L’impression 3D pour la fabrication de miroir en astronomie

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Colloque Fabrication additive appliquée à la physique des deux infinis, 7 Juin 2021

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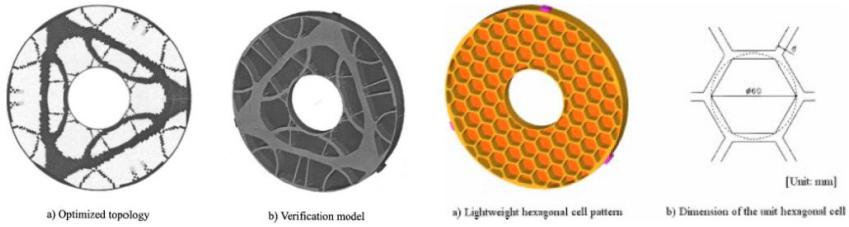
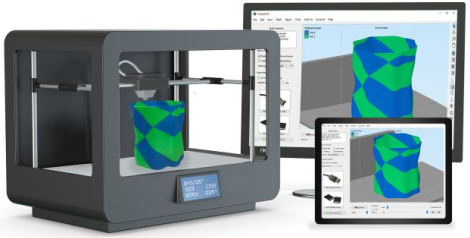
Besoins en astronomie

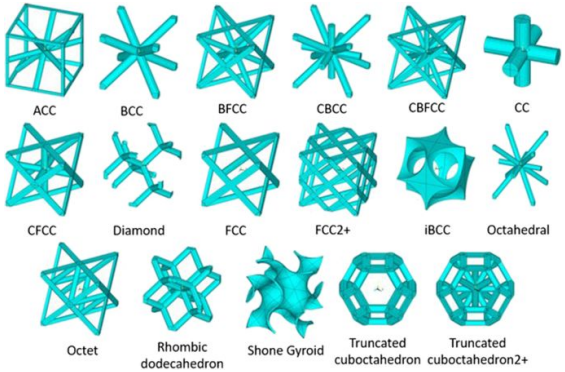
- **Besoins**
  - Instrument compact
  - Faible masse



a) Optimized topology
b) Verification model
a) Lightweight hexagonal cell pattern
b) Dimension of the unit hexagonal cell

- **Outils**
  - Impression 3D
  - Optimisation topologique
  - Lattices





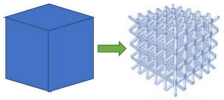
Impression 3D pour l'astronomie

Techniques	Matériaux
Stéréolithographie (SLA)	Polymères & Céramiques
Power Bed Fusion (PBF)	Métaux - Al & Ti

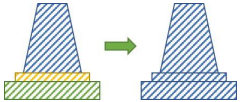
Advantages

Nouvelle méthode de design

Réduction de la masse



Réduction des interfaces

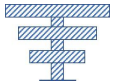


Contraintes

Limitation de design & techniques

Cavités

Overhangs



Tolérance Porosité

Taille Max & Min

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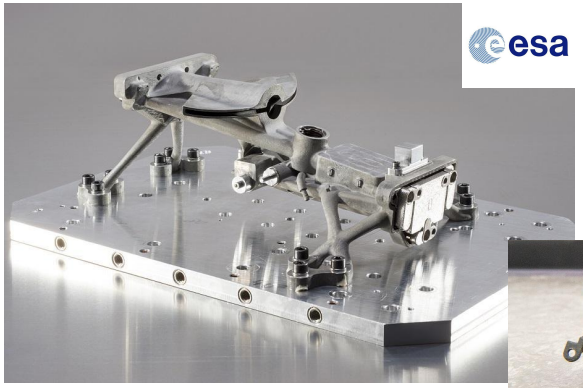
Réduction des interfaces - Optimisation des structures

