Development of novel tape drive targets for use in High Repetition Rate XFEL experiments

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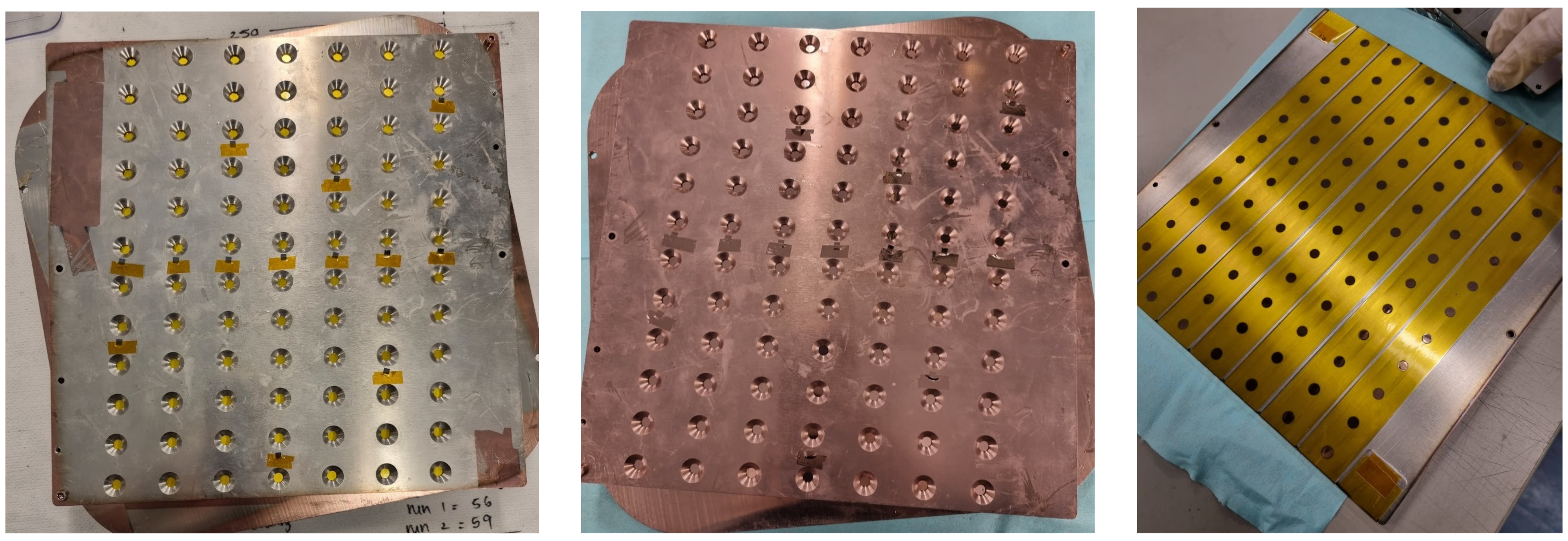
Motivation & Background:

- Dynamic compression of materials to pressures above 100 GPa can be carried out at x-ray free electron laser (XFEL) facilities with high-power laser drivers
- Materials responses at these pressures are relevant to planetary science, material science, and Inertial Confinement Fusion (ICF) [1,2,3, & 4]
- A long-term goal of dynamic compression is to operate at High Repetition Rates (HRR) of 1 – 10 Hz, which requires significant development in many areas, including target design and manufacturing, laser facilities capabilities, diagnostics, and data management [5]
- This poster will show some of the work being done by the Target Fabrication Group at the CLF to:
  - Improve the manufacturing process of the current tape targets
  - Design novel tape targets



(a) (b) (c)

Figure 1: A series of photos showing the initial method of coating, where the Kapton tape is sandwiched between two masking plates, removing the plates after the coating shows the required circular targets.

Sputter coating methods:

Method 1:

- The tape is wrapped around a base plate and sandwiched between two masking plates
- This is then secured to the rotating plate in the sputterer for coating (see Figure 1)

Advantages:

- Targets are isolated from each other
- This approach has been successfully used to make targets for a Gemini experiment

Disadvantages:

- Takes a lot of time to coat both sides of the tape
- It is difficult to wrap the tape around the base plate and ensure that it is completely flat
- Multiple layer targets increase the complexity as the tape needs to be wrapped around the backing plate again so that the masks re-align
- The amount of tape coated in one run is limited due to the size of the backing plate

Method 2:

- Both the tape and mask are fed through a modified tape drive system (shown in Figure 2) , and the mask is now laser cut Kapton
- This system can be coated in two different ways:
  - a) While the tape is stationary (enables thicker coatings)
  - b) While the tape and mask are both moving (quicker coating)

Advantages:

- Targets are isolated from each other
- With a larger coating system, this could coat targets much quicker than method 1
- Ensures the tape is tight throughout the coating process
- No limit on the length of tape that can be coated in one run

