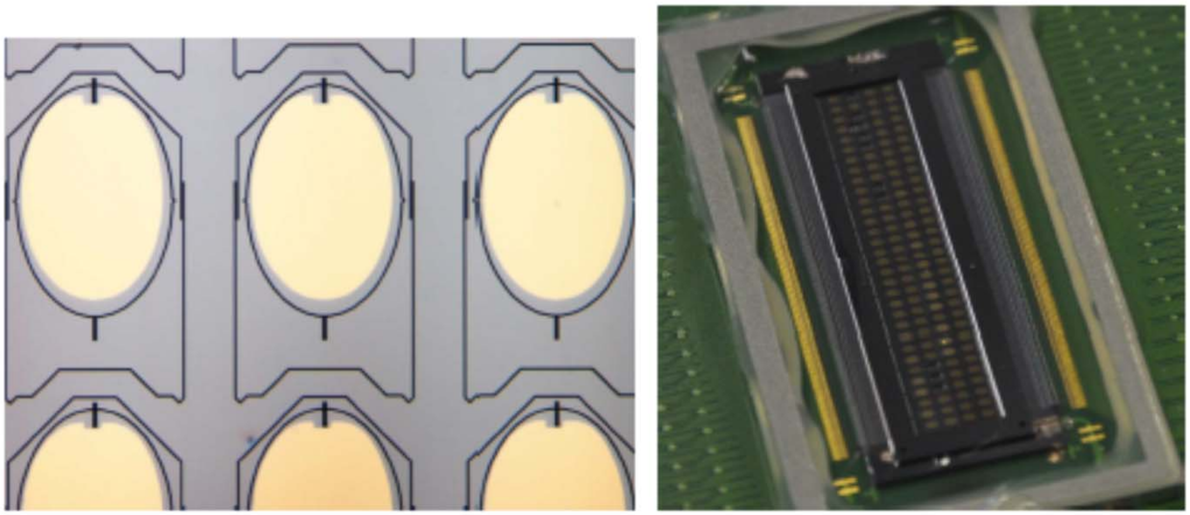


Figure 16: Final MEMS chip from mask set rev. 2 with gold deposition on the mirror frontside.

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Thank you!
European Space Agency