Ozone Monitoring Instrument OMI



OMI 3D printed demonstrator telescope

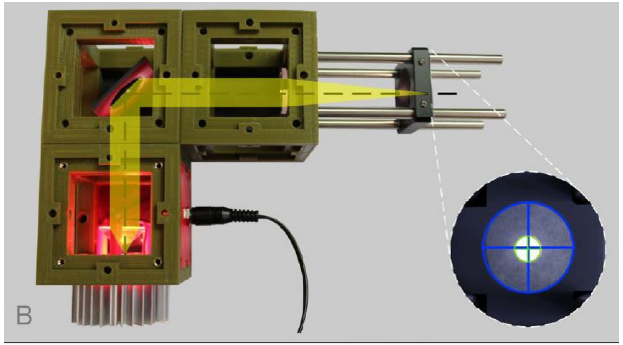
3D printed interior part

Tirer le maximum de bénéfices de l'impression 3D

- Réduction de 73% de la masse initiale
- Réduction des points d'attachement à 4 (initialement 6)
- Réduction du nombre de parties à 3

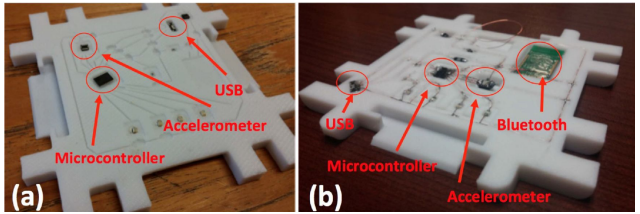
http://www.esa.int/Enabling_Support/Space_Engineering_Technology/Printing_a_telescope_for_space

CubeSat modulables structures



Delmans and Haseloff 2018

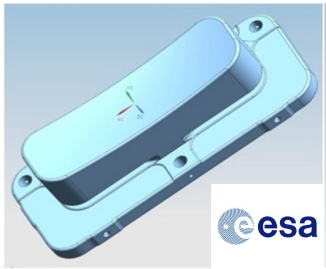
Electronique encastrée



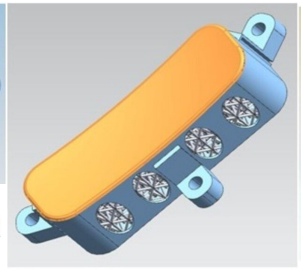
Shemelya, Banuelos-Chacon, Melendez, et al. 2015

Allègement des miroirs tout en gardant ses performances optiques

Miroir primaire de l'instrument TROPOMI



Initial design
Mass: 284.6 g



Lightweight design

Ti64 printed mirror after coating & polishing
Mass: 127.7 g

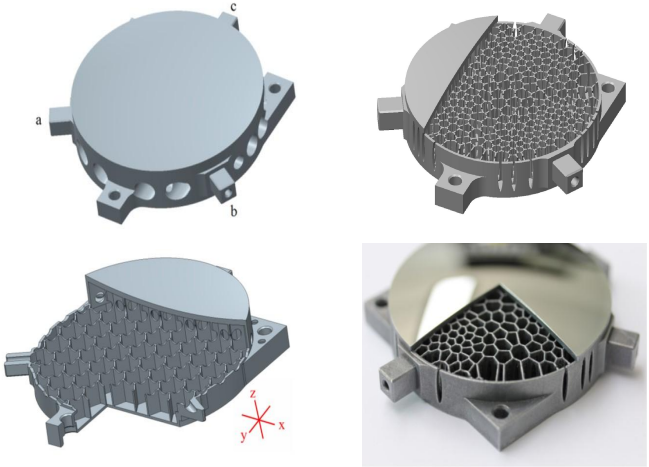
→ Réduction de 54% de la masse initiale

Allègement via une lattice régulière

\+ Revêtement et polissage

http://www.esa.int/ESA_Multimedia/Images/2014/10/Reworking_Tropomi_mirror

Miroir primaire d'un système optique embarqué



→ Réduction de 63% & 60.5% de la masse initiale

Structure interne optimisée en rigidité & masse

Enrico Hilpert, Johannes Hartung, Henrik von Lukowicz et al. « Design, additive manufacturing, processing, and characterization of metal mirror made of aluminum silicon alloy for space applications ». In : *Optical Engineering* 58.9 (2019), p. 1-9.

