TARGET FABRICATIONS PROGRESS FOR MEGAJOULE LASER EXPERIMENTS


12-16 MARCH 2017
A short introduction of the LMJ facility status

Target fabrication progress:

We are developing a thematic approach on LMJ: a large panel of experiments will be done before consolidating the ignition target design with dedicated experiments:

- A lot of different laser targets types are necessary
- Many fabrications developments (Microtechnologies, materials, characterization, assemblies...)

ACKNOWLEDGMENTS TO J-L MIQUEL (PROJECT MANAGER) FOR HIS SLIDES
LASER MEGAJOULE MAIN CHARACTERISTICS

4 Laser bays
- Glass Nd laser, frequency tripled: $\lambda = 0.35 \text{ µm}$
- Designed for 240 beams, 176 will be installed
- Laser energy ~ 1.5 MJ, Power ~ 400 TW
- Pulse duration: from 0.7 to 25 ns

Target bay
- Biological protection: 2 m thick concrete
- Target chamber Ø 10 m
- 200 ports for laser beams and diagnostics

Ignition target
- 2 X 2 cones irradiation: 33° & 49°
- Hohlraum length ~ cm
- Capsule Ø ~ 2 mm

DT cryogenic layer
The LMJ beamlines: most of the components have been qualified on the LIL prototype.
Three main activities are performed during the year
- Mounting of new bundles
- Activation / qualification of the previous assembled bundles
- Plasma experiments

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Usually, only one shift is dedicated to experiments => 1 shot/day
- With both shifts, 2 shots/day have been obtained several times

In the next years: 50 Physics shots + 30 preparation shots (Diagnostic qualification, pointing, synchronization, ...) per year
1- Hohlraum energetics
   Laser plasma interaction, X-ray conversion
   ➞ Control of radiation flux

2- Fundamental data
   EOS, Opacities...
   ➞ Control of matter's behavior under HP and HT

3- Radiation transport
   X-ray absorption, loss, reemission
   ➞ Control of energy transport

4- Implosion hydrodynamics
   Implosion velocity, Shock tuning
   ➞ Control of compression

5- Hydrodynamic Instabilities
   Instabilities growth, turbulence
   ➞ Control of mixing

6- Fusion studies
   Thermodynamic conditions, initiation of fusion reactions
   ➞ Control of ignition conditions

7- Ignition
   Study of different kind of ignition targets
   ➞ Control of DT burning

8- Applications
   Coupling of an ignition target with another target
   ➞ Control of complex powerful system
TARGET FABRICATION
RECENT PROGRESS
WHAT IS TARGET FABRICATION?

Conception
Specific materials
Machining
Assembly
Characterizations
Delivery
# 1 year
Gold holhraums but not only…

Additive manufacturing prototype

Holhraums with liners

- Complete liner:
  - Au 30 µm
  - Cu 1,5µm

- Localized liner:
  - Cu 1,5µm
  - Au 30 µm

Addition of PVD and electrolytic coatings

New process developed

See J. Andre’s poster
### Development of new densities:

**SiO$_2$ aerogels:**
- 20 mg/cc
- 40 mg/cc
- 60 mg/cc
- 80-100 mg/cc
- 300 mg/cc

**Ta$_2$O$_5$ aerogels:**
- 70 mg/cc
- 110 mg/cc
- 275-300 mg/cc
- 500 mg/cc
- 800 mg/cc

### Development of new fabrication techniques:

- Casting to avoid machining and assemblies

### Understanding aerogels aging process and environmental conditions influence on density:

- Density reversibility under vacuum
Low density gold: plasma electrolysis

Foam density strongly depends on ionic salt concentration \( \Rightarrow \) electrolytic phenomenon

Structure and relative density can be controlled with ion salt concentration and overvoltage

Optimization in progress (PhD) to obtain satisfying mechanical resistance necessary to machine this kind of very fragile materials
Praseodymium thin films

Spin-coating and Sputtering

500 nm
2000 nm
500 nm

Glass
Sacrificial layer
Al
Pr
Al

Release
Laser machining
Self supported disk Ø8 mm

Developments with some collaboration with LUXEL

Issues:
- Reducing residual stress
- Ageing: encapsulation between efficient aluminum layers

Surface mass (g/cm²) characterization

No deviation over 2 months under air:
- Al barriers are efficient
- No stress evolution

These membranes will be experimented early 2018 @ LMJ

Al/Pr/Al

High stress

Low stress

Al/Pr/Al

Al/Pr/Al
SPECIFIC MATERIALS: CAPSULES (MANDRELS)

PAMS Mandrels: improve yield

**Injection:** Syringe pump replaced by pressure-based flow controllers: higher flow stability, retro-control on flow rate variations.

