Target Fabrication at AWE - recent changes and the future

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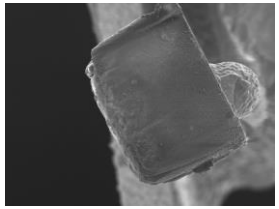
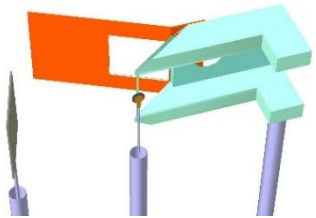
Introduction

- AWE Target Fab mission
- AWE Target Fab relocation
- Review of new locations & capabilities
- Return to Ops
  - Process prove-out
  - Lessons learned
- Recent highlights and challenges for the future
- Conclusion

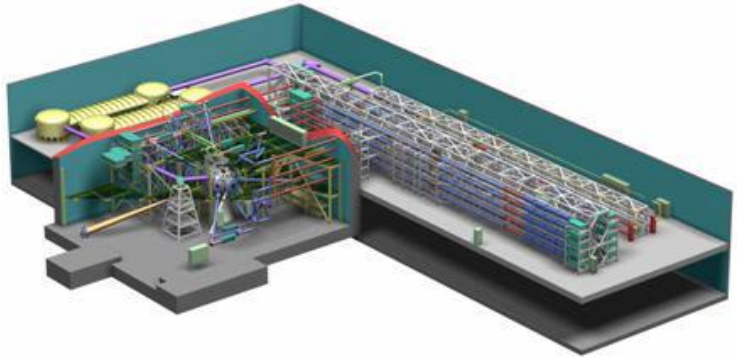
AWE Target Fab Mission

- AWE conducts HED laser-plasma experiments in support of code validation in a CTBT environment
- AWE TF primarily supplies targets for the Orion laser
  - ~ 1000 targets per year
  - Mostly planar target configurations
  - Multiple elements on single shot to exploit Long pulse-Short pulse combination (Orion multi-target mount)

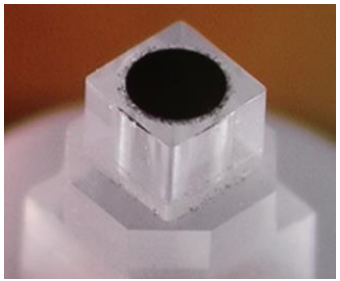




- Also support collaborative campaigns on NIF and Omega
  - 10's of targets per year
  - Complex geometries
- Also supply materials and target components

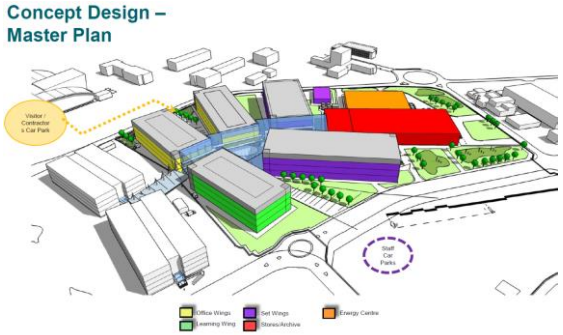


Orion laser:
10 beams 500J ea 1-5ns pulse 351nm
1 beam 500J 0.5ps pulse 1053nm and,
1 beam 200J 0.5ps pulse 527nm or,
1 or 2 additional 1-5ns 351nm "Backlighter" beams



Why are we relocating?

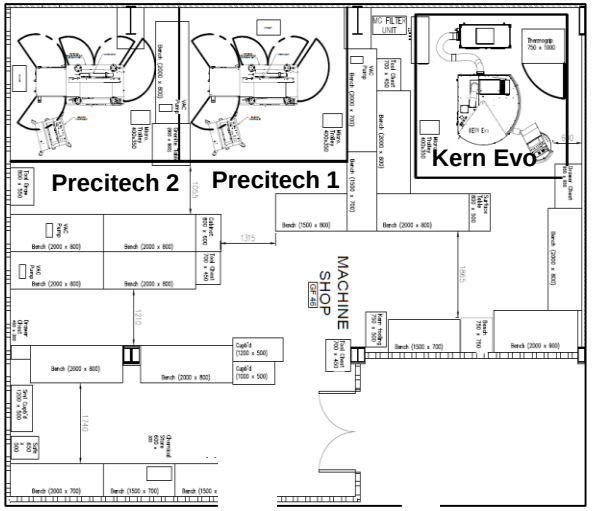
- AWE plans to replace ageing infrastructure with a new complex for science and engineering.
- Target Fab's facilities fall under site footprint - need to be moved to allow work to proceed on the new build.
- Over the last few weeks, we have moved our capabilities into refurbished labs on the ground floor of the Orion building.
- Activities to bring our capabilities back on-line are underway.
- The move has enabled some areas to be upgraded, providing a more integrated in-house capability, suited to future demands from our customers.