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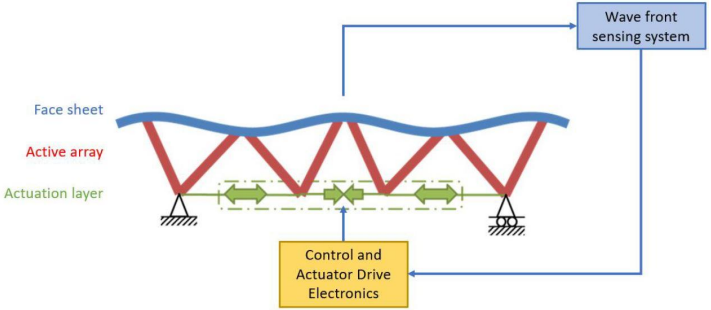
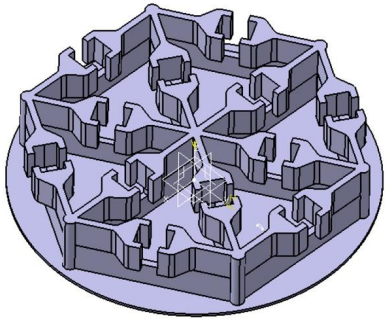
A²IM
Additive Astronomy Integrated component Manufacturing

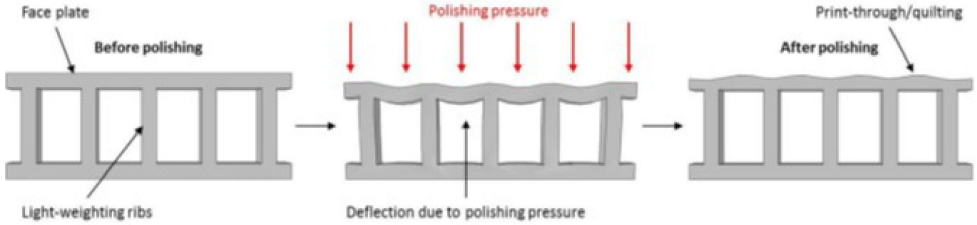
Miroirs déformables – Objectif

→ Imprimer une structure active directement en contact avec la surface du miroir





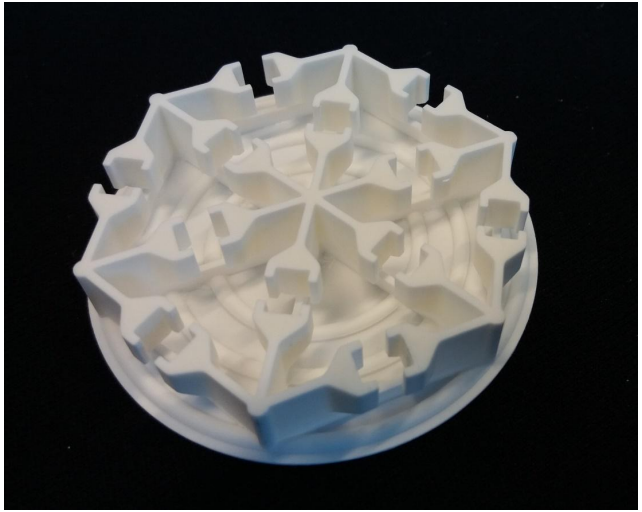
→ Etudier l'impact de la structure pendant le polissage sur la **surface optique**



