

STFC High Power Laser Micro-Target Fabrication

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Target Fabrication Group

Central Laser Facility, Science and Facilities Technology
Council



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Overview

- The CLF and Target Fabrication at RAL - Why do we exist?
- Capabilities
- High Power Laser Targets
- Collaborations
- Future Challenges across Europe



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Target Fabrication at RAL

1. **To make targets** - At present Target Fabrication Group produces ~98% of all solid micro-targets shot at RAL. (~3000 pa, ~150 types pa.)
2. **Knowledge** - Knowing how to make high specification objects of sub-mm size is the whole reason for the Target Fabrication community. The RAL group has a broad scope of fabrication skills and techniques
3. **Experience** - Approximately 25 years of experience in managing and delivering targets for a wide range of experiments.

Most Importantly

The Group is available to enable rapid changes to be made to target geometries and compositions during an experimental campaign, often on a day-to-day basis.

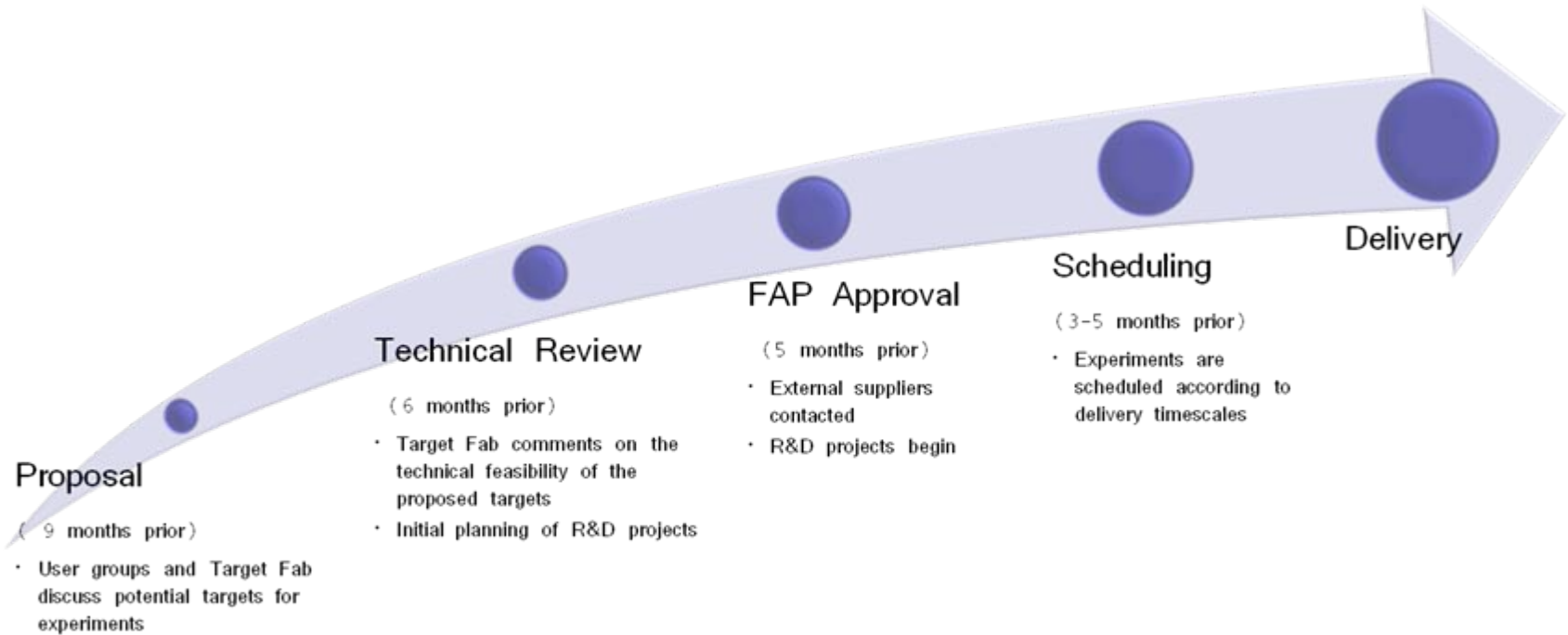
This 'just in time' capability coupled with a programme of long term target delivery makes the Target Fabrication Laboratory a major reason why experimental groups use the facilities at RAL time and again.



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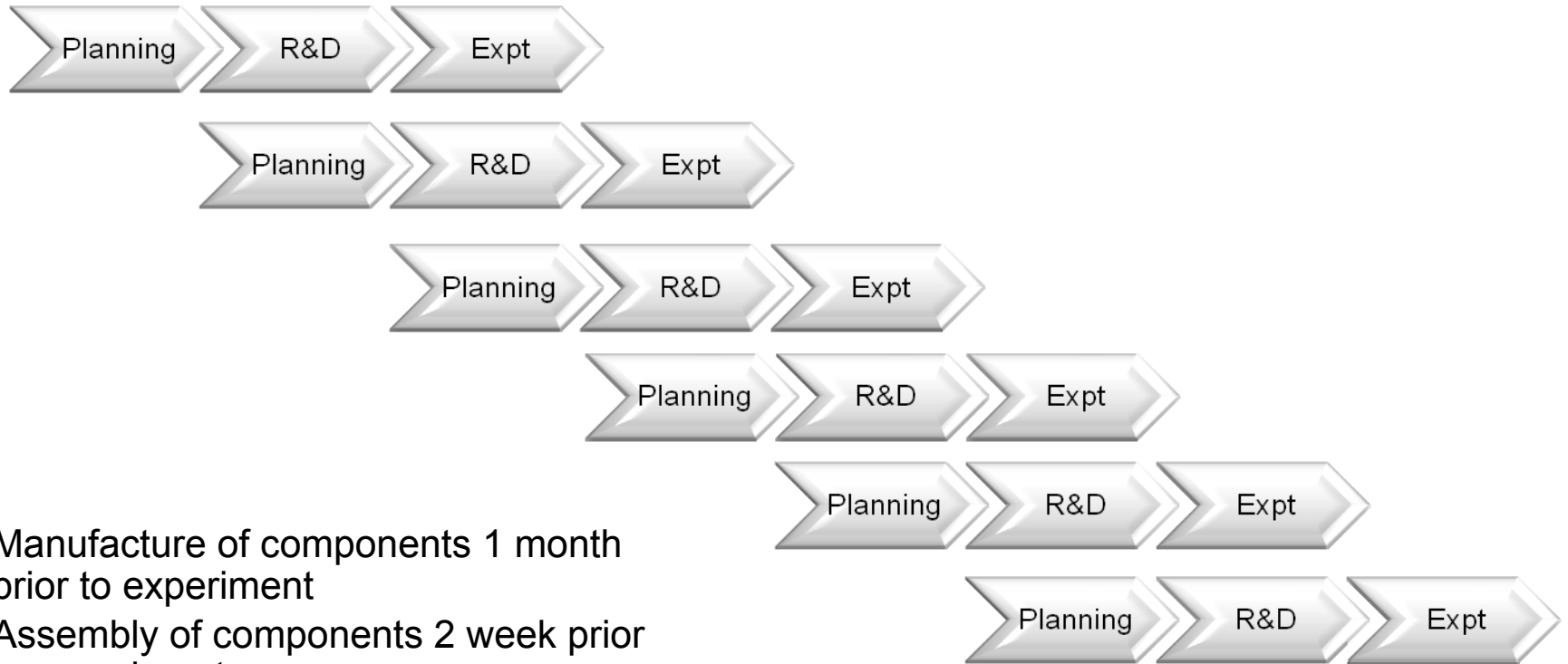
Delivery of Targets



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Delivery of Targets



- Manufacture of components 1 month prior to experiment
- Assembly of components 2 week prior to experiment
- Characterisation of targets 1 week prior to experiment
- Delivery



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What facilities are available?