Capability overview – Precision Machining

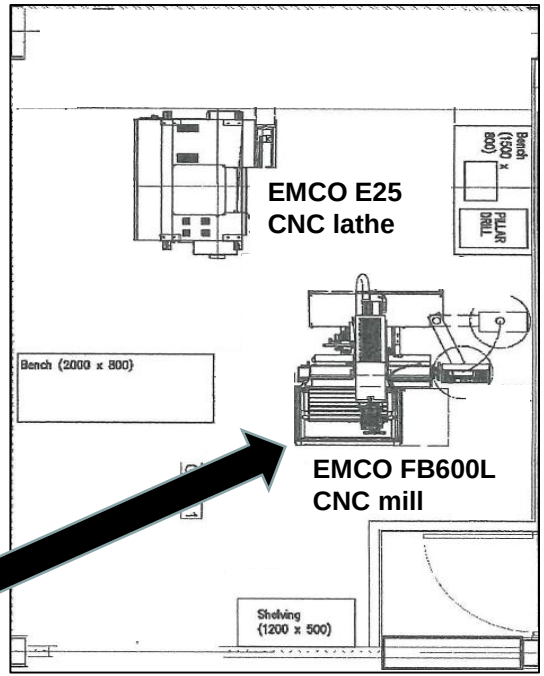
- Precision machining of foams and aerogels, principally for NIF. Also gold components.
- Existing capability – 2 Precitech diamond-turning lathes and a Kern Evo 5-axis precision mill.
- Originally in 2 separate rooms, now consolidated into one.
- Working areas redesigned to facilitate complex integrated machining/ assembly tasks with fragile materials.
- Room also incorporates storage/kitting area for Trials Managers.

- Potential future upgrades:
  - Precitech 1 replacement
  - Compact precision turning/milling station.



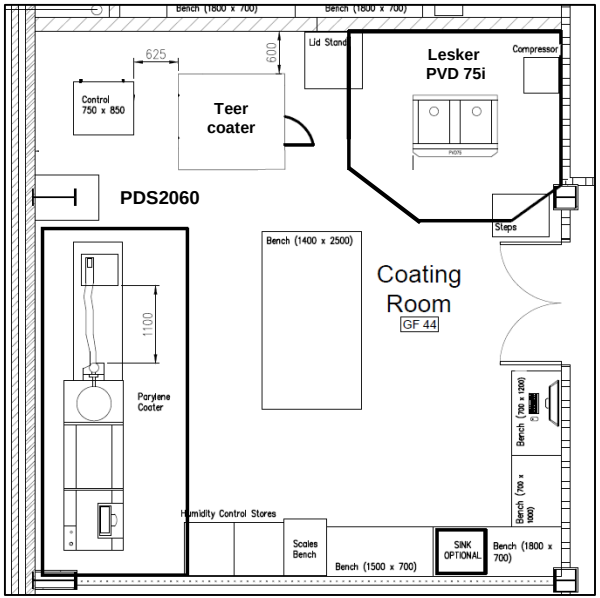
Capability overview – conventional machining

- Previous capability – customised Hardinge lathe (now obsolete) plus manual Weiler lathe.
- Replaced with up to date EMCO E25 lathe and EMCO FB600L mill.
- Will be able to carry out
  - machining of raw copper foam billets to right cylinders
  - Rough machining of other foams (TBC)
  - rough machining of mandrels for hohlraums
  - production of customised fixtures.
- Brings into one room activities previously spread between between buildings.



