In-situ Performance Evaluation of Contaminated Optical Surfaces

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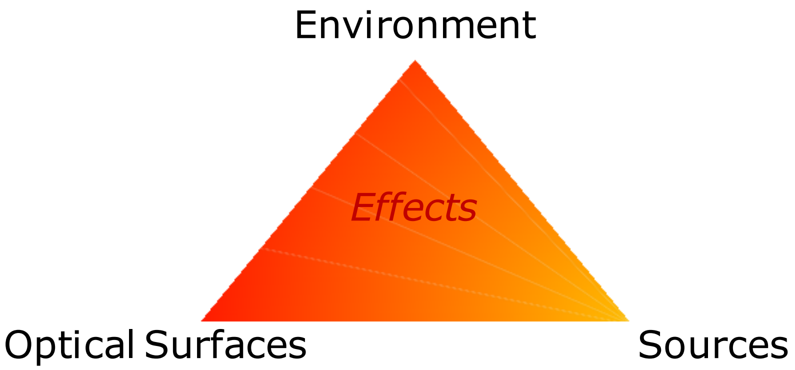
Agenda

1. Introduction
2. Previous work
3. Test Method and Chamber
4. Results: RTV s691
5. Results: Scotch-weld Epoxy Adhesive
6. Data Treatment
7. Closing Remarks

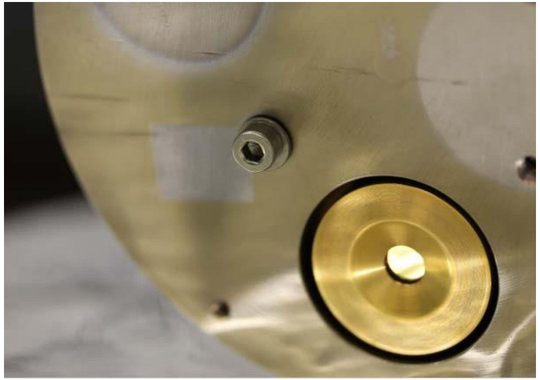
Introduction

The **Contamination criticality** is nowadays recognized by the space community. Throughout the years, many efforts have been directed to understanding and identifying **Outgassing sources**.

However, there is still a general knowledge deficiency related to the **effects** of the presence of such contamination on different optical surfaces.



Introduction



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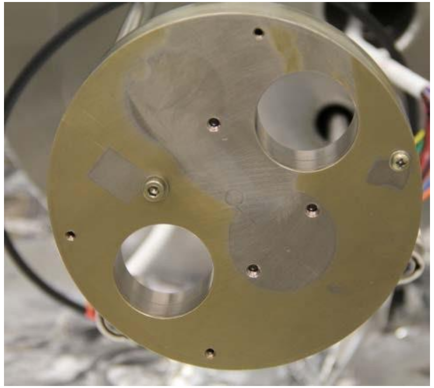

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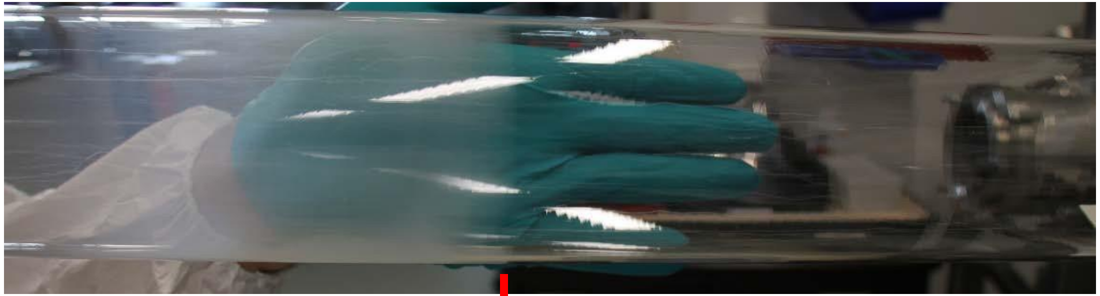
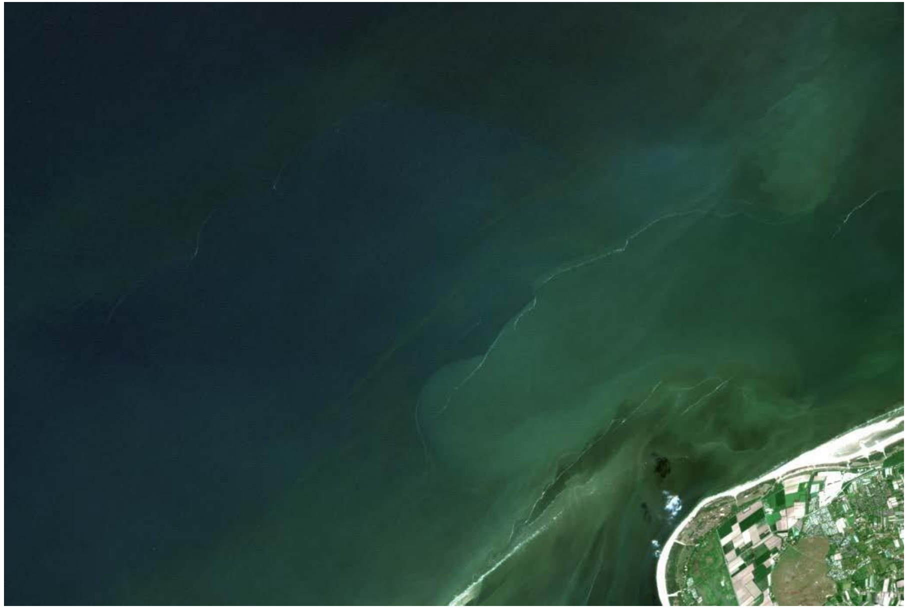


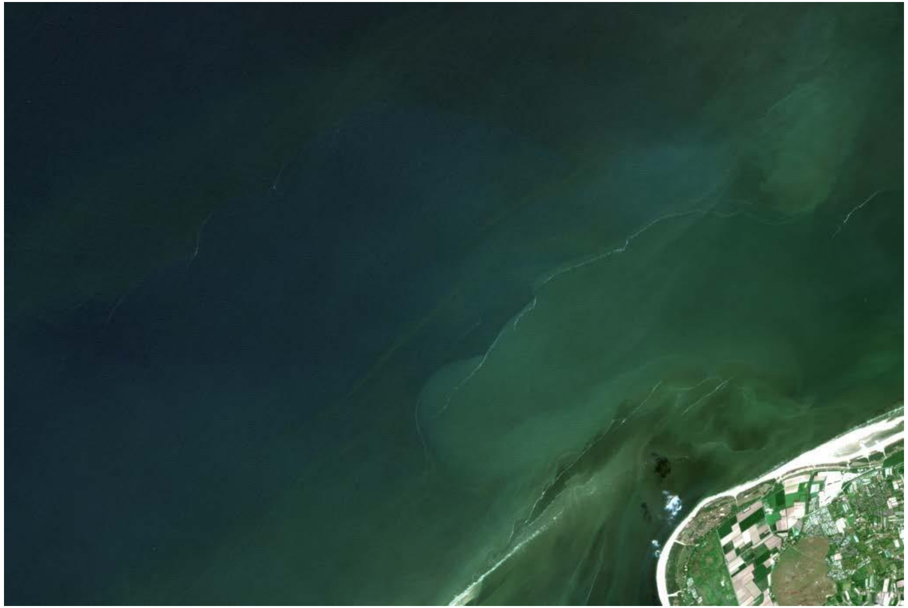
>100C

>350C

Introduction: Effects



Introduction: Effects



Lower Contrast in blue channel; slight increase in noise

Previous Work

- *In-situ Optical Characterization of Outgassed Compounds*, R. Martins et all, Proceedings of the 13th ISMSE, Pau, France, 2015

- *Investigation of contamination effects on critical surfaces*, B. Bras et all, Proceedings of the 12th ISMSE, Noordwijk, The Netherlands, 2013

Main Goals

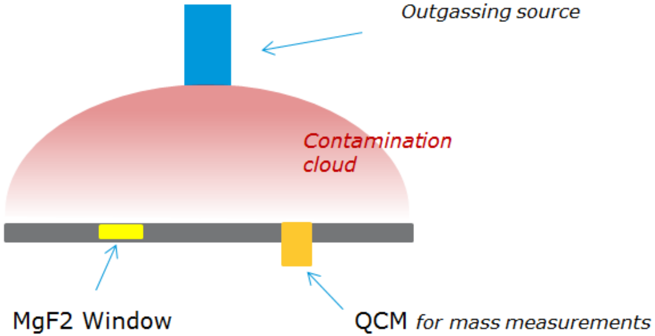
- The **direct determination** of the **effects** of the contaminant film growth: the **spectral response.**
- **Substrate effect** on the film formation (e.g. island vs uniform layer).
- The verification of any mission's contamination budget in respect to the optics performance.
- The **optical characterization of the contamination** layer (by using thin-film techniques to model the obtained data).
- A **database** containing the optical properties of the contamination species. This will enable the estimation of contamination effects on other surfaces.
- **Environmental** effects (pressure, temperature, (V)UV irradiation).