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Capabilities - Thin Film

Coating

A dedicated thin-film coating laboratory provides a solid base of coating capabilities which services the production needs for high rep-rate target delivery as well as providing good research and development facilities to investigate new target technologies.

Plastic Coating

- Parylene films available in the range 0.05 - 25.0 μm .

Spin Coating

- Spin-coating of plastic such as SU-8 onto wafers or glass slides.

Sputtering

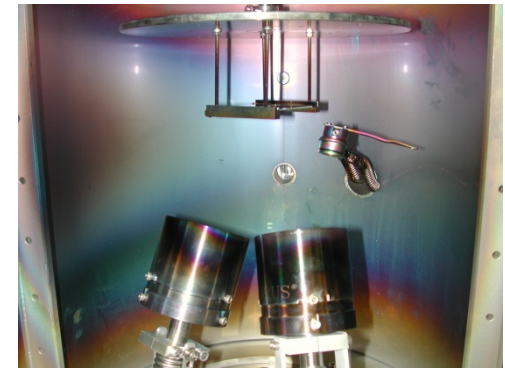
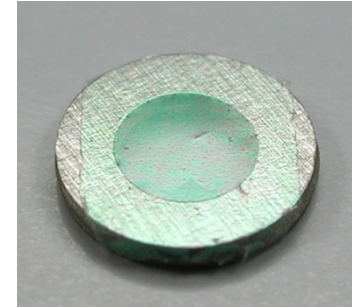
- One RF and two DC power supplies enabling co-deposits.

Thermal Evaporation

- Standard Thermal Evaporation for fast turn-around production of thin films, filters, plasma mirrors.

Electron Beam Deposition

- Layered foils for AFI targets – 25um layered coating



Capabilities - Thin Film Coating

Low-Density Coatings

- 'Low Density Metallic' coatings and 'fluffy' photocathode production.
- Mass flow controlled to give enhanced structure control
- Materials include – Al, Cu, Au, Ti, CsI, KBr.

Structured (GLAD Coatings)

- Glancing angle deposition causes microstructures through shadowing

Gold Plating

- Electro-plating of Gold

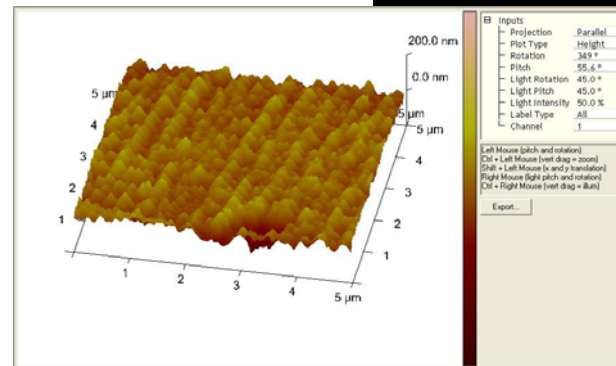
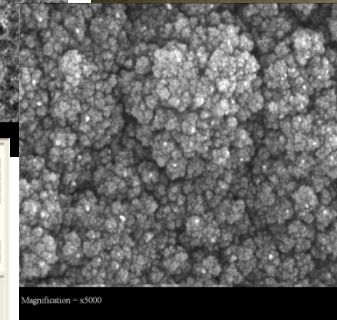
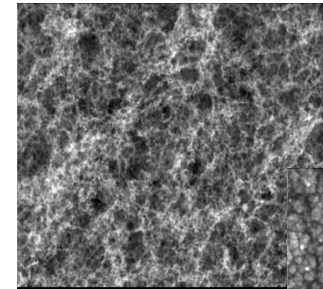
Also see talks by

G. Schaumann:

Electroplating and Lithography

M Beardsley:

Using Innovation to Manufacture Novel Geometries

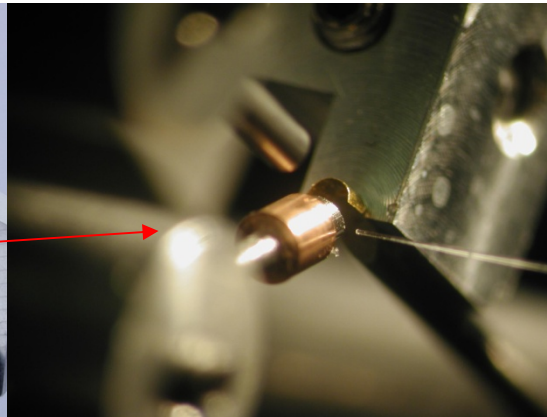
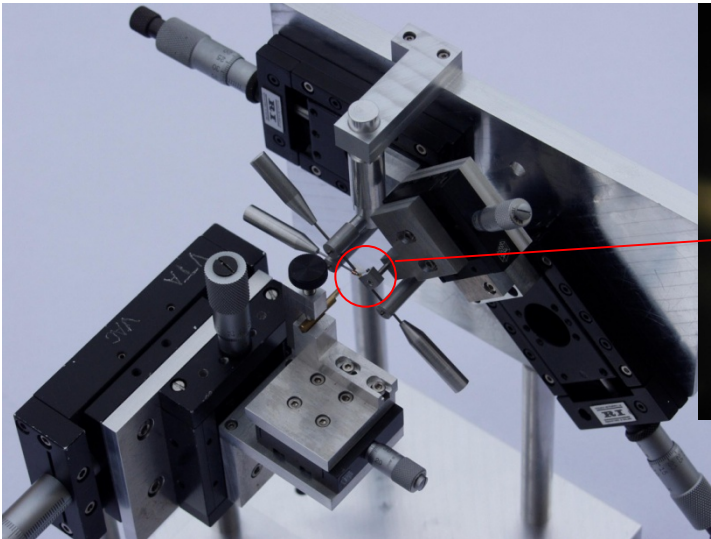


Capabilities – Micro-Assembly

Two fully trained fabricators to enable the group to respond to daily changes in target design geometry.

Extensive expertise in the process of micro-fabrication at the sub-mm level and an understanding of the problems that this poses.

Bespoke jig design for the more complex 3D targets to ensure high repeatability of results and ultra precise assembly.