Capability overview - coatings

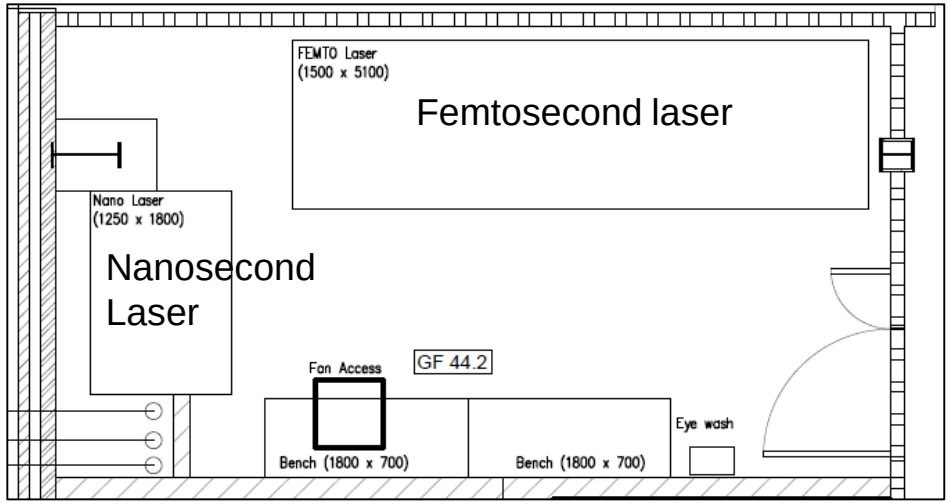
- Capability for metal and polymer thin film coating.
- Existing Lesker PVD 75i and Teer magnetron sputter coater relocated.
- Existing parylene coater (PDS2060) has been moved, but is being replaced by new coater (SCS Labcoater 2).
- Smaller footprint so can be run up in parallel. Pyn N and C.
- Decommissioning of PDS2060 will free up space for proposed Teer coater replacement

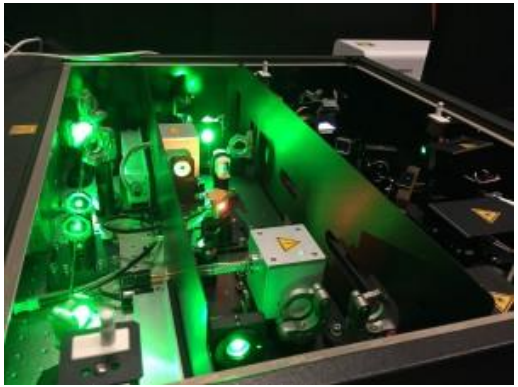


Capability overview – Laser Machining

- Many components machined for Orion campaigns
- Ti:sapphire femtosecond laser machining system (Coherent Libra)
- Nd:YAG nanosecond laser machining system.

- Opportunity being taken to provide femtosecond laser with improved safety enclosure – transform from lab instrument to Class 1 machining station.
- Also reconfigure beamline and diagnostics
- Extended recommissioning period expected.