Test Method and Chamber

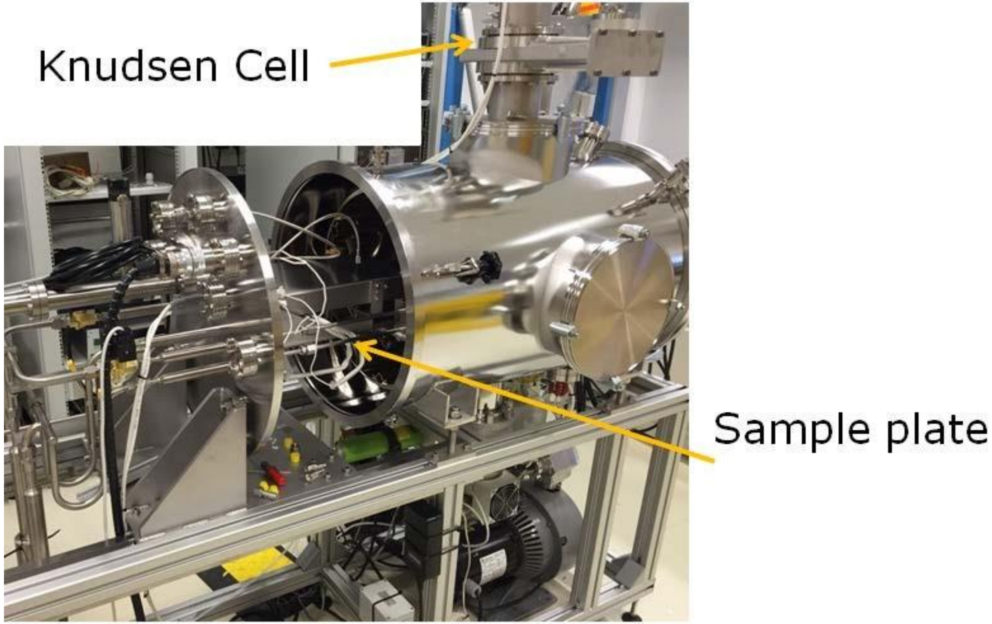
The **new test method** was designed to evaluate ***in-situ*** the performance of optical surfaces **during** the **deposition** of a **contamination layer**.

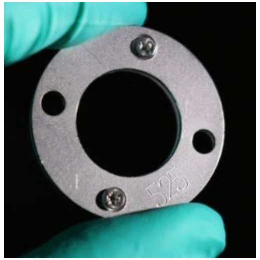
Evaluation of contamination's **direct consequences/effects** on sensitive surfaces.

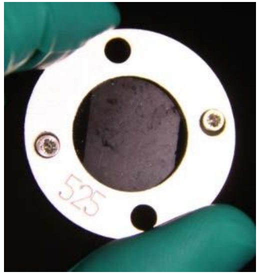
Spectral response: transmittance, reflectance



Test Method and Chamber





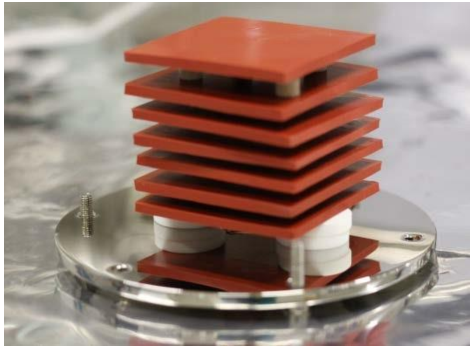


First results

RTV S691

Jaxa vs ESA

Inter-comparison

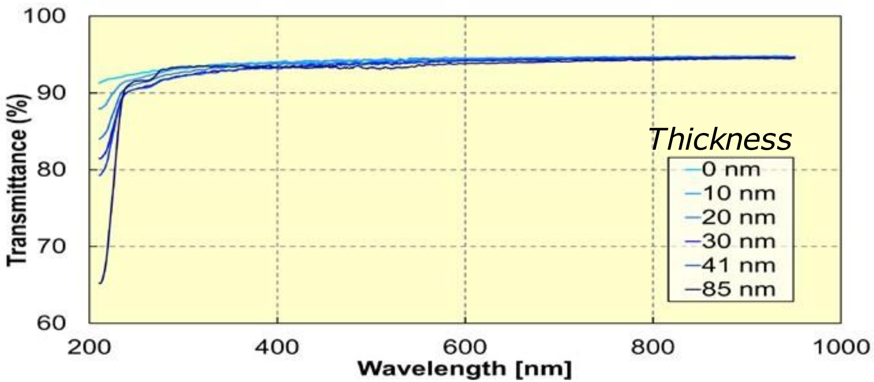


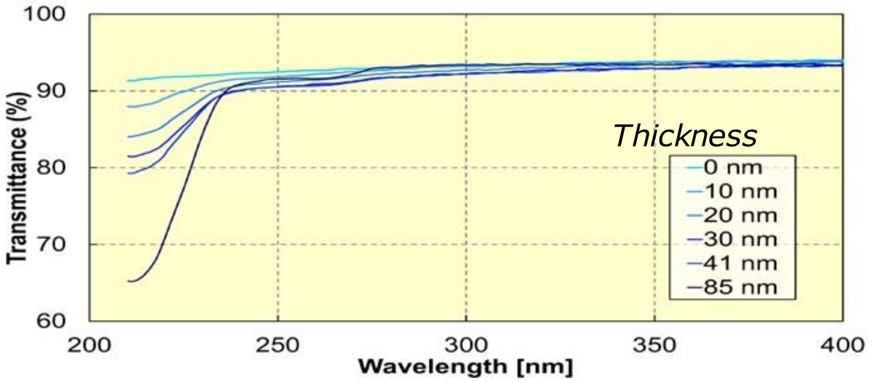
RTV S691: Test Conditions

Item	ESA	JAXA
Pressure	10^{-6} mbar	10^{-6} mbar
Temperature Substrate	-79°C to -82°C	-80°C
Temperature QCM	-78°C	-80°C
Temperature KC	+120°C	+120°C
Optical Substrate	**SiO2**, CaF2, ZnSe	**SiO2**

Contaminant Source Material: **RTV S691**
cured by JAXA

RTV S691: SiO2 In-situ results





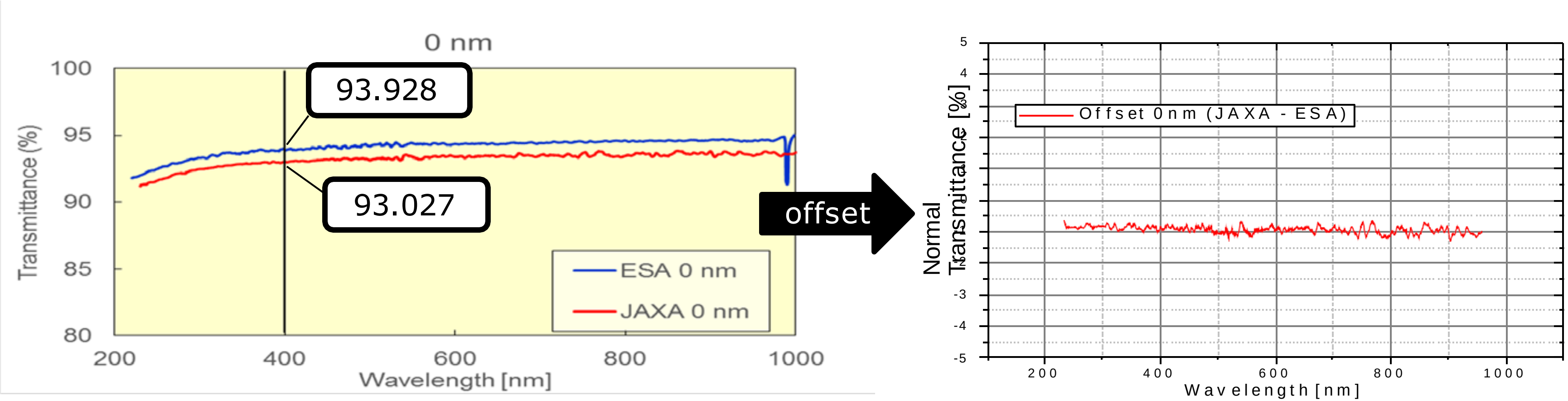
- Main absorption peak: < 240 nm
- Second absorption peak: 270 nm

- Thickness increase = transmittance decrease

- There are small interferometer fringes noticeable from a thickness of 85 nm.