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Capabilities – Characterisation

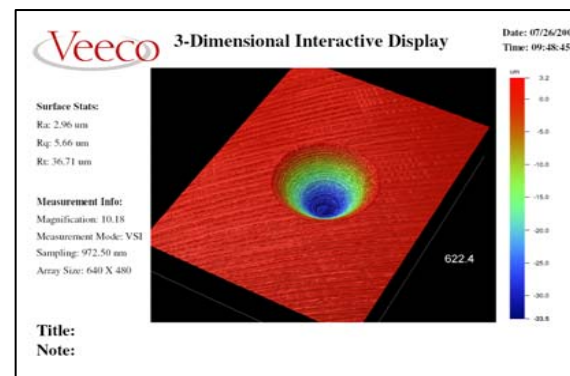
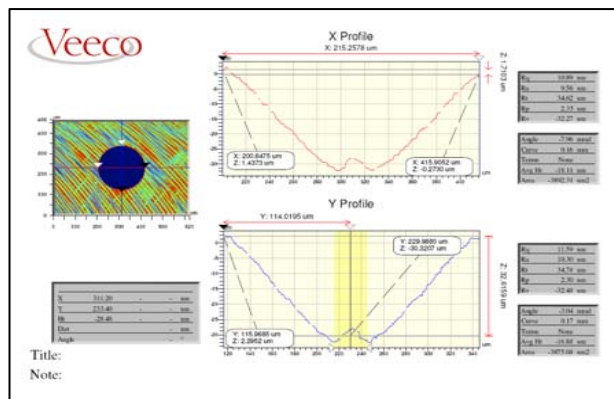
The Target Fabrication laboratory has an extensive suite of instruments that are specifically geared towards characterisation of high power laser targets.

Facilities include:-

- High specification optical microscopes with advanced contrast techniques
- Co-ordinate measuring microscope with laser scan system
- SEM with EDX, Backscatter detection, 3D image capture and surface reconstruction and measurement
- Wyko white light interferometer with advanced film analysis software.
- Surface profiling systems for thin film measurements and surface characterisation.

Access to other equipment including

- AFM systems



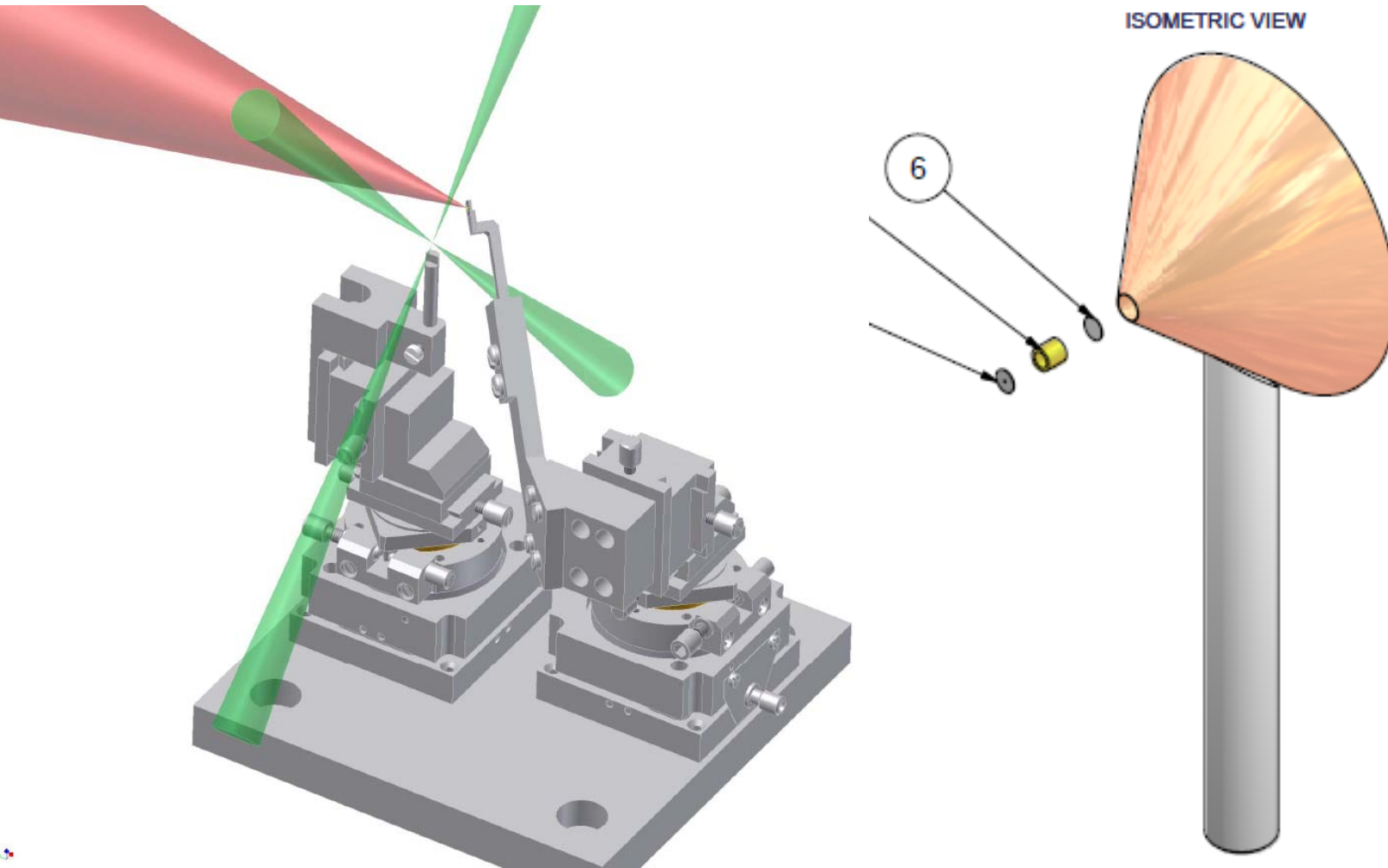
What Targets Do We Produce?



