Fabrication of Planar Laser Targets with Sub-Micrometer Thickness Uniformity

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Fabrication of Planar Laser Targets with Sub-Micrometer Thickness Uniformity
The Cu EOS Targets

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The selection of target specifications requires close collaboration between Target Fab and Physics.

To make the targets manufacturable, the specifications were re-examined and revised several times.

Polystyrene (CH) ablator
- thickness uniformity ±0.3 µm

Iodine-doped polystyrene (ICH) preheat shield
- thickness uniformity ±0.25 µm

Al baseplate
- thickness uniformity ±0.25 µm

Cu sample
- thickness uniformity ±0.1 µm

Bond < 3 µm
Bond < 0.5 µm measured to 0.1 µm

To make the targets manufacturable, the specifications were re-examined and revised several times.
The target specifications necessitate a very precise manufacturing strategy. The required level of precision is approximately 10× that of most laser targets.

- **Au support ring**
  - CH ablator: $t = 32.5 \, \mu m$
- **ICH pre-heat shield**
  - Al baseplate: $t = 62 \, \mu m$
  - Quartz windows: $t = 100 \, \mu m$
- **Cu Sample**
  - $t = 43 \, \mu m$

The required level of precision is approximately 10× that of most laser targets.
The specified thickness uniformities of the components require high-precision fixturing methods.

A batch of targets is built on a 6 mm thick 100 mm diameter Al disk. Both sides of the disk are diamond turned so that the faces are parallel to 0.1-0.2 µm.
To meet the specifications for the baseplate-sample joint, the Cu sample is deposited onto the Al baseplate.

The requirements for the Cu-Al interface are very demanding.

- Cu-Al interface must be < 0.1 \( \mu m \)
- Outside the 25 \( \mu m \) region on either side of the edge of the Cu, all flaws must be < 0.1 \( \mu m \)
- Al disk must not be warped, scratched, pitted, or otherwise damaged
- Cu must have adequate adhesion for diamond turning
- Cu must be placed on Al disk in a band with radial tolerance of \( \pm 10 \mu m \)

A great deal of research has gone into identifying an acceptable method of depositing Cu onto the Al disk.
The masking process is designed to accommodate flaws created in the electroplating process.

The selected deposition process sputters 3-5 μm of Cu onto the Al and then electroplates additional Cu.

The 100 mm Al disk is masked with precisely placed Kapton tape prior to sputtering.
After sputtering 3-5 $\mu$m of Cu, additional Cu is electroplated onto the sputtered Cu.
The deposited Cu is diamond turned to a thickness of 43 µm

A band of Cu of thickness 43 µm and width 1 mm is left on the surface of the Al.

Machining may leave a 1 µm step in the Al, but it must be known to within 0.2 µm.

The Cu is then carefully measured in several locations with an LVDT mounted on the machine tool.
The Cu-side of the disk is placed against another precision narrow-land vacuum chuck.

Centering guides allow the ring of Cu to fit precisely into a groove in the chuck.

The Al disk is machined to a thickness of 62 µm to form the baseplate.
Precise pads of iodine-doped polystyrene (ICH) are bonded to the Al using a special assembly station.

An LVDT measures the thickness of the adhesive in 4 spots.
After finishing the pre-heat shields, pads of polystyrene are bonded and machined to form the ablators.

The pads of iodine-doped polystyrene are diamond turned to the required thickness to complete the pre-heat shields.

The pre-heat shields are then measured again with the LVDT in 4 spots.

To form the ablators, the process of bonding, measuring, machining, and measuring is repeated with pads of polystyrene (CH).
Targets are laser cut from the 100 mm disk and bonded to windows and support rings.

The “ablator – preheat shield – baseplate – sample” subassemblies are laser cut from the 100 mm disk.
Summary - close collaboration between Target Fab and physicists is crucial to designing manufacturable targets

- Metrology is almost as labor-intensive as the fabrication process.
- The required level of precision is approximately 10× that of most laser targets. Extreme care must be taken at each step of the process.
- Appropriate fixturing of the workpiece is critical to achieving the manufacturing and metrology tolerances.
- The seating of the workpiece against the vacuum chucks must be verified at each step.
- A great deal of research has gone into identifying an acceptable method of depositing Cu onto the Al disk. Sputter-seeded electroplating was identified as an acceptable method of depositing the Cu.
- Batch processing allows several targets to be produced from each 100 mm disk.