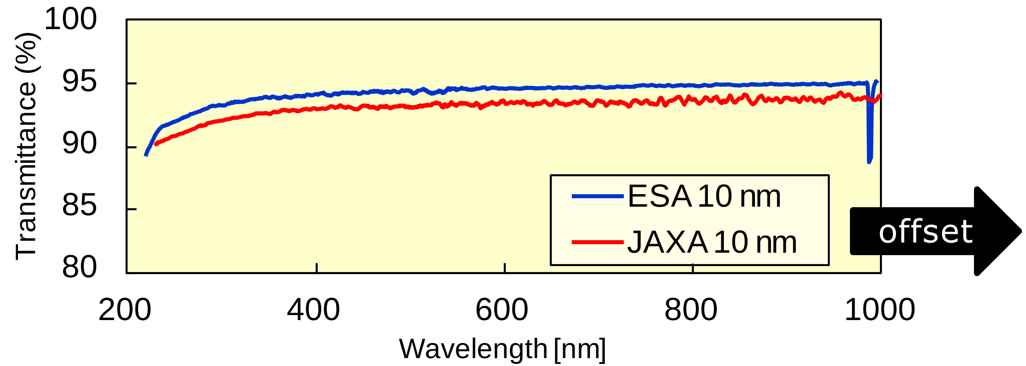
RTV S691: Comparison to JAXA results

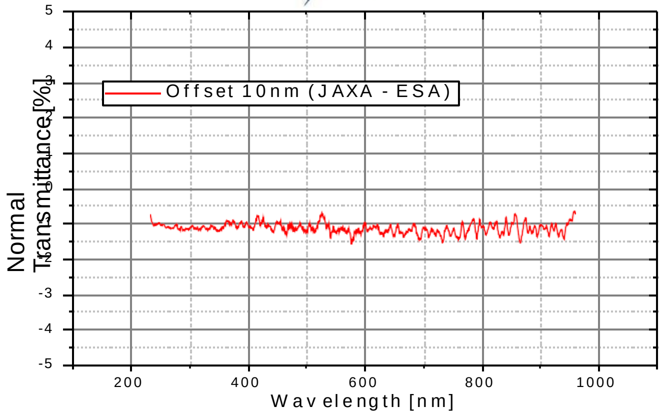
Contaminant Thickness: 0nm

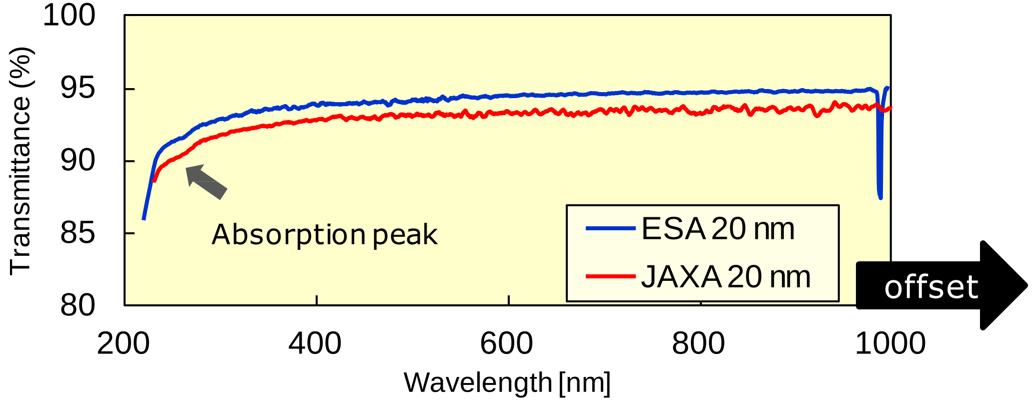


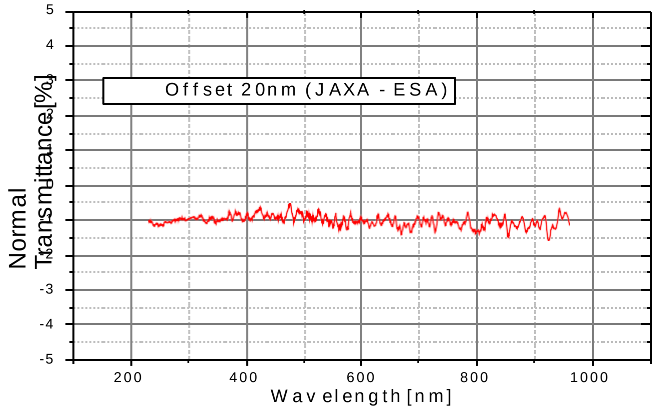
- Offset of approximately 1% over the whole wavelength range.