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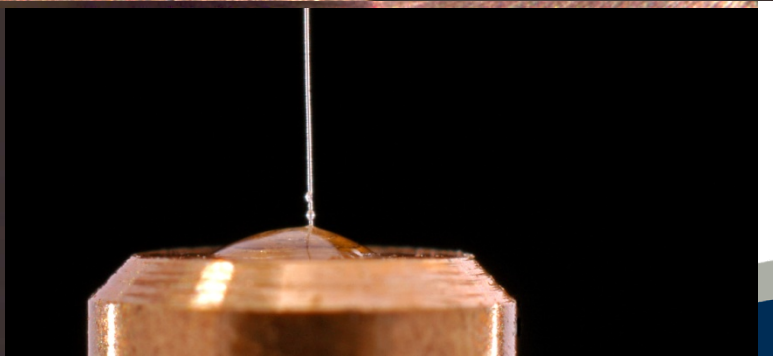
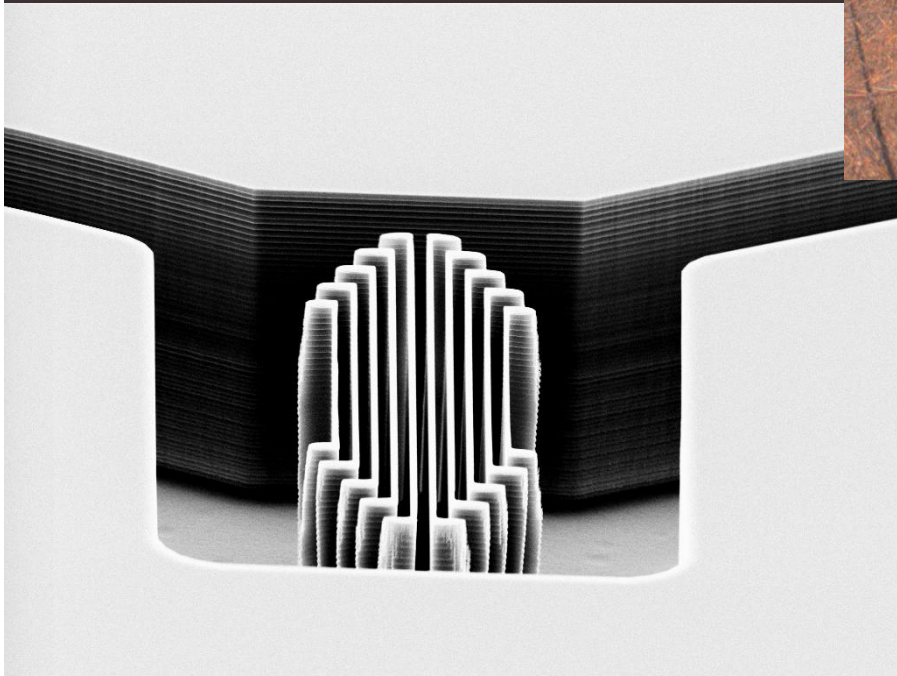
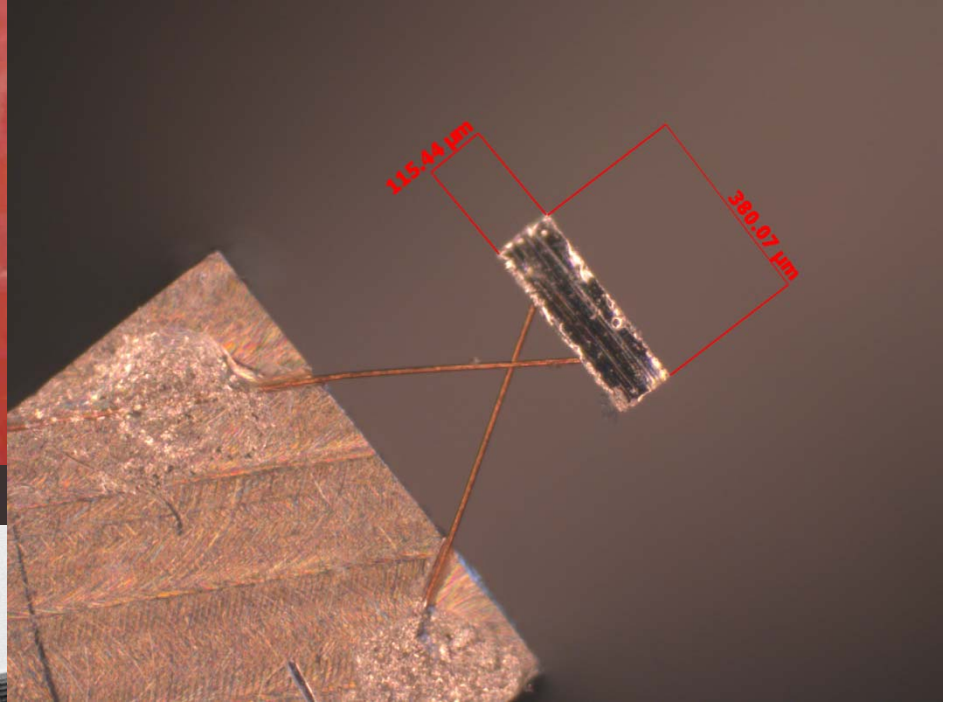
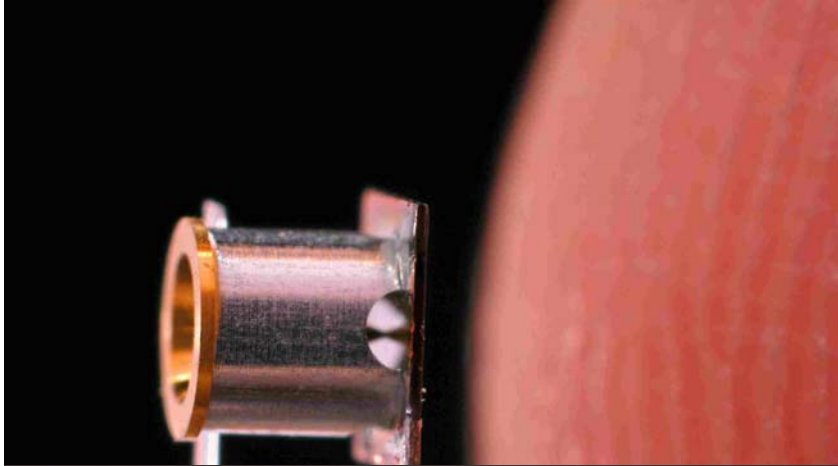
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High Power Laser Targets



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Applications of the Targets Produced

- Fast Ignition
 - Electron transport experiments, cone geometry investigations
- Astrophysics simulations
 - YSO, Astrophysical jets, Supernova Remnants.
- Warm Dense Matter experiments
- X-ray scattering experiments
- Shock compression
- Ion acceleration
 - Laser synchrotron source investigations
- Proton radiography
- X-ray laser experiments



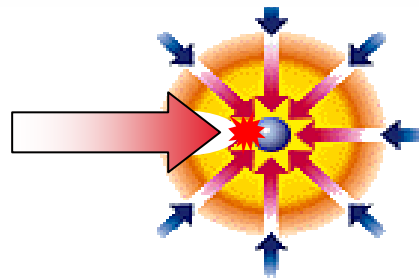
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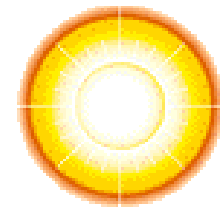
'Fast Ignition' Route to Reduced Scale