Prototypes : 2 techniques – 2 matériaux

Stereolithography

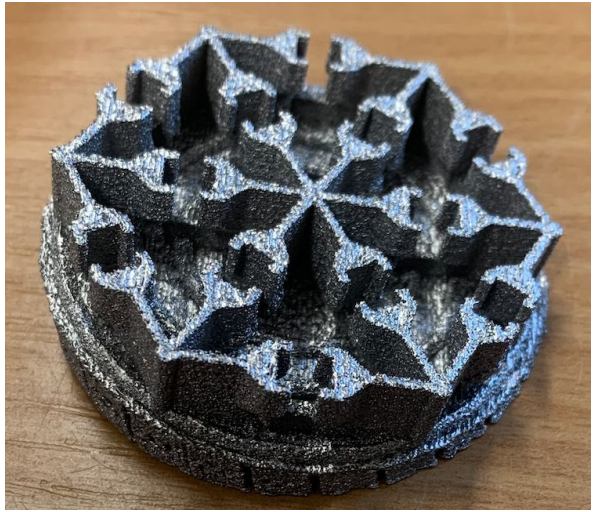
Alumina: Al2O3



TNO

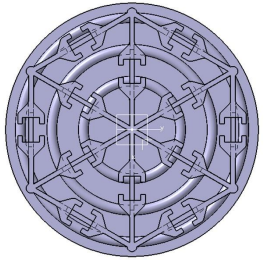
Electron beam sintering

Titanium: Ti-64Al-4V

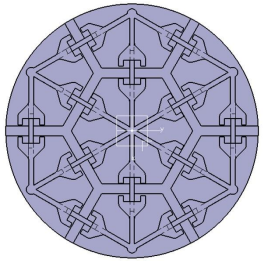


Sheffield University

Prototypes: Planning

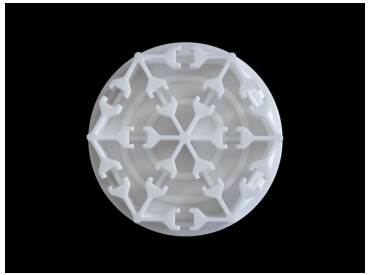


Circle design

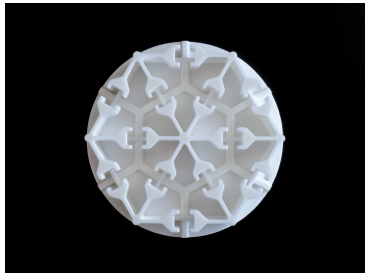


Honeycomb design

New printing set



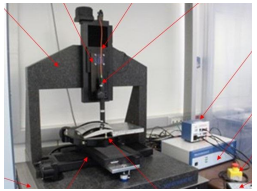
24 samples in total



8 Alumina | 8 Ti64 | 8 Ti64 Hot isotatic Pressure

Measure

Profilometry measurement to extract mid Frequencies and characterise roughness



STIL profilometer

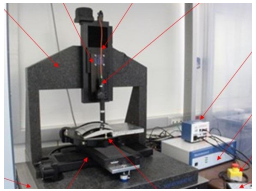
Polishing

The same polishing process applied on all the samples

Credit: Winlight

Measure

Profilometry measurement to extract mid Frequencies and characterise roughness

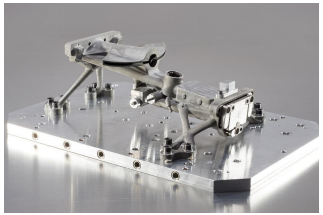


STIL profilometer

Contact : hermine.schnetler@stfc.ac.uk
carolyn.atkins@stfc.ac.uk

Conclusion

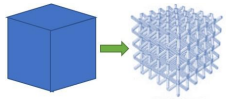
L'impression 3D une nouvelle façon de concevoir



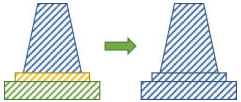
Advantages

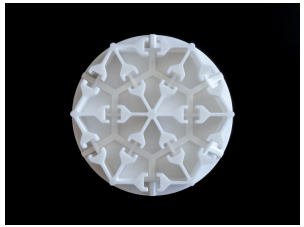
Nouvelles méthode de design

Réduction de la masse

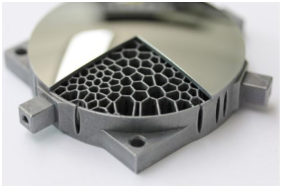


Réduction des interfaces





Pre-processing & Post processing



PS: I am looking for a job