RTV S691: Comparison to JAXA results

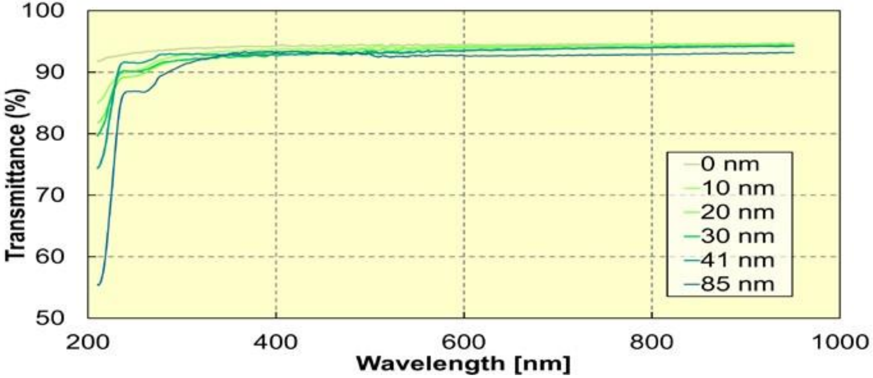


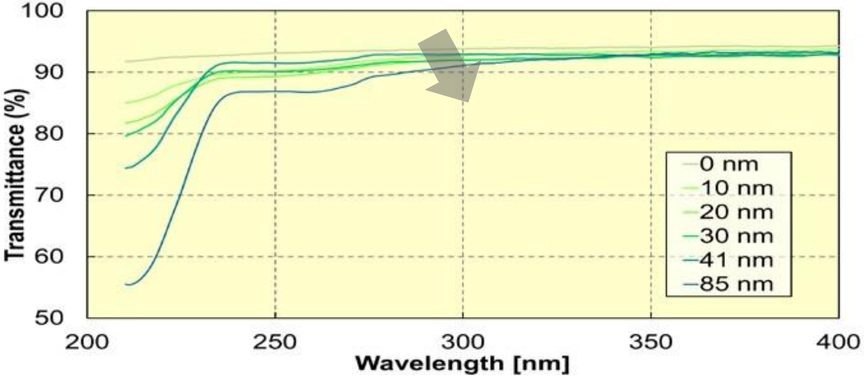






RTV S691: CaF2 In-situ contamination results

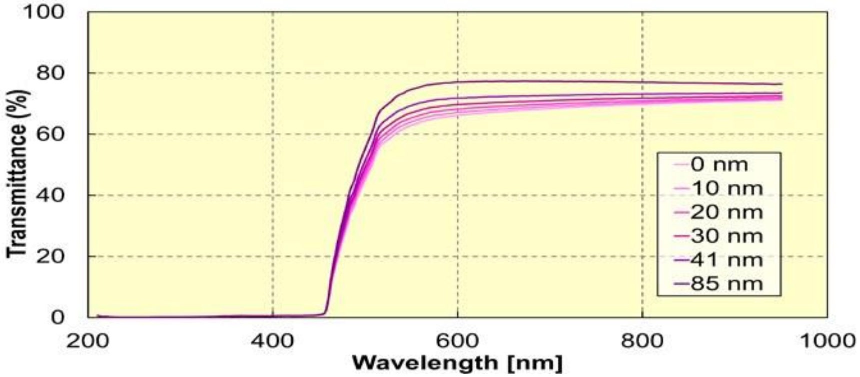


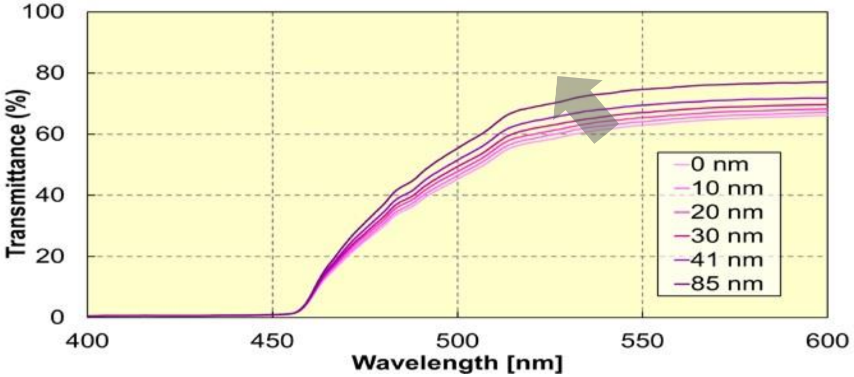


- Main absorption: < 240 nm
- Second absorption peak: 270 nm

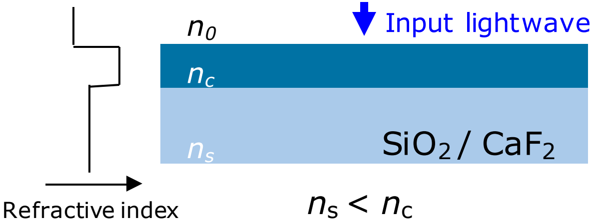
- Thickness increase = transmittance decrease

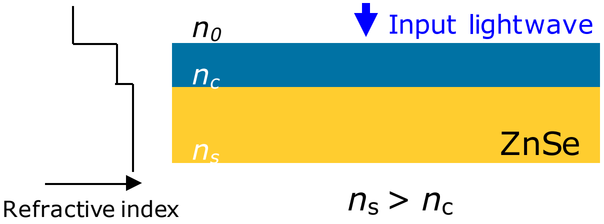
RTV S691: ZnSe In-situ contamination results





- Thickness increase = transmittance increase

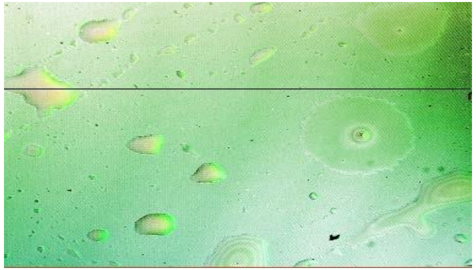
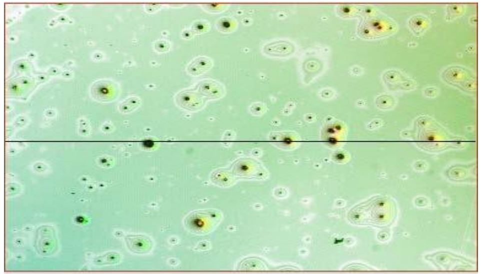
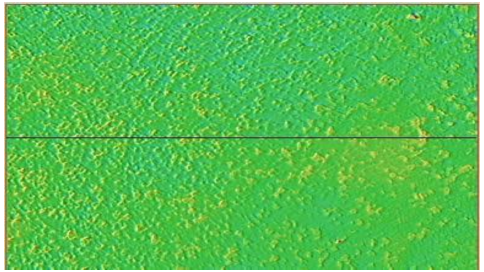
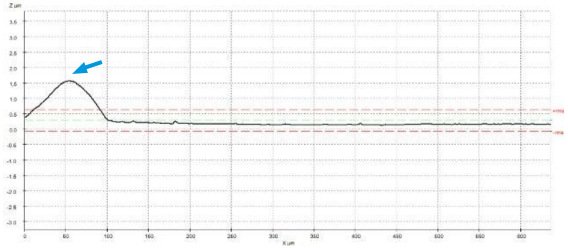
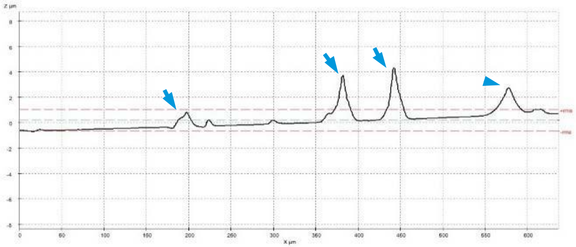
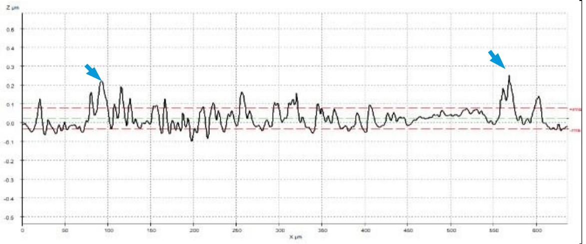




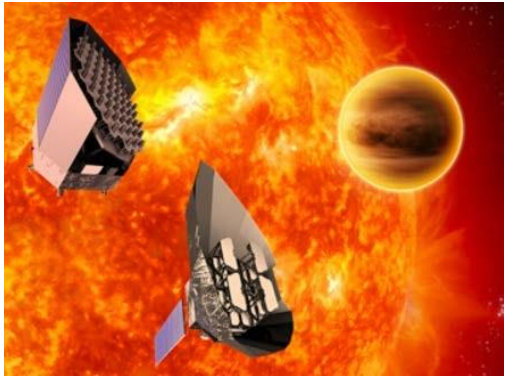
	Refractive Index at 600nmλ
SiO2	1.46
ZnSe	2.61

RTV S691: Surface observation

Leica Confocal Microscope

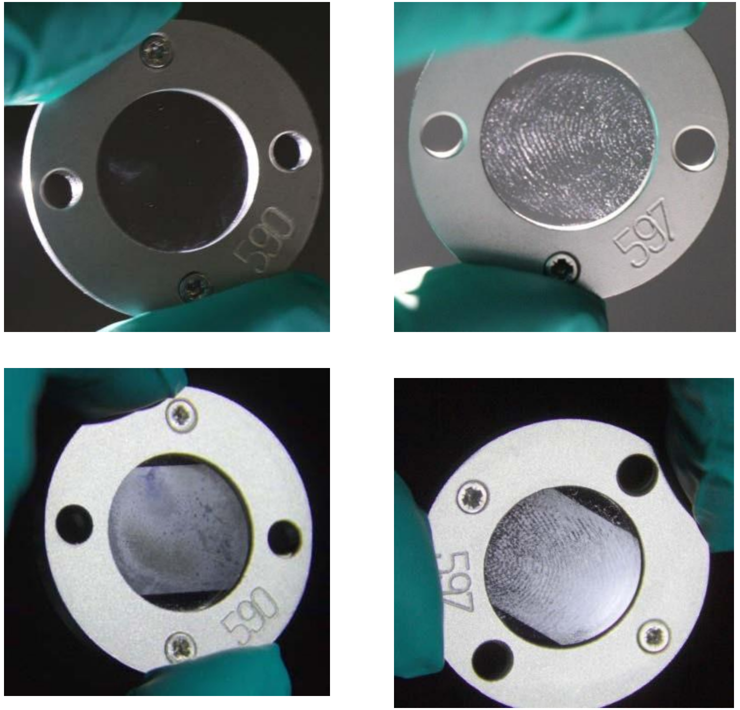
SiO_2	CaF_2	ZnSe
		
		

