THALES

Molecular adhesion in spatial projects

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Thales SESO

Agenda

Molecular adhesion = optical bonding = optical contacting

1. Thales SESO

- Key figures
- About us

2. Molecular adhesions realized at TSESO

3. Corner Cubes

- Massive Corner Cube
- Hollow Corner Cube R&T with CNES
- Hollow light-weighted Corner Cube for MTG
  - Manufacturing
  - Optical performances
  - Mechanical performances

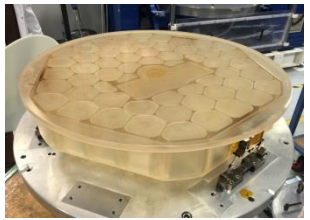
1. Thales SESO

Key figures

- Created in 1965, member of Thales since 2011, attachment to TAS in 2016
- 130 technicians and engineers
- 4000m² of production area including 400m² of cleanrooms

About us

- Activities : Conception and manufacturing of opto-mechanical systems
  - Conception : optic, mechanic, coating
  - Manufacturing : preform, light-weighting, polishing, coating, integration, measurement
- Products
  - Precise optics (low WFE and roughness)
  - Large component (until diameter 1.7m)
  - X-ray mirror and bimorph, laser components
  - Opto-mechanical system



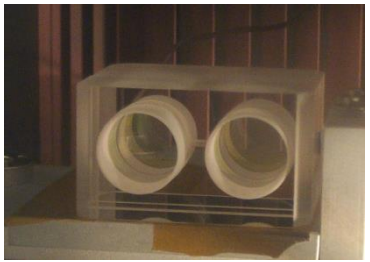
- Fields of application : Space, Science & X-ray, Astronomy, high power laser optics

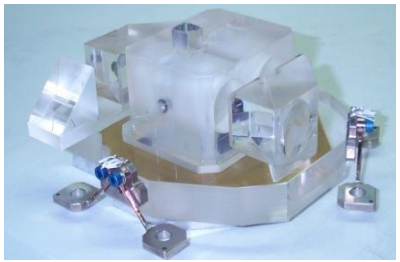
2. Molecular adhesions realized at TSESO

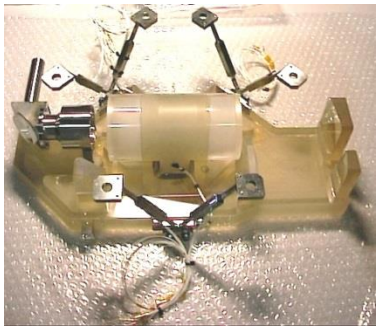
Benefit of molecular adhesion : attach 2 pieces of glass without glue so without constraints induced by glue. System with thermal stability

Aladin : Fabry-Perot interferometer

- Double channel
  - 3 plates in silica
  - length difference between channels of 100nm
  - Cavity under vacuum, diameter : 35mm
- Simple channel
  - 2 plates in silica, 1 in Zerodur
  - Cavity under vacuum, diameter : 45mm
- Surface accuracy about λ/100PTV
- Molecular adhesion (optical contacting)
- Maximal stress < 1MPa
- Launched in 2018, very good results regarding to ESA



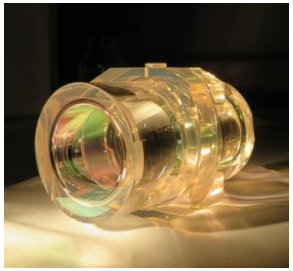




2. Molecular adhesions realized at TSESO

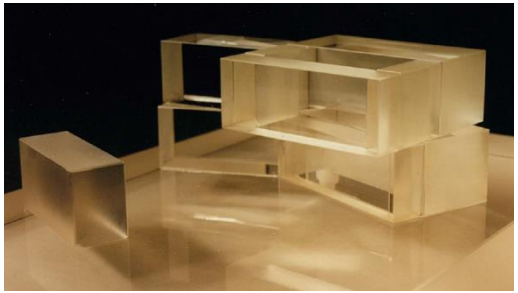
ATLID : Fabry-Perot interferometer

- Zerodur/Silica
- Cavity under vacuum
- Diameter : 42mm and 70mm
- Molecular adhesion
- Maximal stress < 1MPa



Double Fizeau interferometer

- Silica components with angular tolerances of 5''
- Surfaces λ/100PTV
- Positioning of optical components on a silica base plate by molecular adhesion
- Maximal stress < 1MPa