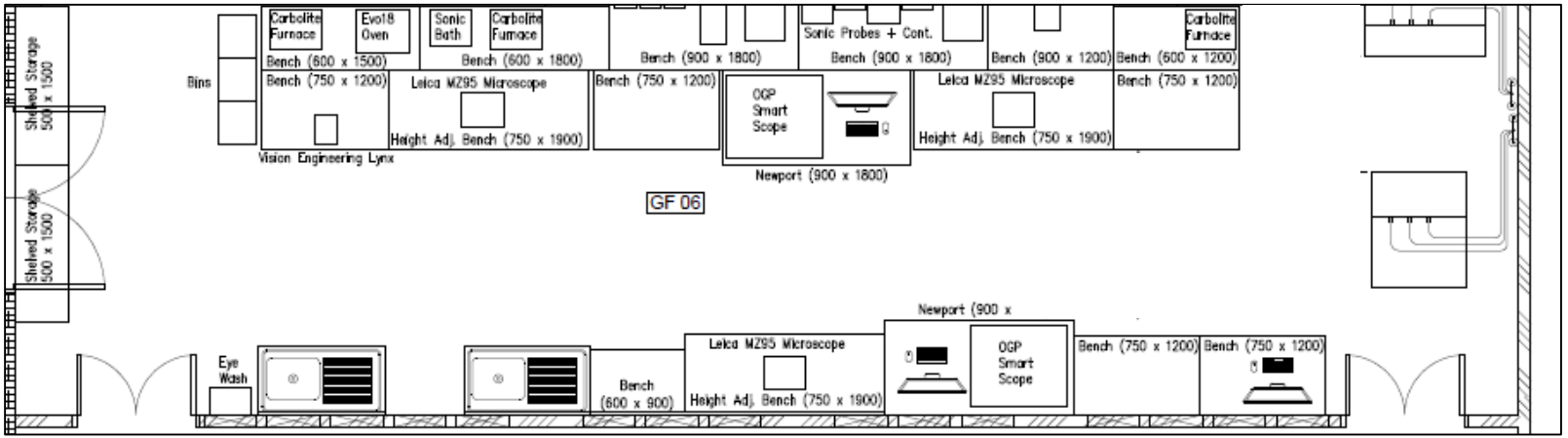




Capability overview - Assembly

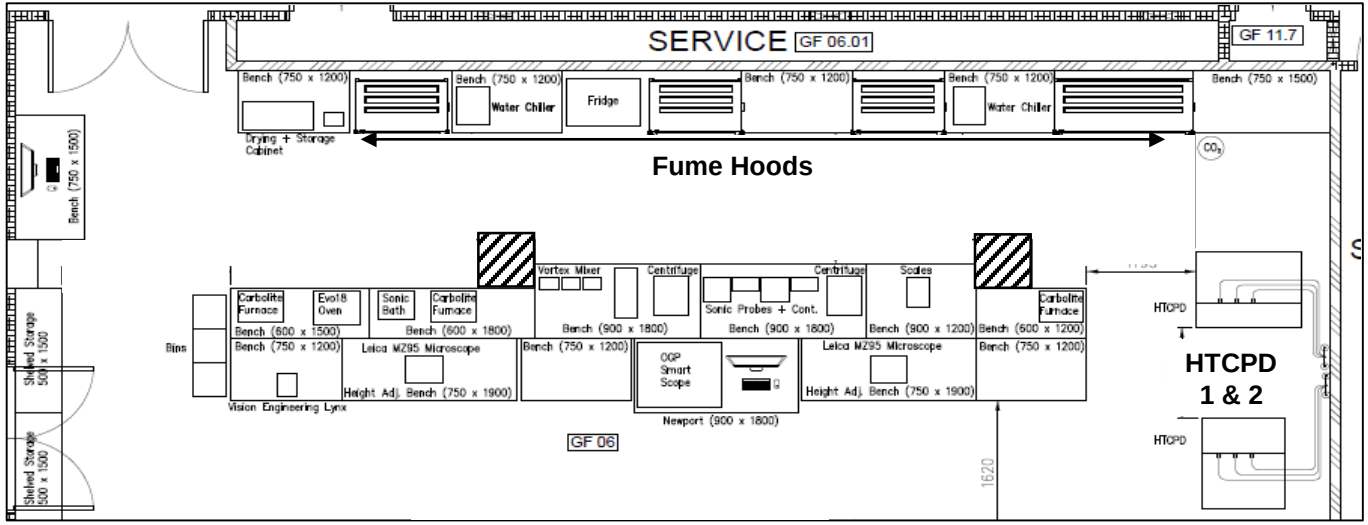
- Sharing a room with foam & aerogel chemistry
- Class 7 clean room.

- Three hand assembly stations.
- Two (NIF-capable) OGP Vantage 250 assembly stations.
- Original “Orion-spec” OGP is redeployed in Characterisation room