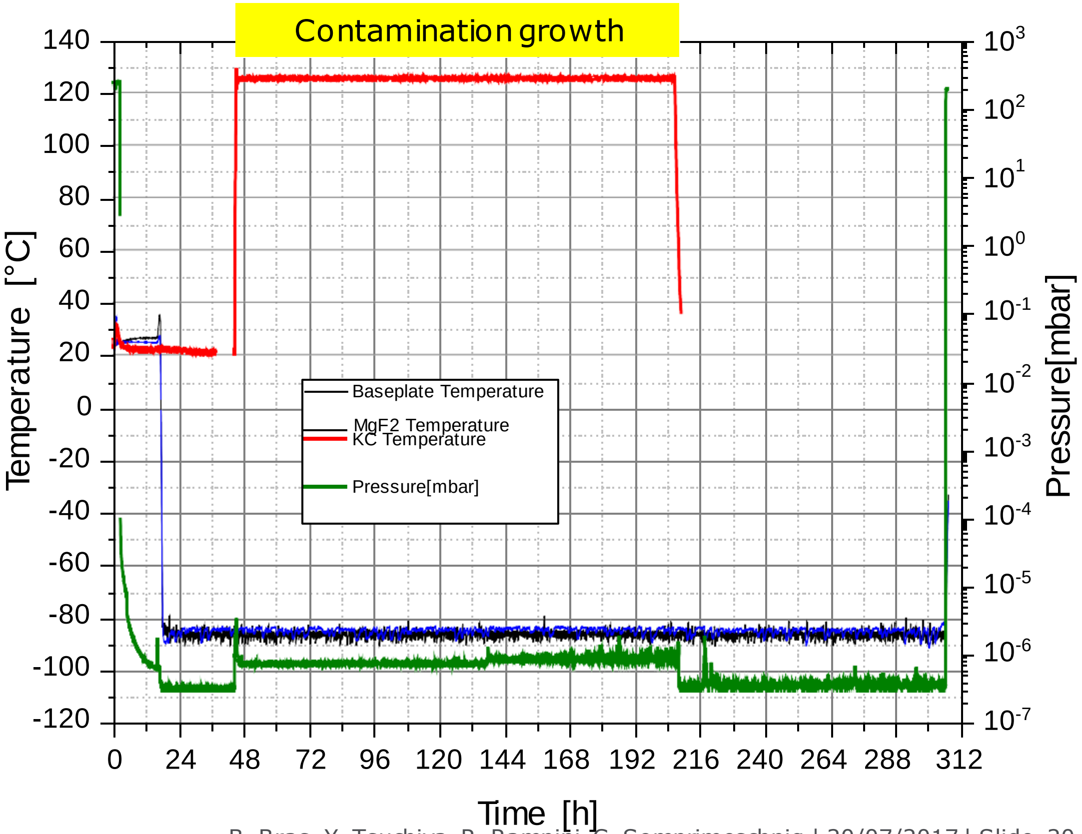
Scotch-weld Epoxy Adhesive



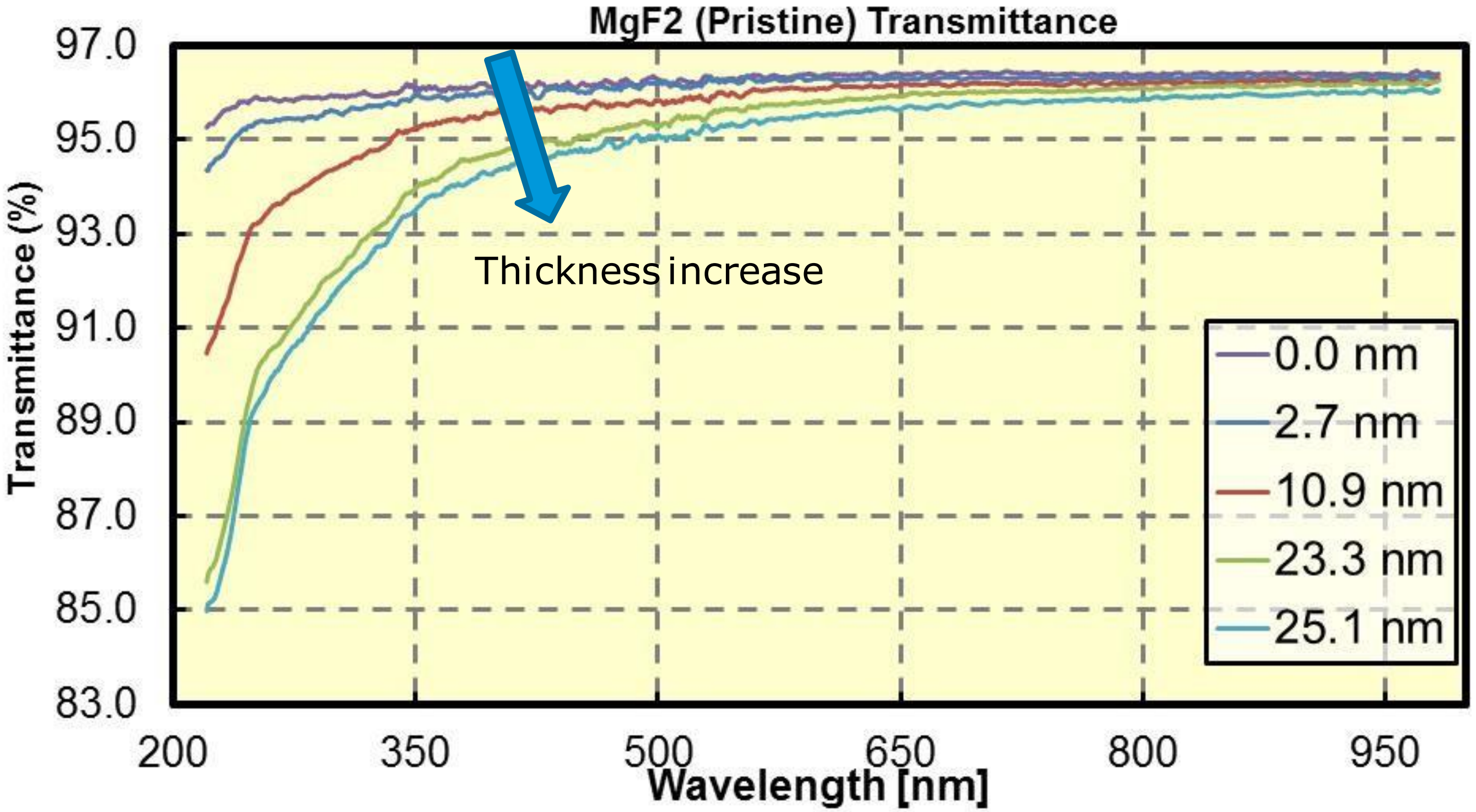
Sponsored by
Plato Mission

SW: Test Conditions

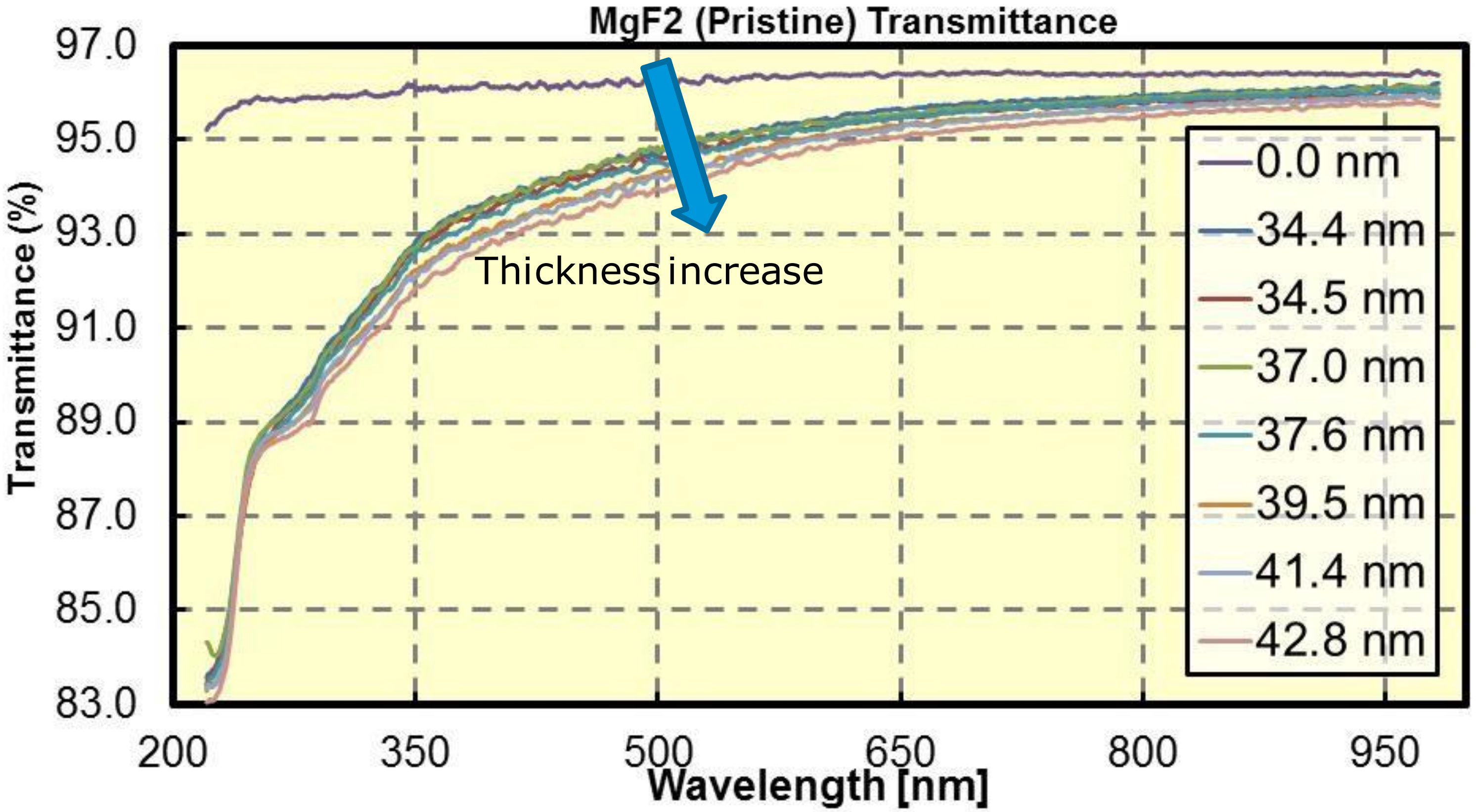




SW: Clean MgF2 – 0 nm to 25 nm



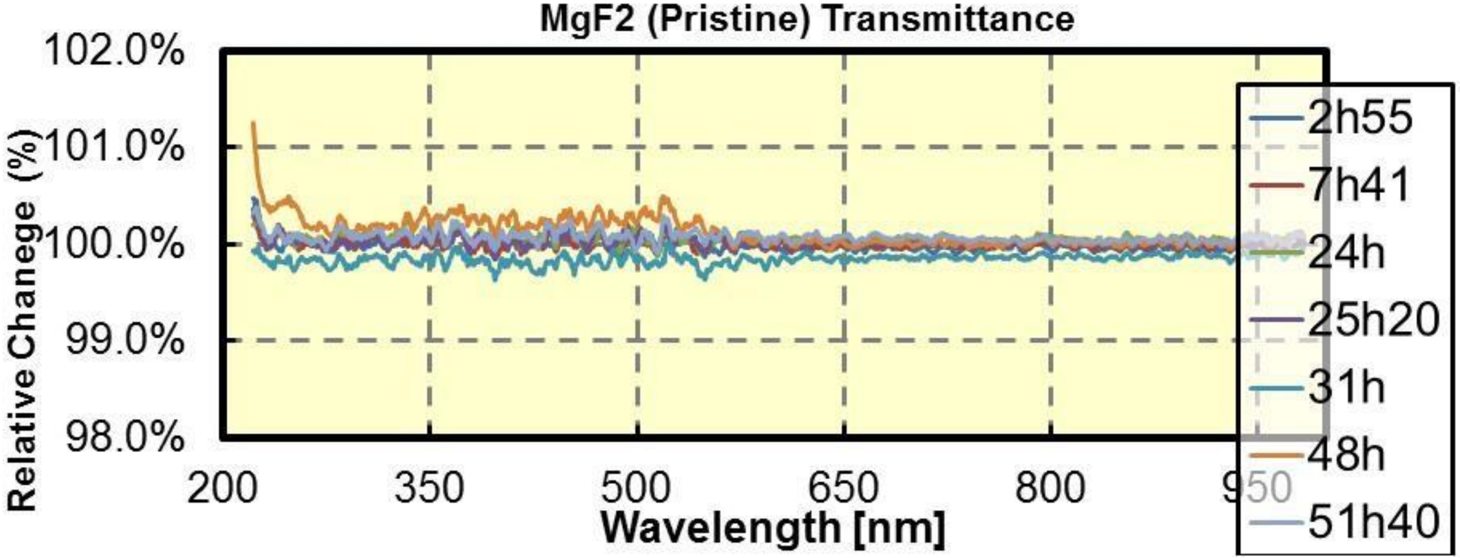