Compress



Heat

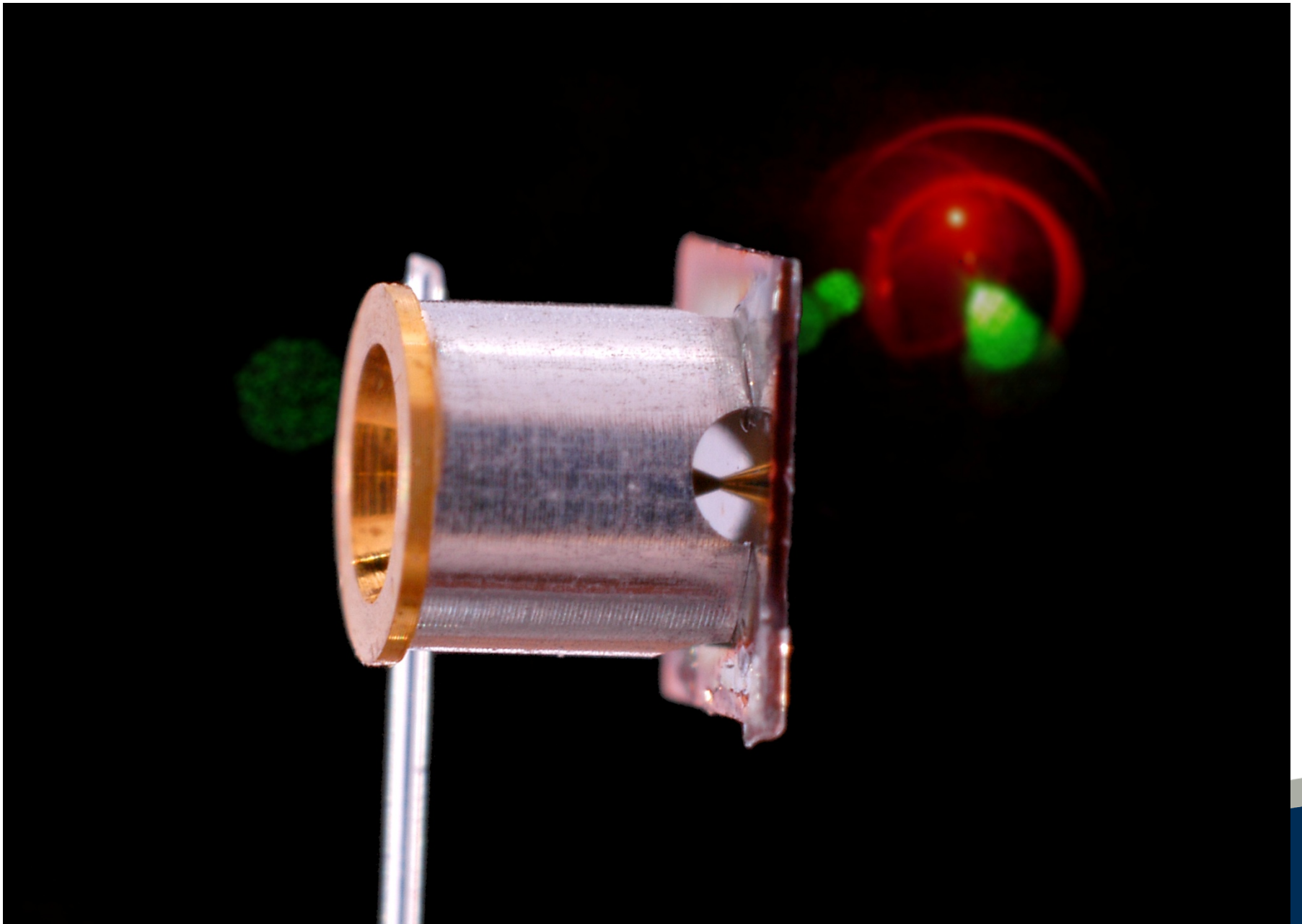


Energy output



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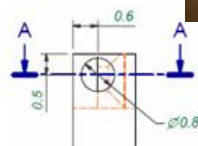
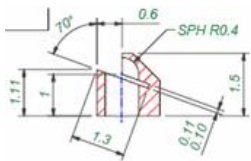
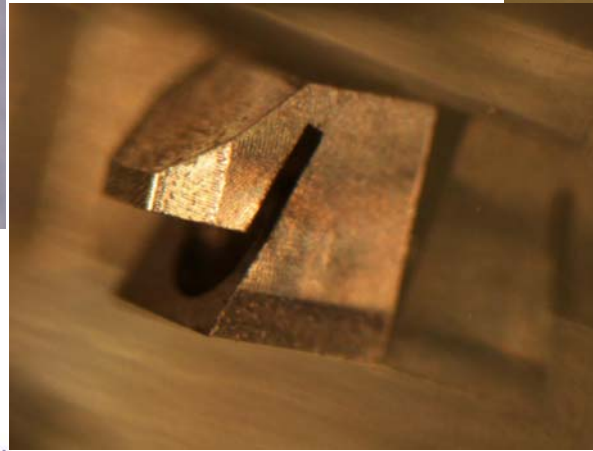
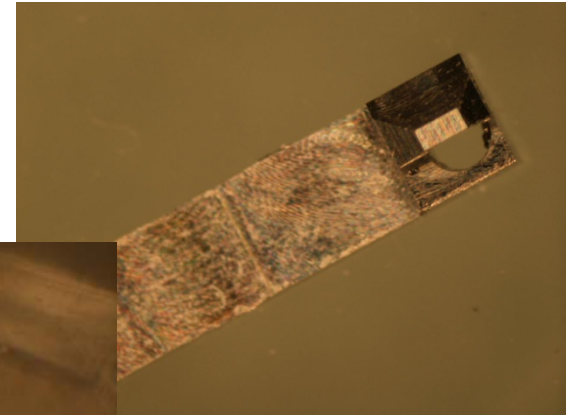
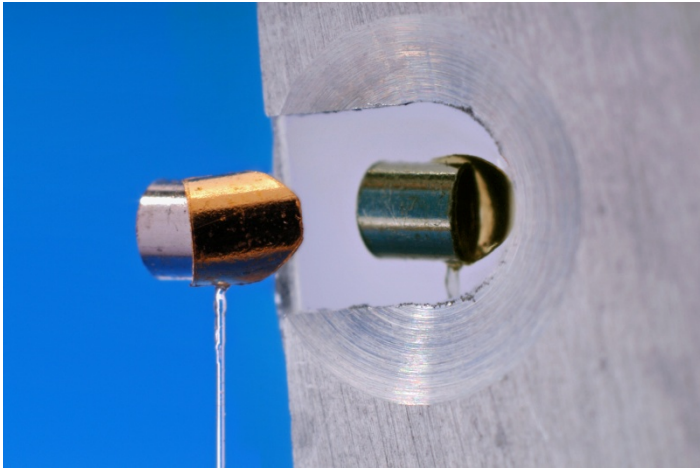


