ASSEMBLY AND CHARACTERIZATION OF EOS TARGETS FOR LMJ EXPERIMENTS

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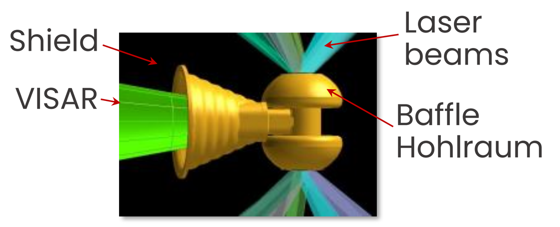
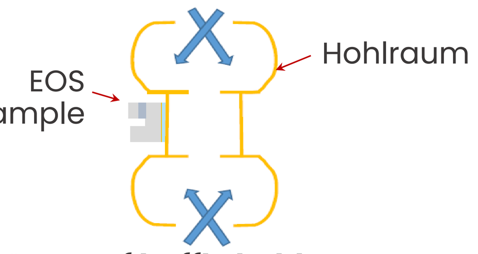
Context

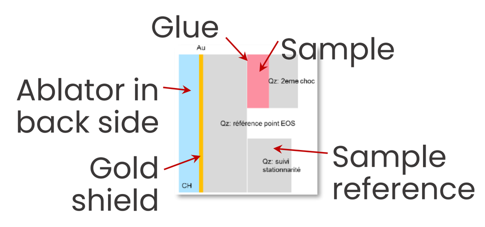
CEA designs, develops and manufactures targets, especially EOS targets, to be experimented on the LMJ [1].



Setup of indirect-drive experiments

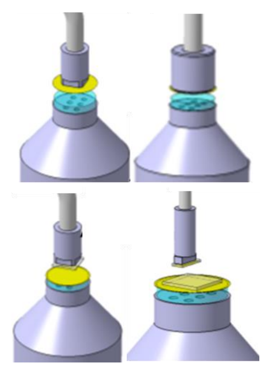


Setup of baffle hohlraum



Multilayered physics package

Several specific tools are developed to reach these specifications



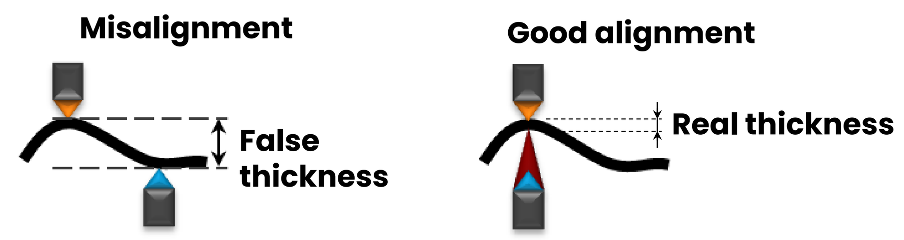
Sample specifications:

- Thickness material (ablator, samples…): < 200 µm, U < 1 µm,
- Roughness and flatness < 500 nm,
- Glue thickness: < 5 µm, U < 1 µm,
- Obtain these values in the ROI for experiment.

The conventional instruments can find limitations in their capabilities to measure thickness and flatness for the thinnest membranes. To overcome this situation, a dedicated equipment is under development.

Probes' adjustment

Main error measurement → probes misalignment



Estimation of probes misalignment error:

Extrapolation of maximum intensity coordinates

→ Alignment precision: 0.2 µm

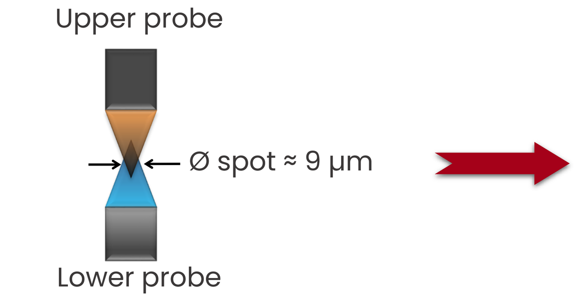
Probe alignment drift during characterization: < 2 µm

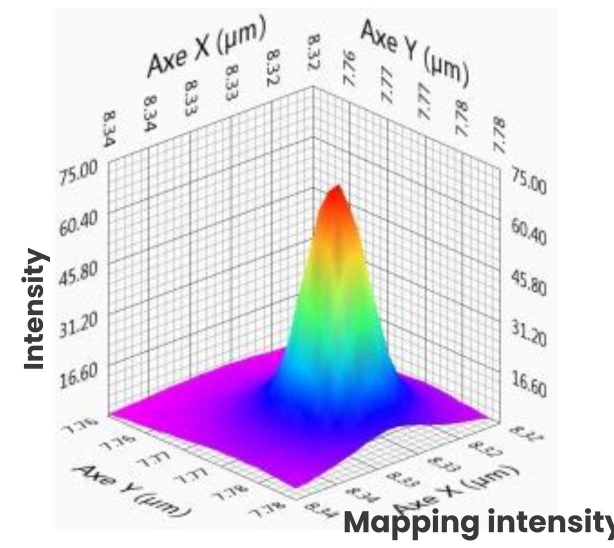
Sample flatness default: < 5°

→ Thickness error < 18 nm

Alignment methodology

Assumption: In perfect probe coaxial alignment, the lower probe catches the upper probe light.