SW: Clean MgF2 –up to 43nm



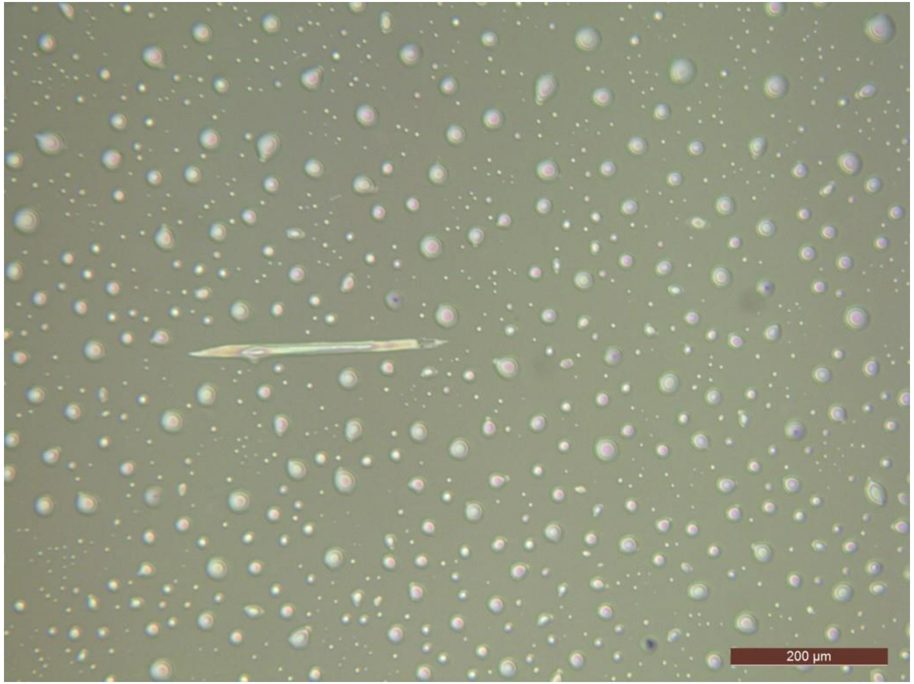
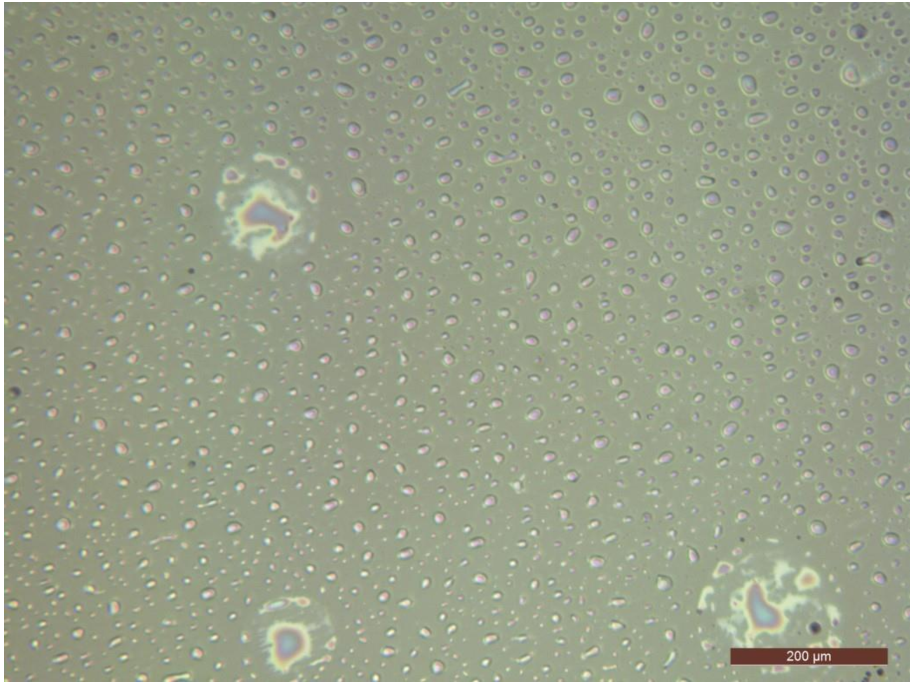
SW: Stability

After the growth of the contamination layer, the samples were kept in vacuum at isothermal conditions (-85°C) during >50h. To assess possible *time-dependent* phenomena.