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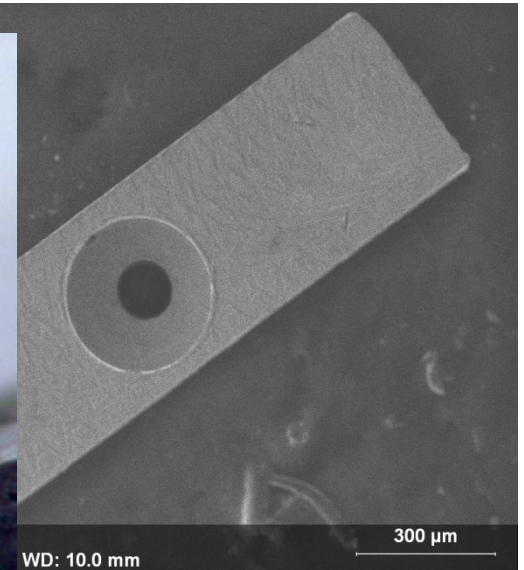
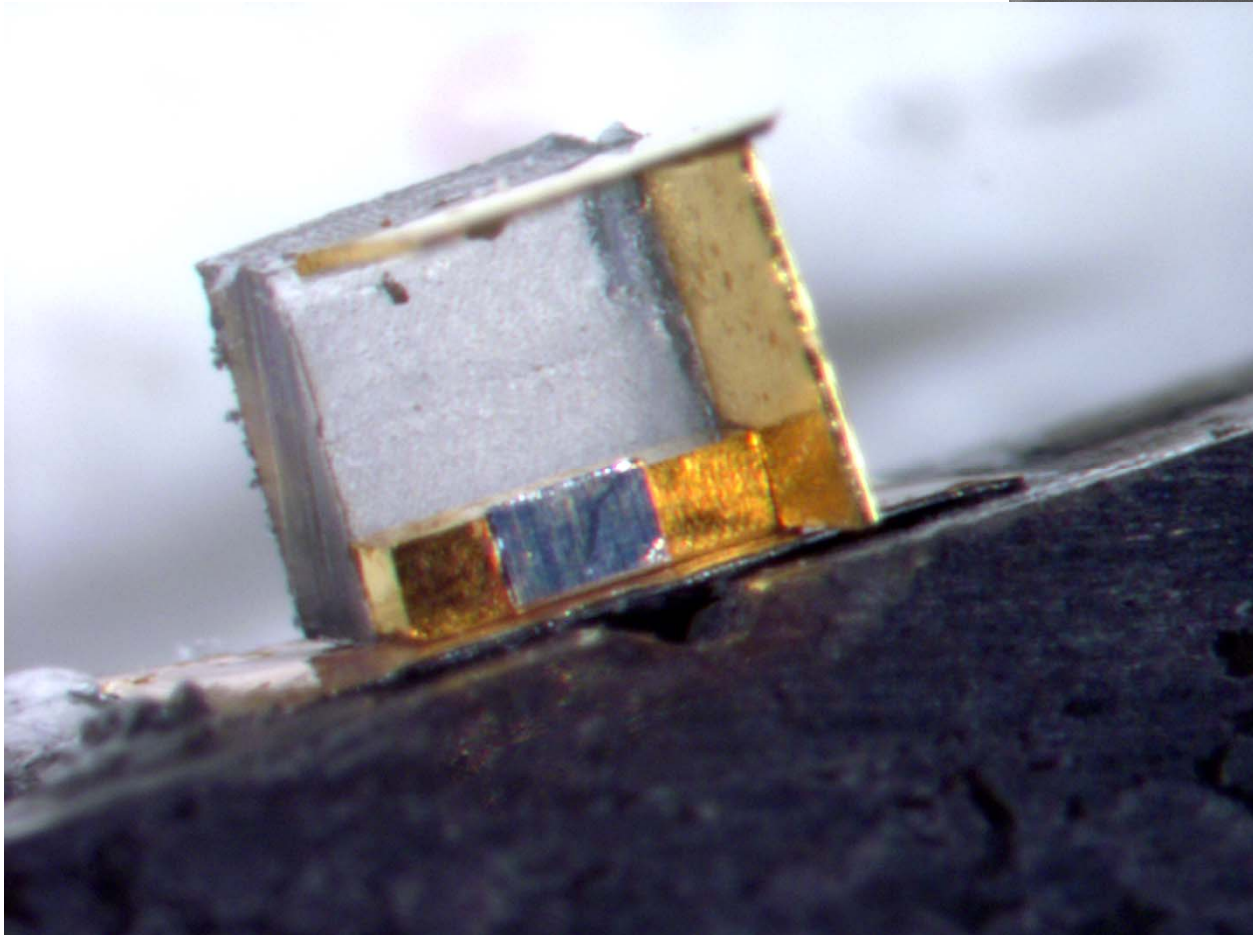
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X-Ray Backlighter Targets

Targets to image other target interactions using x-rays generated by a variety of materials



X-Ray Backlighter Targets



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Collaborations and Target Examples



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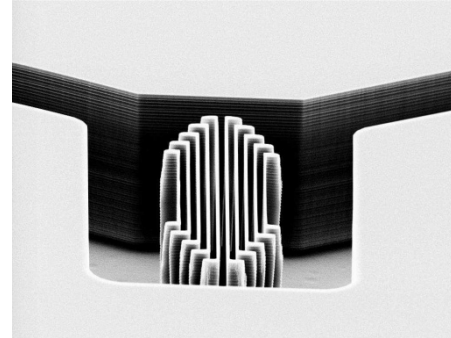
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MEMS Manufacture

The Target Fabrication Group works closely with the Micro-Nano Technology (MNT) Group (formerly CMF) with its considerable experience in the manufacture of MEMS devices, especially high aspect ratio structures.

Processing steps can typically include:-

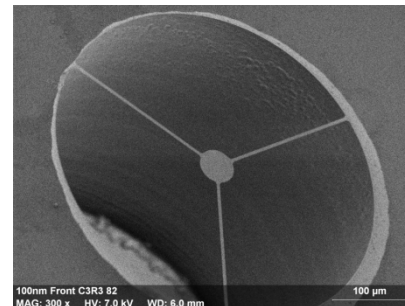
- Photolithographic or e-beam mask production
- Deep reactive ion etching
- Wet processing



These processes allow the production of large numbers of high specification targets that could not possibly be produced in other ways.

Examples include

- Disk based targetry is being developed for use on the high rep-rate Astra Gemini system
- Mass production for LIBRA ion source grant



Also see talk by

B.Stevens:

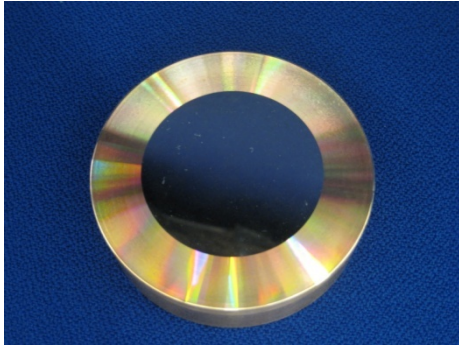
Micro and Nano Technology Processes for the High Volume Manufacture of Laser Targets



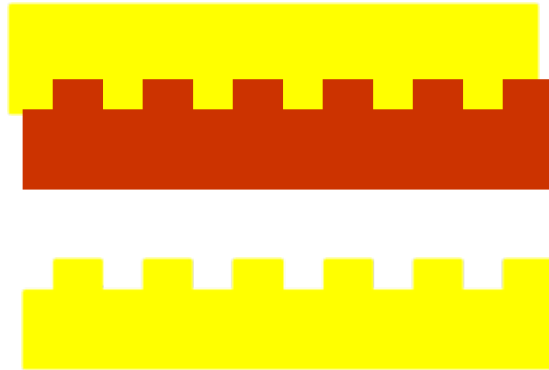
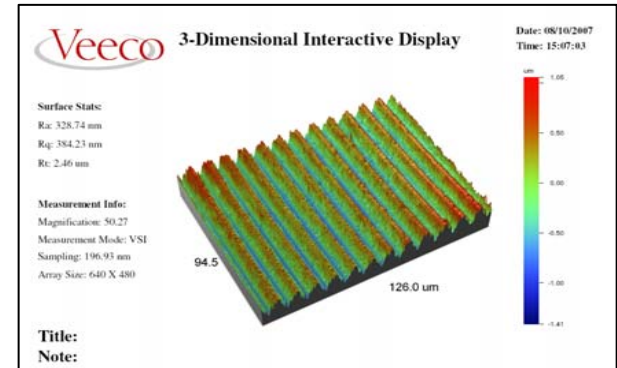
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Diamond Point Turned Micro-groove Targets

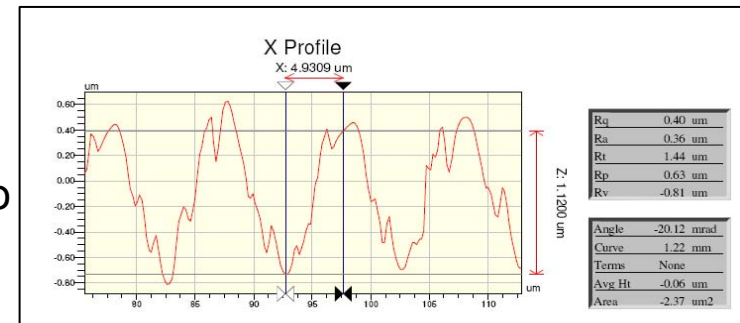


Diamond turned Copper mandrel with 2um pk-v and 3um wavelength



Mandrel is sectioned and plated with a desired thickness of gold.