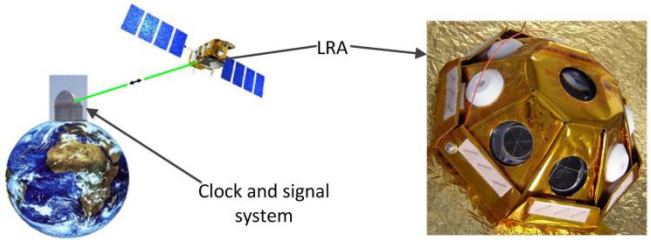


3. Corner Cubes

Massive Corner Cube

- Benefit of this design : High mechanical stability with important field of view and easier to manufacture : no integration concern, only one summit to realise with precision, possibility to deal with one angle

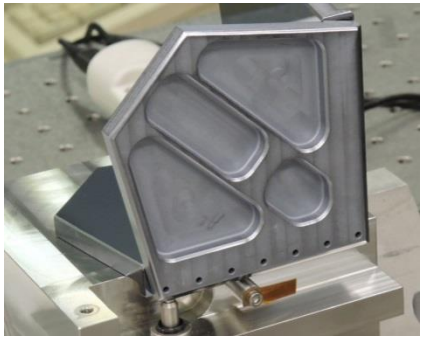
- SARAL :
  - Measurement of sea surface height, significant wave heights and wind speed
  - Launched in 2013
- LRA : Laser Retro-reflector Array with CNES
  - To calibrate the precise orbit and altitude
  - 9 CC developed by TSESO
- Corner Cubes :
  - Angle error : 1.6''
  - Specified deviation : 7''
  - WFE : 40 nm RMS
  - Clear aperture : 30mm
  - Mass total : 1.4kg

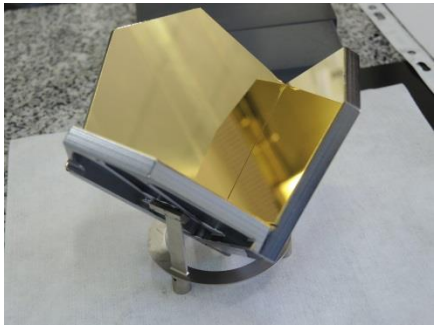


3. Corner Cubes

Hollow Corner Cube R&T with CNES

- Assembly of 3 plates of silicon light-weighted
- Irreversible molecular adhesion (AMI)
- Optical properties
  - Angle 2.5''
  - Surfaces at λ/10
  - Clear aperture : 100mm
  - Capable of extended wavelength range (UV to Infrared)
- Mechanical properties
  - Maximal Stress : 2 MPa
  - Mass with MFD : 280g
  - Good stability

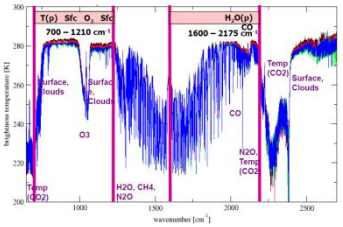




3. Corner Cubes

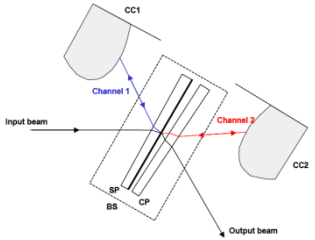
Hollow light-weighted Corner Cube for MTG

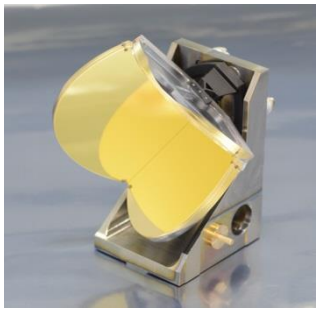
- MTG - IRS : Infra-Red Sounder
  - Goal : to know information on horizontal and vertical gradients of temperature and moisture in atmosphere → spectral measurement of clouds (chemical composition)
  - Application : severe weather warning like storm, volcanic ash, pollution etc.
  - Instruments : interferometer and telescopes



- Corner Cube
  - Part of the interferometer : 1 Beam Splitter and 2 Corner Cubes
  - Design constraints due to spatial application :
    - **Low mass**
    - **High stability**
    - High mechanical resistance
    - Good optical performances

→ Hollow light-weighted corner cubes





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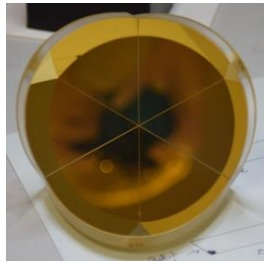
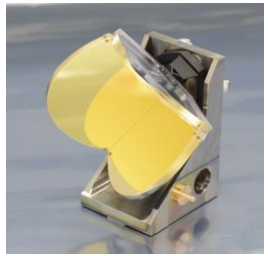
2. Corner Cubes