Relative change to last spectrum acquired during layer growth (#17)

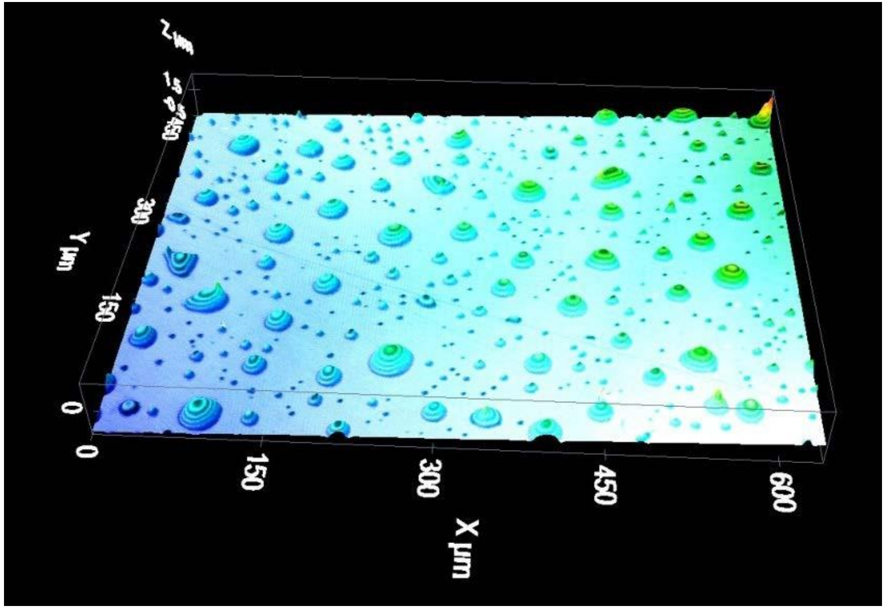


SW: Optical Microscope

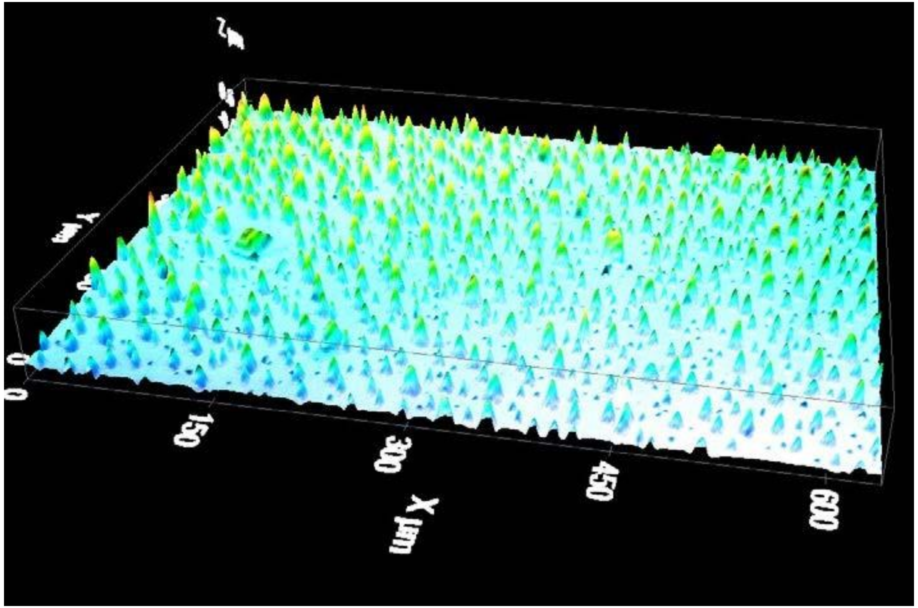
Clean MgF2 window	O2 Plasma treated
	

SW: Confocal Microscopy

Clean MgF2 window



O2 Plasma treated



Data Treatment Methods

A) **Absorption Coefficient**

Nasa Report 4740

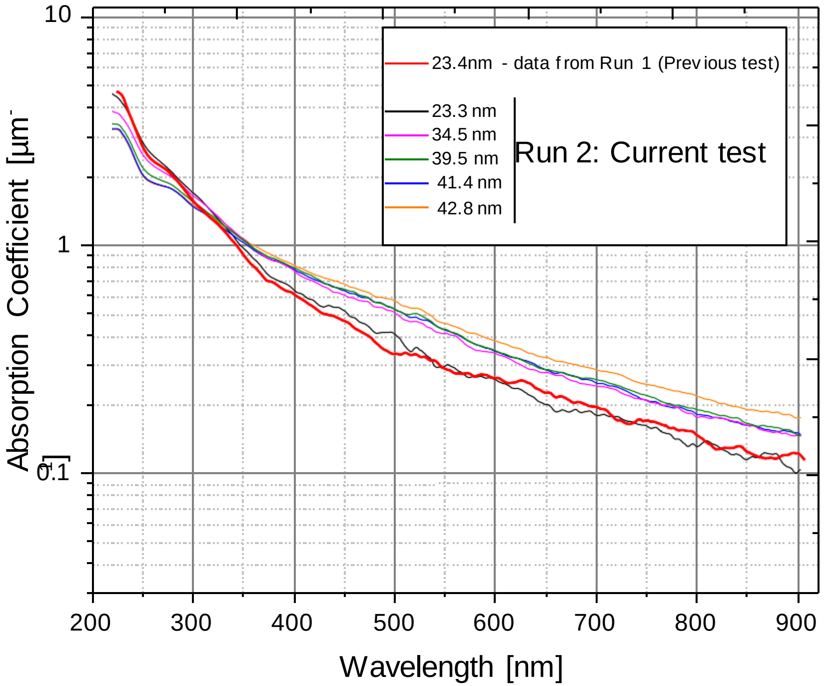
Contamination Control Engineering Guidelines

B) **Complex Index of Refraction**

Spectra Modelling

Absorption Coefficient

Calculation of the Absorption Coefficient of the outgassed contaminants from Scotch-weld Adhesive

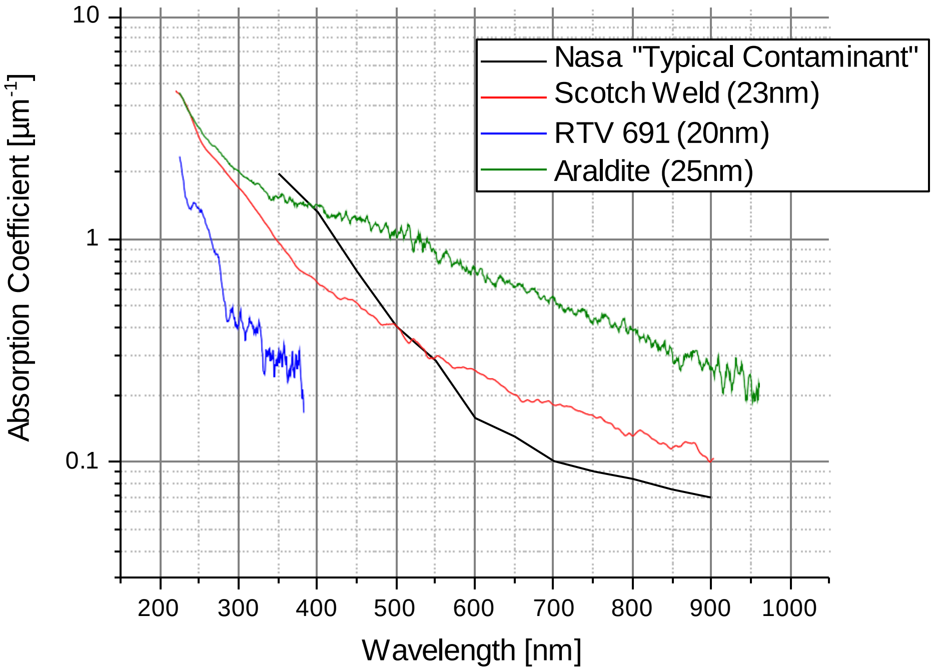


$$\tau^{x}(\lambda) = \tau(\lambda)\exp[-\alpha_c(\lambda)x]$$

Thickness derived from QCM, assumed density = 1 g/cm^3

Absorption Coefficient

- Comparison between different outgassing sources.