Copper is etched away to leave gold foil.



Material is characterised processed and shot

Also see talks by

I Durazo-Cardenas:

Fabrication of Micro-structures Surfaces by Single Point Diamond Turning



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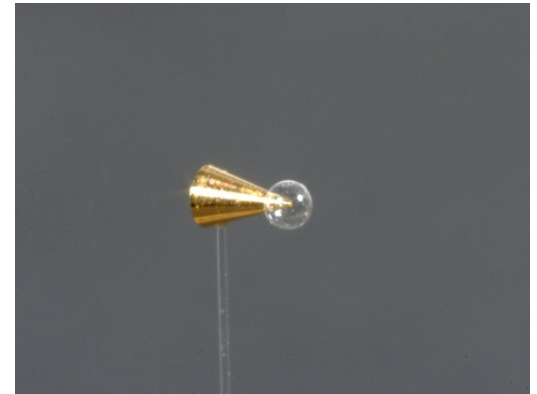
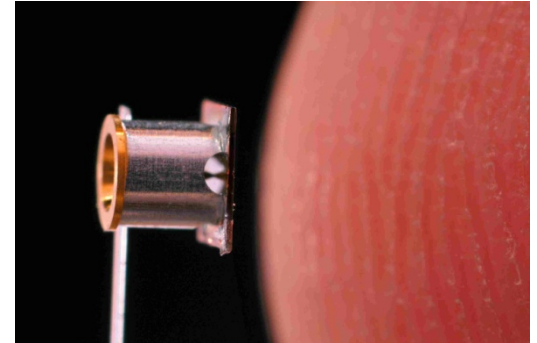
High Precision Micro-engineering

The Precision Development Facility of SSTD has extensive capability in precision micromachining, particularly with two HAAS and two KERN CNC micro milling machines. The PDF also has experience in producing specialist prototypes of targets at short notice.

In support of Target Fabrication PDF provides:-

- Micromachining / Microcomponent manufacture
- Bespoke high precision assembly jigs
- Specialist Electroplating

An ongoing programme of development is helping to solve problems such as mass production of cones and target delivery for high rep rate laser systems.



Also see talks by

M Beardsley:

Using Innovation to Manufacture Novel Geometries

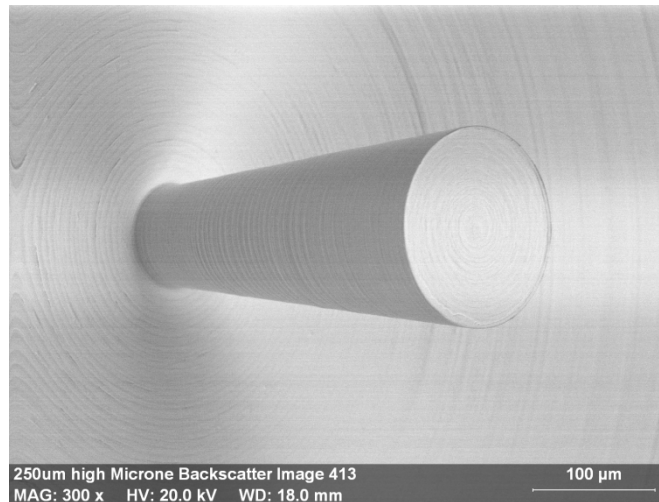
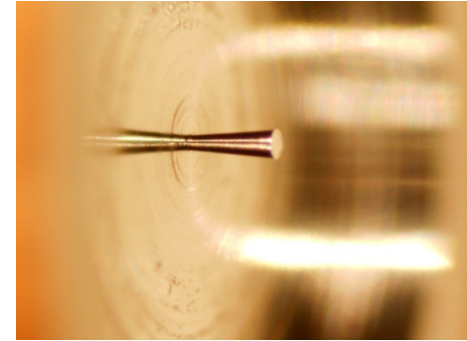
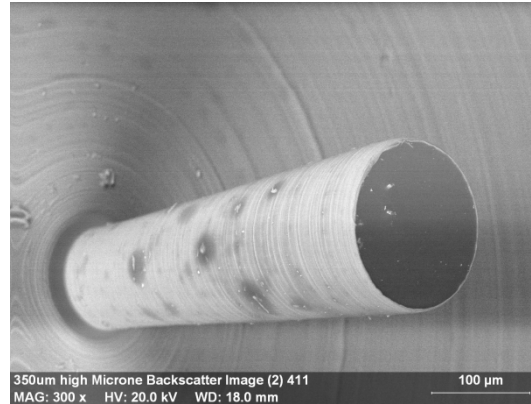
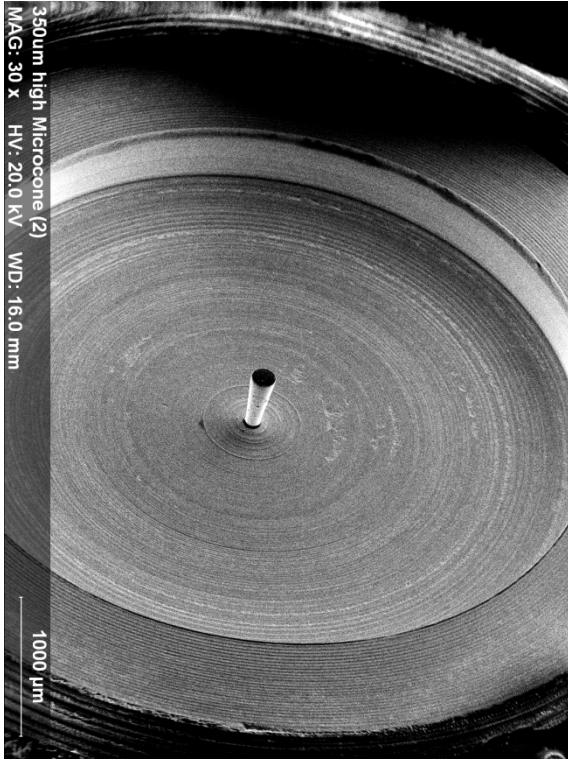