Mapping intensity

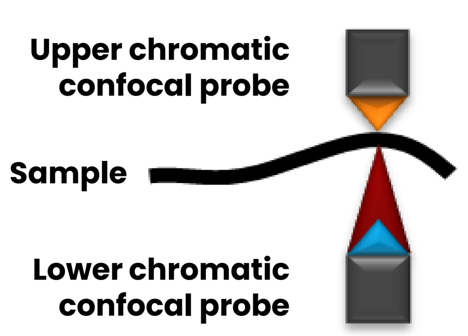
- Validation with standard samples:
  - Titanium Gauge: (14,6 ± 0,2) µm
  - Stainless steel gauge: (100,03 ± 0,02)

→ **E = (14.87 ± 0.07) µm**

- **Deviation: 1.85%** compared to expected value
- Measurement uncertainty: ± **0.47%**
- Systematic error: ***Cs* = −0.27 µm**

Experimental device

This equipment is based on two chromatic confocal probes placed above and below the sample to characterize.



Probe's specifications:

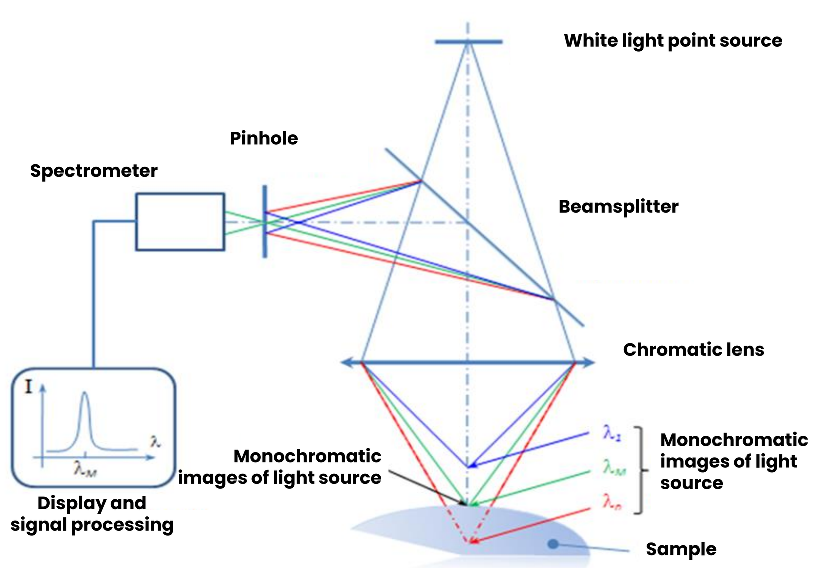
- Measuring range: 400 µm
- Working distance: 10.8 mm
- Accuracy: 40 nm
- Lateral resolution: 3.7 µm

Principle of chromatic confocal imaging

An incident white light source is imaged through a chromatic lens into a continuum of monochromatic images along the axial direction.

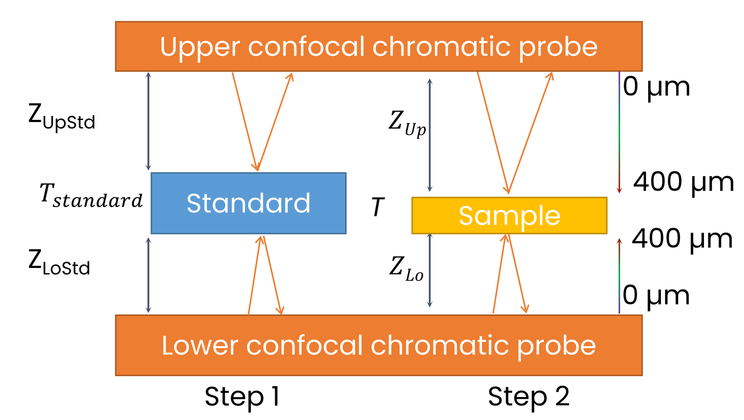
When an object is present in this "colored" field, a unique wavelength is perfectly focused at its surface and then reflected into the optical system.

This backscattered beam passes through a filtering pinhole into a spectrograph which determines the wavelength has been perfectly focused on the object.



Thus, sample surface position or transparent object thickness is accurately determined in the measuring field.