Hollow light-weighted Corner Cube for MTG

- Manufacturing
  - Fine polishing of 3 mirrors in fused silica
    - Low roughness : < 0.6nmRMS
    - Low flatness : λ/10 on adherence area
    - Precise angle : 90° ± 0.5''





  - Light-weighting
    - For the same dimensions, field corner cube is 10 times heavier
  - Adherence : enhanced molecular adherence
    - Adherence of 2 similar and clean surfaces (local attraction by Van der Waals or hydrogen bonds)
    - Treatment is done in order to improve the mechanical resistance of molecular adhesion interface
    - Shock tests done on samples and corner cube in collaboration with CNES and LMA
    - Dimensional stability due to the absence of mechanical part or glue
    - Risks of contamination associated with degassing are avoided
  - Gold coating an integration
    - To reflect from 633nm to 15µm
    - Bonding on MFD, grounding, screwing on support

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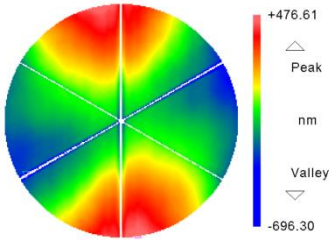
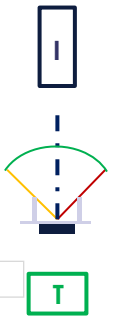
2. Corner Cubes

Hollow light-weighted Corner Cube for MTG



- Optical performances
  - Angles between mirrors at 90° ± 1''
  - Wave Front Error (WFE) < 250 nm RMS
  - Clear aperture : 100mm
  - Matching of corner cubes
    - Important and stringent specification for interferometer is ΔWFE, the difference of WFE between the 2 channels
    - ΔWFE is a combination of Beam Splitter WFE and both Corner Cube WFE
    - ΔWFE can be improved by orienting one CC with the other one and by orienting both CC with BS
      - » Orientation of one CC with the other one : improvement about 15%
      - » Orientation of both CC with BS : improvement about 25%
    - For flight model : manufacturing of 4 CC and choice of the two which give the best ΔWFE performance
  - Measurement configuration
    - Direct measurement with theodolite alignment
    - Reproducibility measurement of 17nmRMS



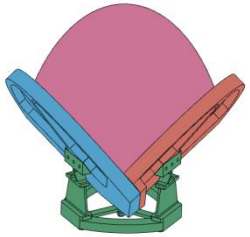
Interferometer

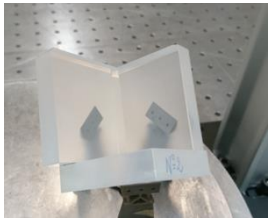
CC on MFD and on support

Reference plate

Theodolite

2. Corner Cubes

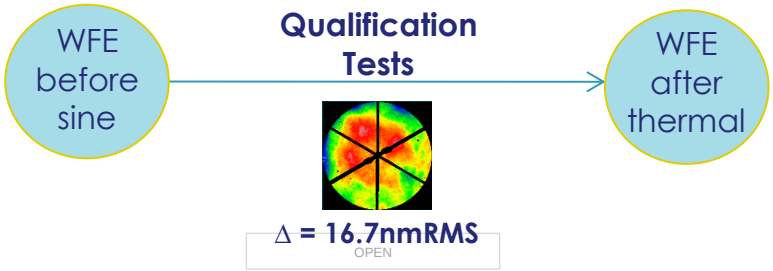




Hollow light-weighted Corner Cube for MTG

- Mechanical performances
  - Mass : 250g with MFD
  - Corner Cubes mockup tested until rupture to determine mechanical admissible :
    - 2 CC in Sine test : rupture at 3.5g and 5.5g on the edge of adherence area as predicted by analysis
    - 1 CC in Shock test : defect appeared at 650g, rupture at 700g
    - Maximal stress : 4.5 MPa
  - Mechanical margins positives for all environments

- Flight model design tested :
  - 1 CC passed with success sine / random / shock and thermal vacuum test at qualification level
  - No evolution of optical performances with environmental tests



Conclusion

Molecular adhesion in spatial projects

- High stability : no constraints induced by glue between 2 optical parts
- High mechanical resistance
  - Molecular adherence : Maximum Stress = 1 MPa
  - Irreversible molecular adherence : Maximum Stress = 2 MPa
  - Enhanced molecular adherence : Maximum Stress = 5 MPa
- Process with high level of precision
  - Manufacturing of each parts with severe performances
  - Precise assembly, require a specific know-how

→ In line with stringent environment conditions and requirements in spatial applications