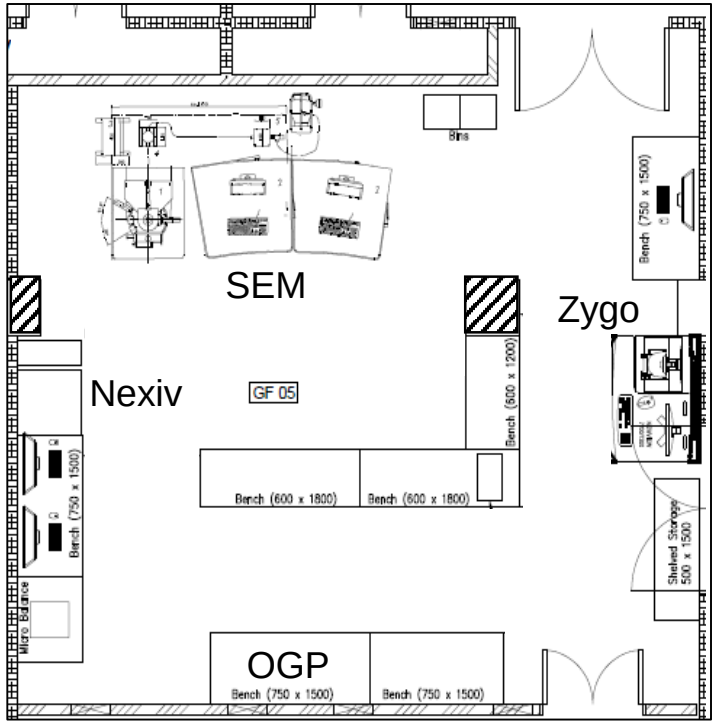
Capability overview - Chemistry

- Development and manufacture of copper foam, CRF, and aerogels (currently silica, tantala and iron)
- Sharing room with Assembly
- Class 7 clean room.
- Four recirculating fume hoods.
- Two Ocellus high temperature critical point driers.



Capability overview – Characterisation (metrology)

- Main metrology capabilities located in Class 7 clean room next to assembly.
  - Zeiss SEM
  - Nexiv CMM
  - Zygo white light interferometer
  - Microbalance
  - IDMS
  - Keyence Digital microscope



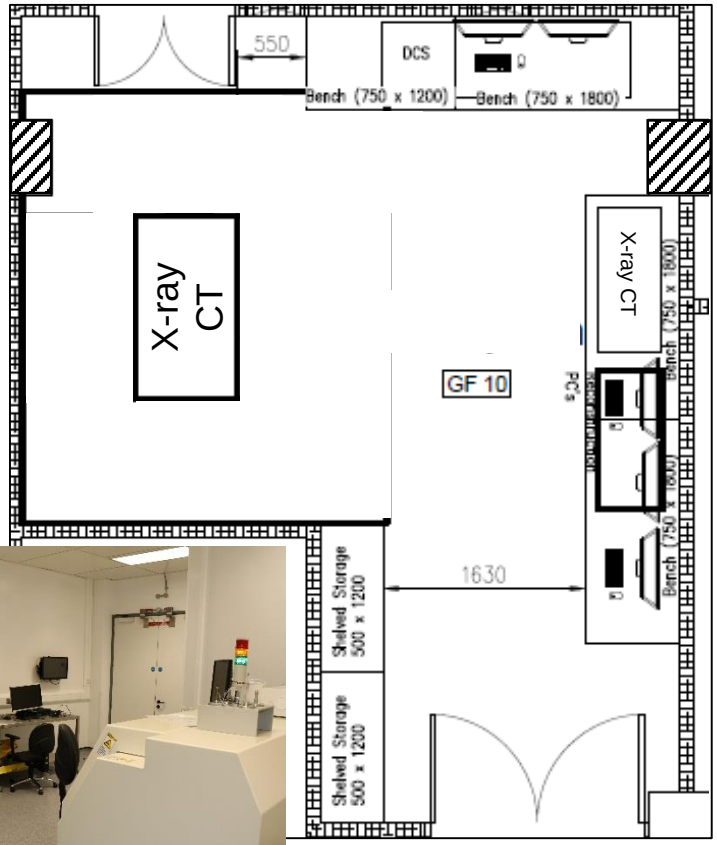
- Original (Orion spec) OGP - can act as assembly station or video CMM

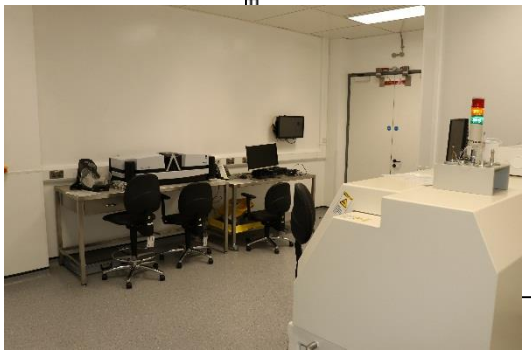
Capability Overview – Characterisation – x-ray analysis

- Across corridor from main characterisation lab:
  X-ray analysis lab.