Disadvantages:

- Compared to method 1, it is harder to get thicker targets

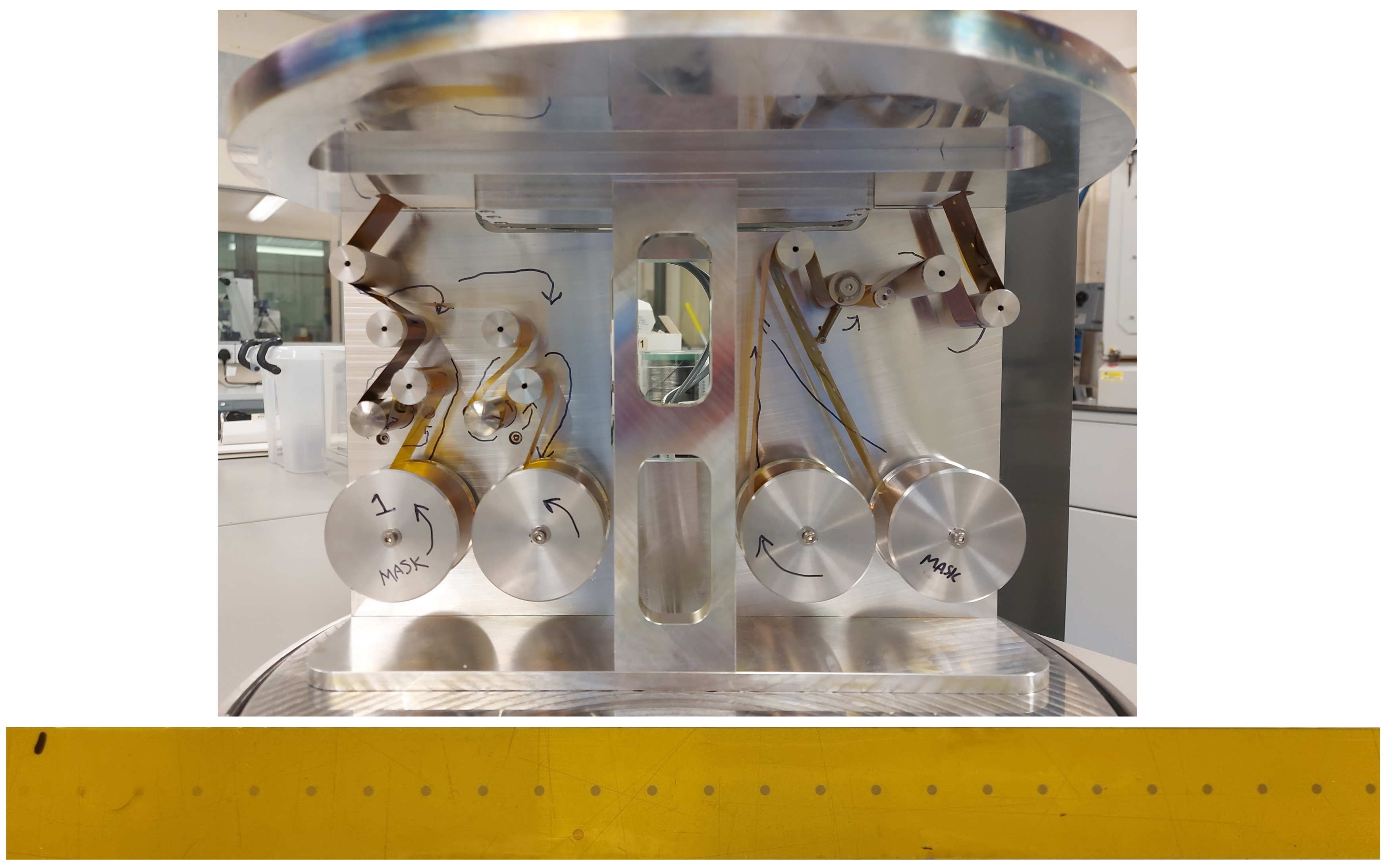
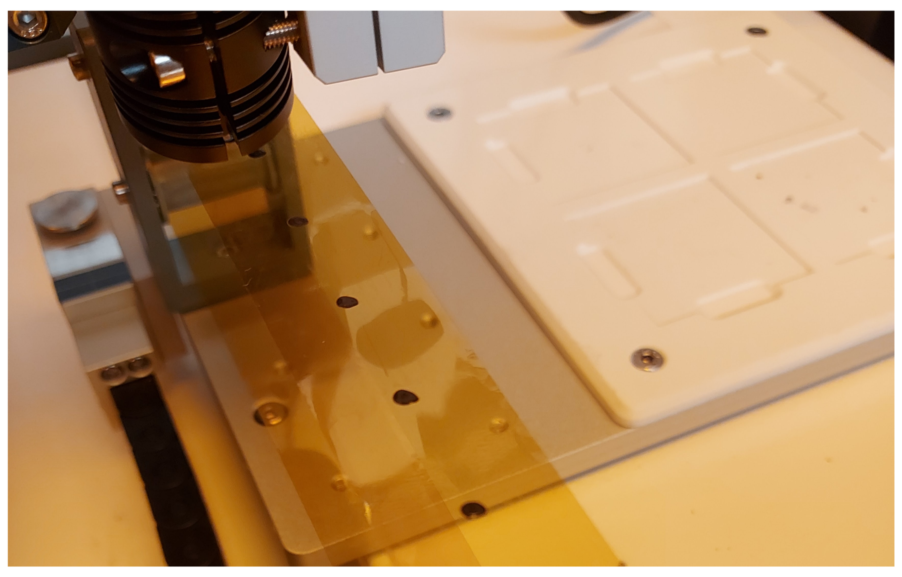