Measurement processing



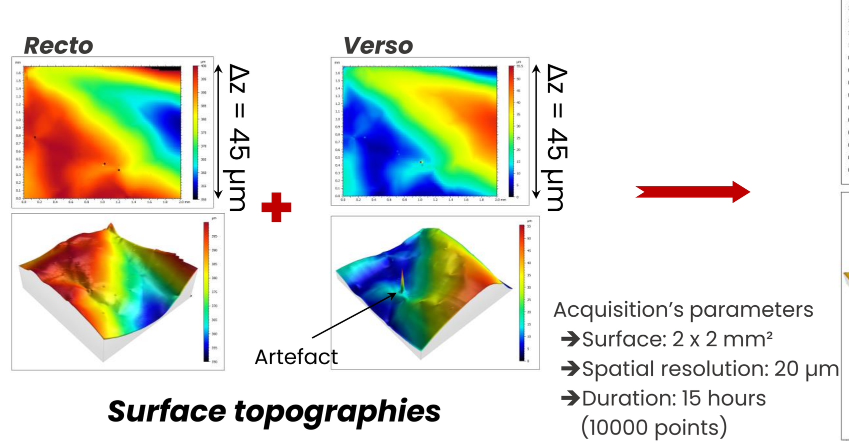
Step 1 : The distance separating two probes is estimated by using a thickness standard (*Tstandard*, *ZUpStd* and *ZLoStd*).

Step 2 : The sample is placed instead of standard (*ZUp* and *ZLo*).

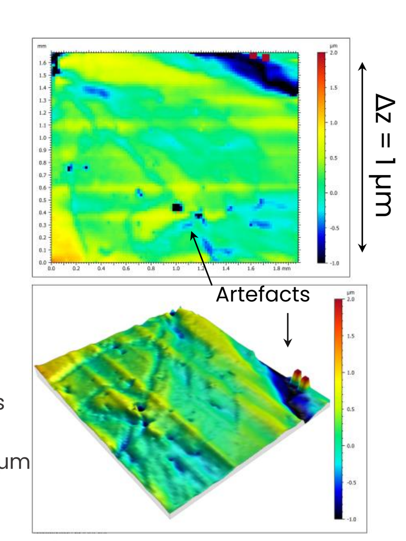
Step 3 : Thickness sample is estimated with following relation:

$$T = T_{standard} + (Z_{UpStd} - Z_{Up}) + (Z_{LoStd} - Z_{Lo})$$

Results



Surface topographies

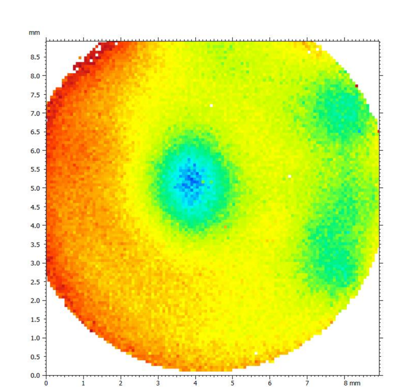


Thickness cartography

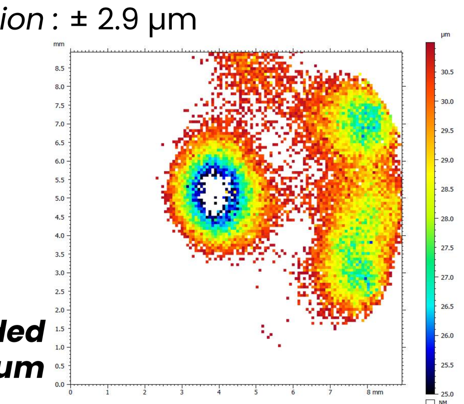
Thickness cartography is independent of flatness defaults.

Characterization of opaque material

- **Targets specifications:**
  - Target n°1: (28 ± 3) µm
  - Target n°2: (30 ± 3) µm
- **Issues:**
  Thickness inhomogeneity resulting of honing and polishing
- **Solution:**
  Development of a detailed analysis of thickness cartography
  → Identification of ROI need to specifications
  → Determination of laser cutting plan

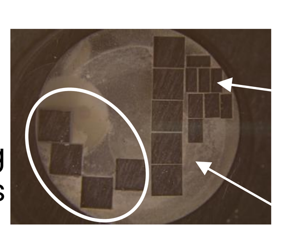


Thickness cartography of metal foil with EMMiE.
Diameter 10 mm,
Standard deviation : ± 2.9 µm



Extraction of values included in specifications: (28 ± 3) µm

- **Results :**



Training pieces

Target n°1
Thickness between 27.48 µm and 29.43 µm ± 0.16 µm

Target n°2
Thickness between 31.00 µm and 31.72 µm ± 0.13 µm

- Optimizing laser cutting
- Improvement in thickness homogeneity of samples

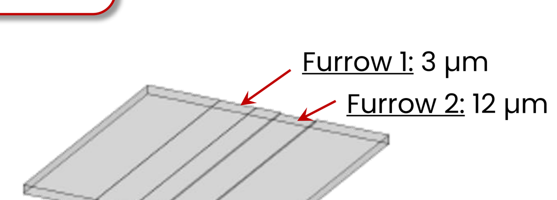
Characterization of transparent material

- **Issues:**
  - Saturation of opposite sensor,
  - Misdetection.