**Curing:**
- Setting and monitoring installation parameters and fluorobenzene concentration → Software development
- Measuring fluorobenzene concentration all along the curing process in each bottle (Coated quartz crystal microbalance developed by CEA Le Ripault)

A943 PAMS shell meeting expectations (50% yield)
SPECIFIC MATERIALS: CAPSULES (GDP)

169.9 µm thick CHSi 4% at.

Roughness optimization

After GDP coating

After polishing

Yield before polishing 20%
Yield after polishing 45%

After GDP coating:
- First capsules without any bumps
- Some “light” scratches are observed inherent to polishing

Other “new” GDP studies:
- New dopants (poster)
- Asymmetric capsules

Ongoing work:
Master the outside shape to fit a specific function
**In-situ run out correction on UP lathe**

Development of custom spindle neck with X/Y adjustment

**Applications:**
- Run out correction
- Controlled shift of revolution axis

**Development of a custom µ-milling machine (4 axis)**

**Applications:**
- Foam & aerogel complex shape machining

**Investigation in µ-EDM**

Development of combined “turning” / “milling” by µ-EDM

**Applications:**
- Machining of “hard” materials (steel, Ta, W, B4C, etc.)

Compliant design, sub-micron adjusting capability

Milling in Low density foam

Tungsten carbide holhraum

See J. Andre’s poster
MACHINING : LASER

**Excimer laser**
- UV pulsed laser
  - 193 nm / 50 Hz / 30 ns

**Femtosecond laser**
- Ti:Sa ultrafast laser
  - 800 nm / 1 kHz / 150 fs

**Surface finishing**
- Removal of foams layers on the surface of metals
  - Foam over-thickness < 5 µm

**Cutting of rare-earth samples under dynamic vacuum**
- Controlled thermal effect on the edge (prevention of oxidation)

**Low density materials shaping. Example of Ta2O5 0,5 g/cc**
- Top/bottom diam.: 200 µm / 400 µm
- Optimized laser & motion parameters + Specific mask shape
ASSEMBLY

To face increasing target complexity and further increasing targets production

New assembly station prototype

Recasting of optical systems and command control / measurement software

Turrets motorization

Fast turret positioning

Specific automated stations: membrane gluing

Tools: additive manufacturing

Sucking nozzle for cone manipulation

Sucking nozzle for spherical ½ hohlraum manipulation

- Adapt assembly stations to new target geometries and increase reactivity
- Focus technicians on valuable operations & automatize assistance on repetitive actions
- Secure assembly operations (minimize sample manipulations)
Objectives:
1. Secure our means
2. Increase performance
3. Purchase or develop new means to answer to our needs

See L. Reverdy’s talk
V. Dutto’s poster
O. Raphael’s posters

Spheremapper
Thin film thickness cartographer
Confocal probes
Sample holder
Moving stages

Calibration samples to compare AFM heads
Opaque or transparent samples
3D measurements

X-ray tomographer
DEVELOPMENT OF 2 cryostats IN COLLABORATION WITH CEA GRENOBLE

**Cryoteci – D\textsubscript{2} cryostat**
- Cryo-thermometers calibration
- Keyhole target validation (liquid D\textsubscript{2})
- Useful temperature range is 15K-25K.
- Pulse tube as cold source
- Double thermal shield

**MVT-S – DT cryostat**
- DT ice layer conformation studies
- Temperature range 10 – 25 K
- Stability +/- 1 mK
- Pulse tube tandem for better stability

- Command control, gripper and thermal shield optimization in progress
- Delivery planned in 2 years @ Valduc tritium facility

- Last adaptations in 2017
- Tests on real target in 2018
TRANSPORT TO EXPERIMENTATIONS SITES

HED physic studies
Thank you!