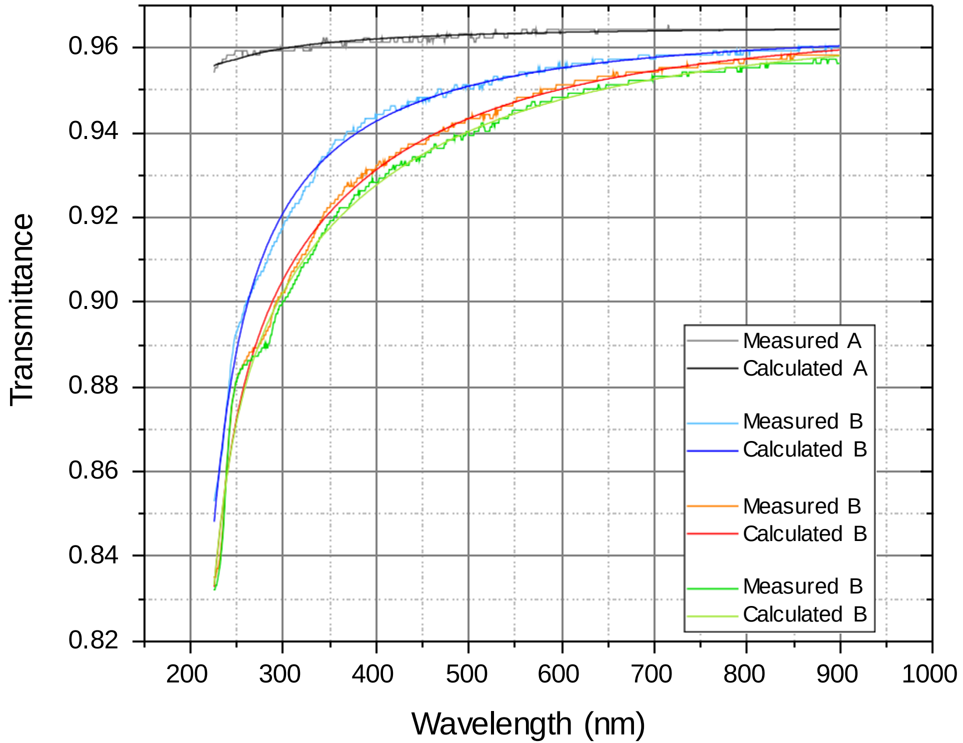


Comparison plots for qualitative information only

Araldite and RTV 691 data from the commissioning phase of the facility (different temperatures of the source, substrates, …)

Complex Index of Refraction Modelling

Full Characterization

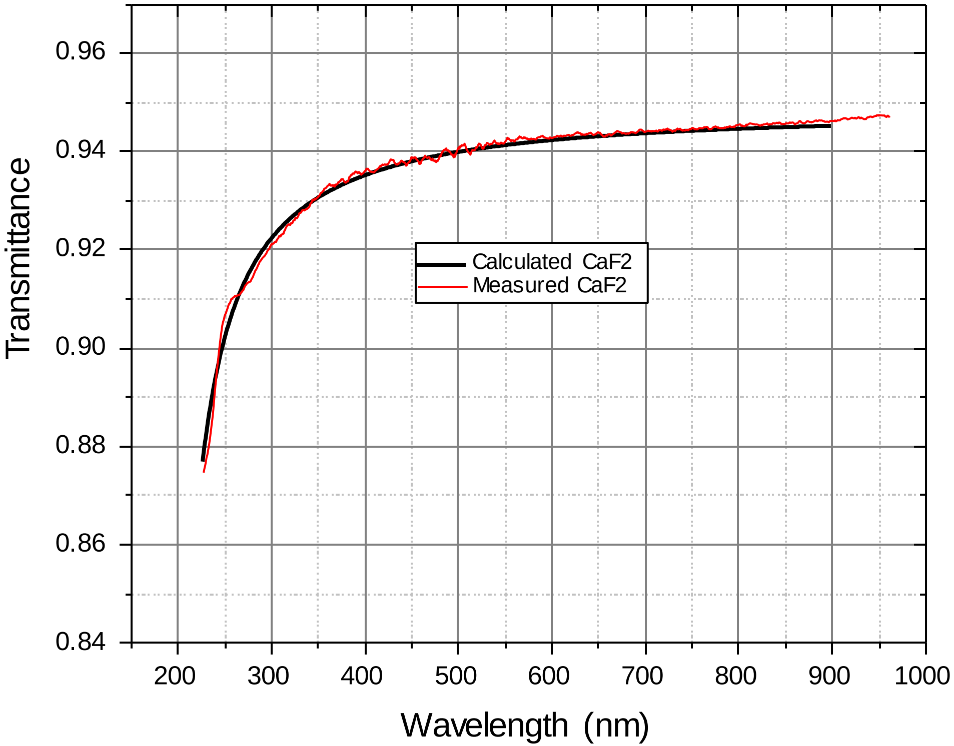


MgF2 substrate

Thickness QCM (nm)	Model (nm)
0	**0**
25	**26.7**
39	**39.2**
43	**42.4**

Complex Index of Refraction Modelling

Full Characterization → Validation



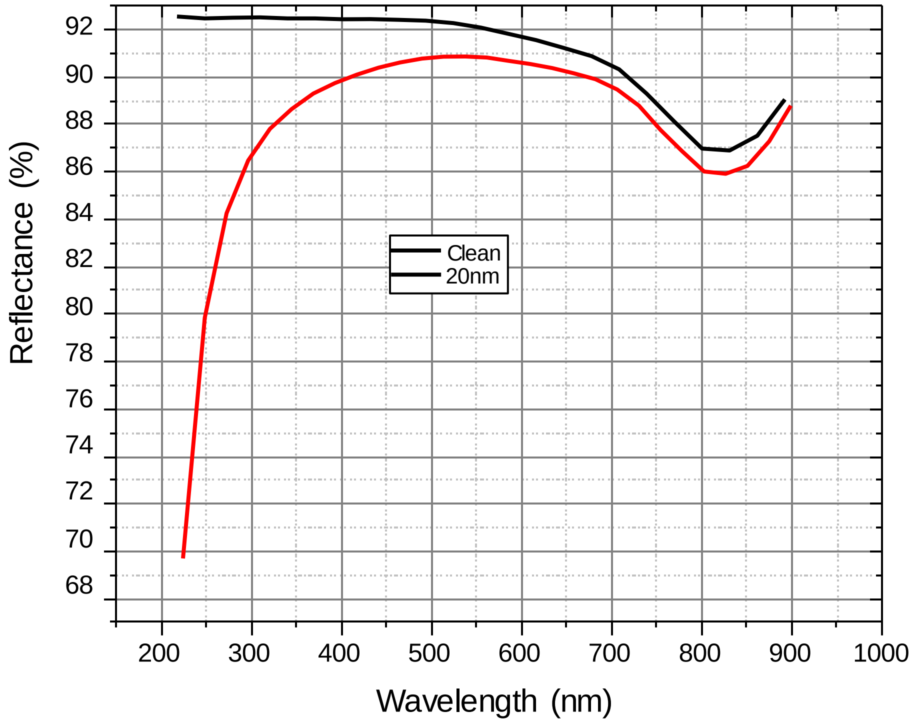
CaF2 substrate

Predicted thickness: 15.5nm

Model Result: 13.7nm

Complex Index of Refraction Modelling

Full Characterization → Validation → Prediction



Al mirror with 20nm thick

Closing Remarks

- Closer to **understanding** the effects of contamination on the overall performance of the subsystem.
- Mission’s contamination budget **verification**.
- **Affinity** substrate/contamination.
- **Environmental** effects (pressure, temperature, (V)UV irradiation).
- **Database**.

Thank you for your attention!!