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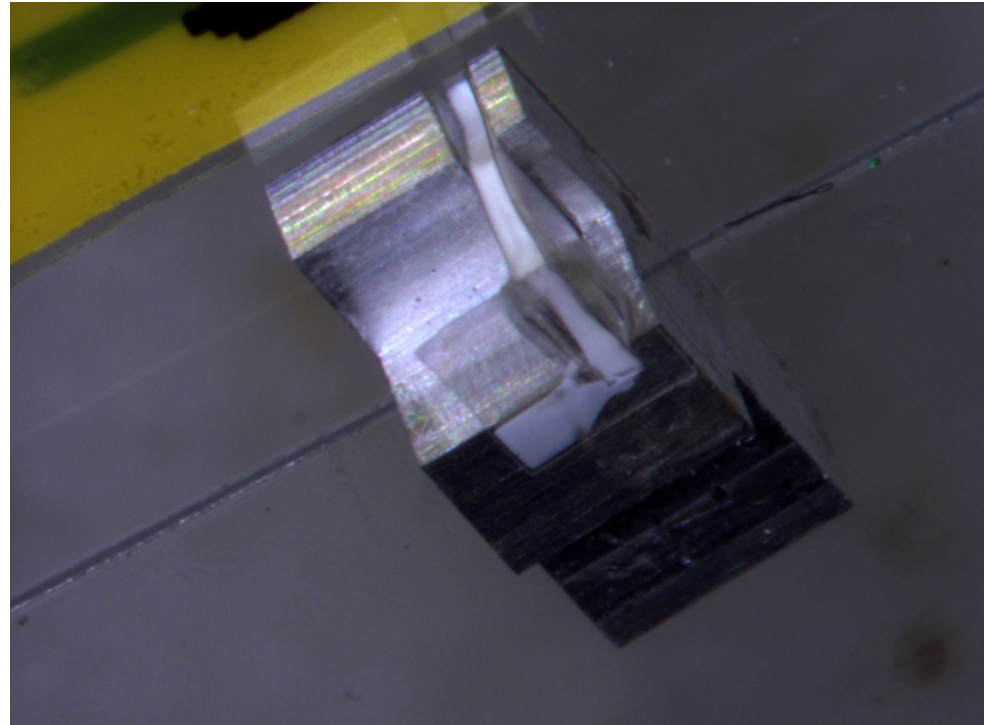
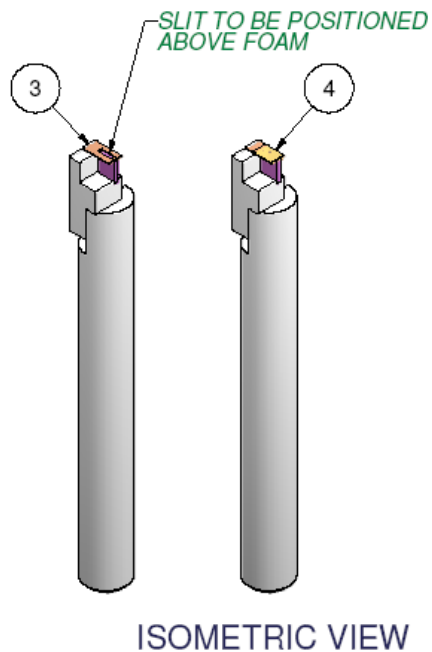
High Precision Micro-engineering

Production of micro-cone targets for fast electron collimation



Complex Foam Targets

The combination of high precision micromachining, foam production and micro-assembly allows the production of some highly complex 3D target geometries. These can be some of the most challenging targets!



Also see talks by

W. Nazarov:

**Low Density Foams Used in High Energy
Laser Experiments**



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Complex Foam Targets

The first HiPER experiment is using some of these complex foam targets.



Also see talks by

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Future Challenges

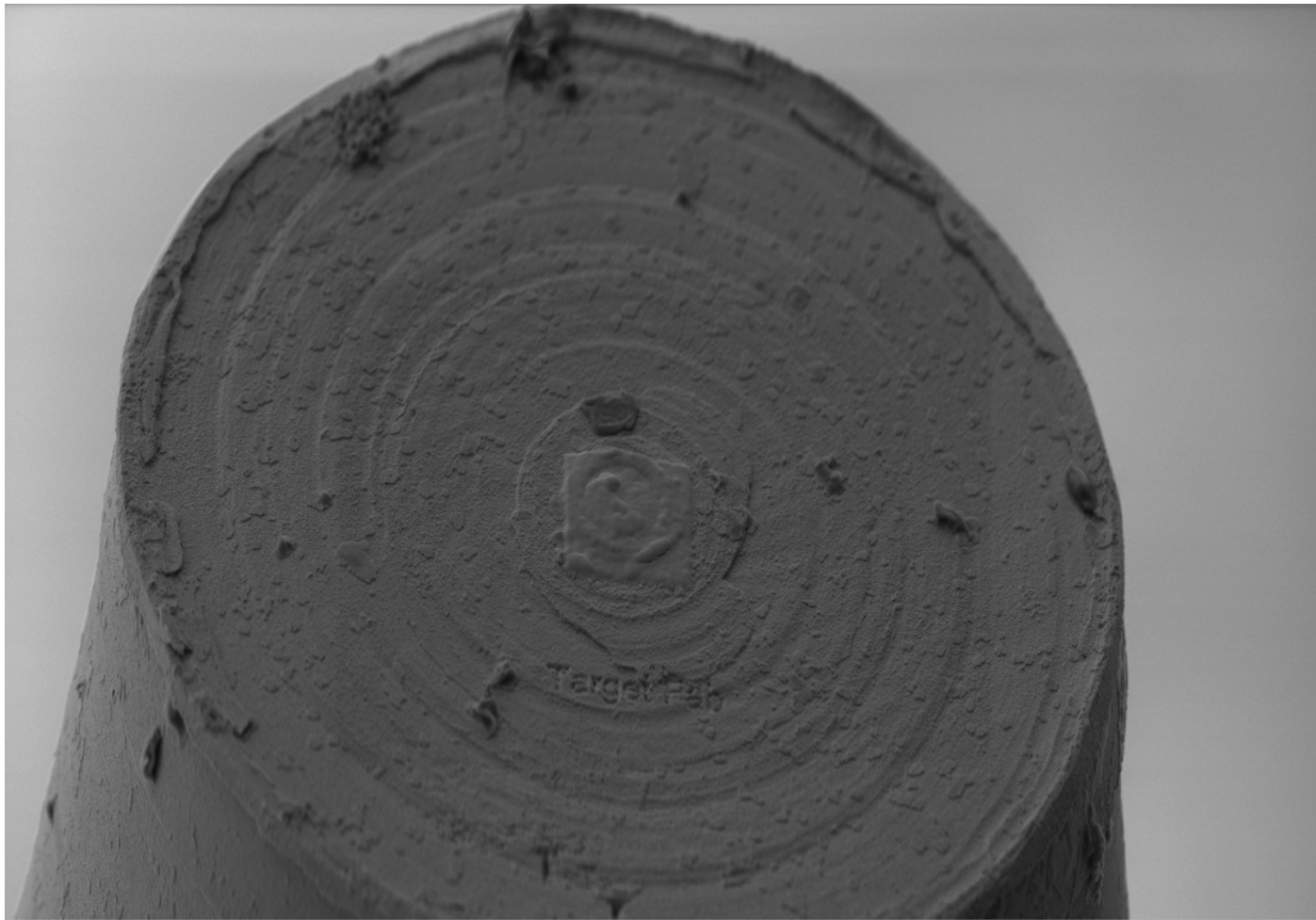
- Currently 3000 targets for 18 experiments ~ 1 year
- Astra Gemini Jan 2009 – 3000 targets for 1 experiment ~ 1 month

- Over 10x increase in target demand cannot be met using standard target fabrication techniques

- Possible solutions
 - Mass Production of components
 - Leads to mass assembly and automated assembly challenges
 - Other production techniques – micro moulding and injection moulding???

- IFE Power Station (via HiPER)
 - Will need approx. 650,000 targets a day
 - DT ice, cryogenically filled
 - Injected to centre of 10m vacuum chamber
 - Need to withstand a nuclear burn residue of preceding target





Mag = 1.07 K X 10 μ m WD = 5.1 mm EHT = 5.00 kV FIB Lock Mags = Yes Signal A = SE2 Date :3 Oct 2008 Time :16:57:19
1540XB-27-20 FIB Imaging = SEM Noise Reduction = Pixel Avg. FIB Probe = 30KV:100 pASystem Vacuum = 2.72e-006 mbar



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