Figure 2: Top: An image of the modified tape drive system that feeds both the tape and its mask through the sputter coater. Bottom: An example of a coated tape created by moving and coating at the same time.

Slurry targets:

- Silicon slurry targets of diameter 2 mm and thicknesses between 80 and 300 um have been successfully deposited and cured using the Fisnar robotics system at the CLF
- The slurry was made using a UV-curing epoxy and silicon grain mix with a ratio of 10:1 and an average particle size between 1 and 5 um



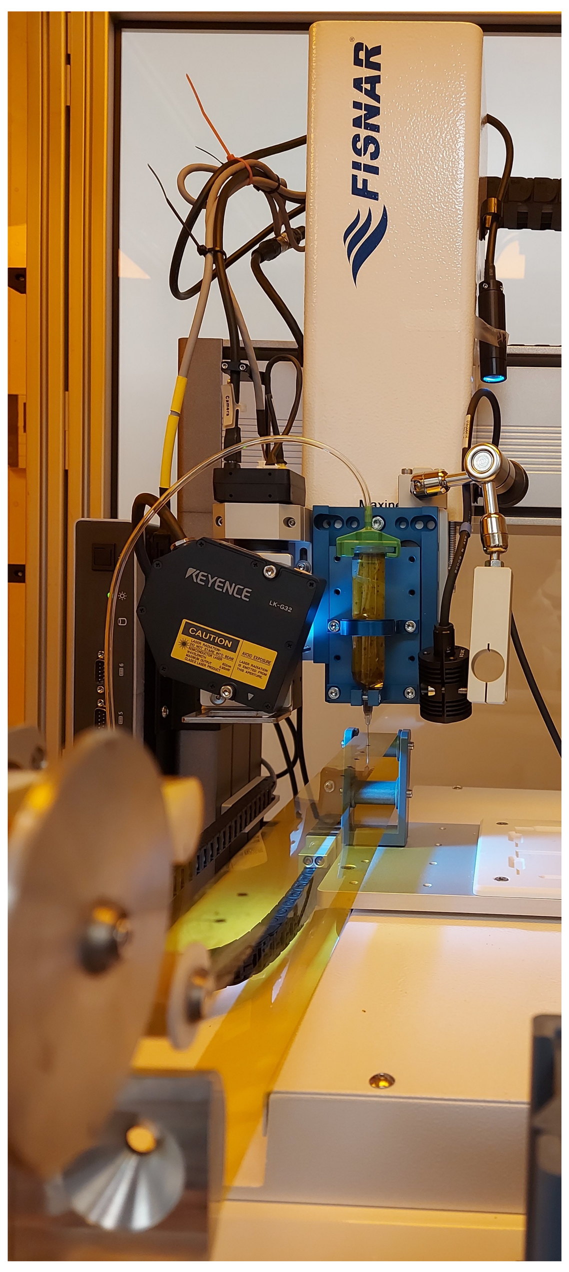


Figure 3: Left: Close-up image of the targets made using the experimental setup shown on the right. Right: An image of the set-up used for creating the silicon slurry targets, including dispensing and UV curing the slurry mix.

References:

[1] *D. Milathianaki et al., "Femtosecond Visualization of Lattice Dynamics in Shock-Compressed Matter", Science, vol. 342, no. 6155, pp. 220-223, 2013.* [2] Wu, D. et al. "*Unveiling grain size effect on shock-induced plasticity and its underlying mechanisms in nano-polycrystalline Ta",* Mechanics of Materials 160, 103952, 2021. [3] N. Amadou et al., *"Probing iron at super-earth core conditions",* Physics of Plasmas, 22, 2, 2015. [4] Zylstra, A. et al. *"Burning plasma achieved in inertial fusion*", Nature 601, 542–548, 2022. [4] *Ma, T. et al. "Accelerating the rate of discovery: toward high-repetition-rate HED science", Plasma Physics and Controlled Fusion 63, 104003, 2021.*

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CLF central laser facility