Methodology to be adapted

- **Solution:**
  - Alternating operation,
  - Focus on the first surface.

- **Applications**
  → Milled quartz characterization



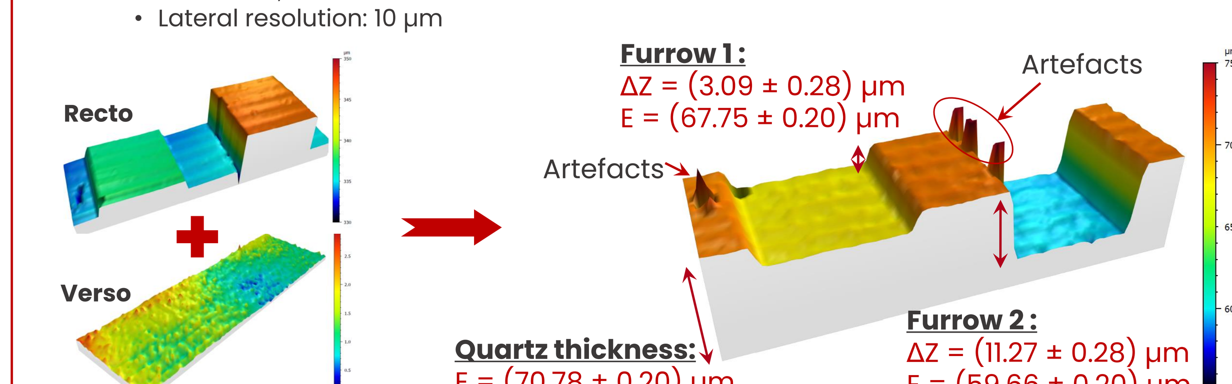
- ***Standard characterizations:***

→ Thickness measurement with mechanical comparator: (70.9 ± 0.5) µm

→ Depth of furrows with interferometric microscopy: Furrow 1: (3.14 ± 0.04) µm; Furrow 2: (11.28 ± 0.04) µm

- ***Thickness characterization:***

Acquisition setup:
- Area : 1 x 0,3 mm²
- Lateral resolution: 10 µm



- Good agreement between instruments
- Thickness measurement more accurate

This device gives thickness measurements in the bottom of furrow.

Glue thickness

Interface	Quartz / Quartz	Quartz / Polished metal	Polished metal / Polished metal	Quartz / Not polished metal	Polished metal / Not polished metal
Mean thickness of glue (µm)	**1.0**	**1.7**	**1.8**	**4.4**	**6.0**
Standard deviation (µm)	1.1	1.3	0.8	1.3	1.7
Higher thickness (µm)	3.2	4.9	2.8	5.7	8.4
Lower thickness (µm)	-0.3	0	0.7	2.9	3.1

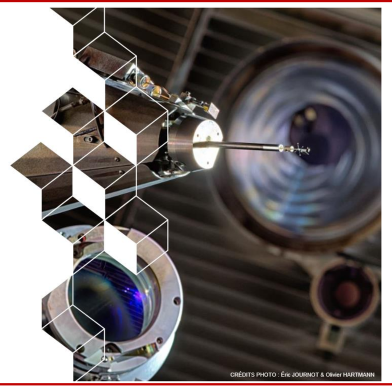
Roughness: Quartz < 100 nm → Polished metal < 500 nm → Not polished metal ≈ 1 µm

Conclusion & prospects

This equipment gives thickness cartography of opaques or transparents materials with submicrometer uncertainties. It uses two chromatic confocal probes located on both sides of sample. The precision is improved with a dedicated alignment process.

Combined with topographies of assembled samples, theses thickness cartographies give us the possibility to estimate the thickness of glue with a sufficient precision.

Currently, we develop the measurement processing to characterize the multilayered samples [2] [3].



Bibliography

[1] Caysac W. and *al.*, "Experimental capabilities of the LMJ-PETAL facility", High Energy Density Physics, 52 (2024).

[2] Miks A. , Novak J. and Novak P., "Analysis of method for measuring thickness of plane-parallel plates and lenses using chromatic confocal sensor", Applied Optics, vol. 49, No. 17 (2010).

[3] Claus D. and Nizami M.R., "Influence of aberrations and roughness on the chromatic confocal signal based on experiments and wave-optical modeling", Surface Topography: Metrology and Properties, 8 (2020).