- Replacing workhorse Xradia CT (now obsolete) with 2 new machines:
  - Bruker 1272 with auto-changer for routine scanning.
  - Zeiss 610 Versa for R&D scanning

- Density Characterisation System (DCS) will also be in this room





Process prove-out

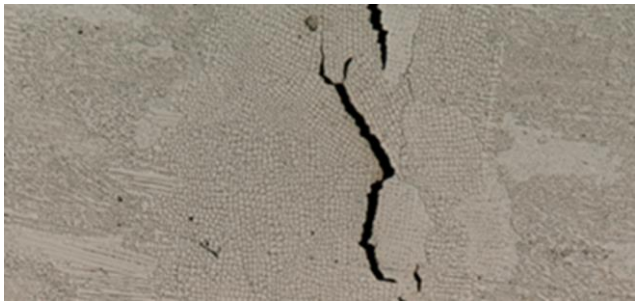
- We needed to define suitable methodologies to prove-out each target fabrication process prior to restarting operations. Different approach taken depending on the equipment involved:
  - Major machining equipment – decommissioned and recommissioned by original equipment manufacturers (OEM). For Precitech lathes, manufacture of test pieces before and after.
  - Coating – coaters decommissioned and recommissioned by coater maintenance contractor (ESC), TF team lay down representative sample coatings on each machine.
  - Laser machining – make test pieces before and after the move. Laser systems decommissioned and recommissioned by OEM.
  - Assembly – Assemblers to make several examples of agreed set of target designs of varying complexity. OGP's recalibrated by OEM
  - Foams and aerogels – TF team carry out several production runs of each process, demonstrate that output is representative of pre-move manufacturing.

Lessons learned during the move

- Positives
  - Able to take opportunity to upgrade or modernise some of our capability
  - Closer to Orion – become single team
  - Moving away from ageing infrastructure and services – also better facility support
  - Very positive response from the teams – everyone has stepped up!
- Challenges overcome
  - Ensured project scope is to reinstate the capability – not “Lift and shift”
  - Team cohesion (good communications are paramount!)
  - Maintained existing deliverables to customers – despite drift in project dates.
  - Clashes with other major site projects
  - Non-compliance of old equipment to latest regulations (e.g. Hardinge lathe, laser machining)

Highlights - new characterisation capabilities

- X-ray CT
  - Existing Xradia Micro 200 has had to carry entire campaign and R&D programme – literally running 24/7, even though it is obsolete.
  - Replacing with 2 machines:
    - Bruker 1272 with autochanger to handle routine scanning of copper foam. Less human intervention required when combined with -
    - Zeiss Versa 610 for R&D scanning and challenging material combinations
  - Automated analysis code in Aviso Inspect developed by the Manufacturing Technology Centre. Increased yields with less hands-on effort.
- Optical microscopy
  - Keyence digital microscope – up to 2500x magnification, huge depth of focus, resolution down to microns
  - Improved capability to diagnose issues with components and sub-assemblies.

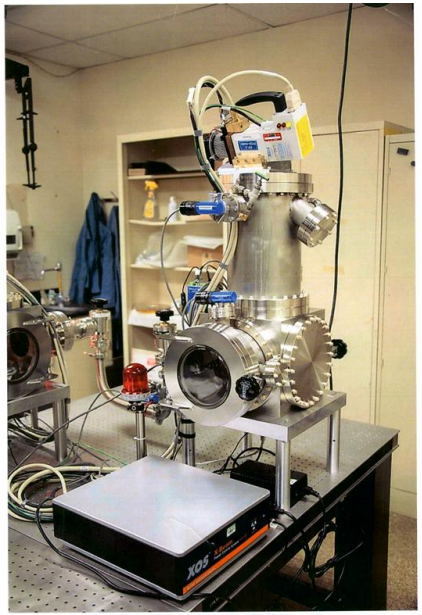


Example image of etched weld section – features down to < 5 microns

Density Characterisation System (DCS)

Designed and manufactured by Diagnostics Team at Los Alamos National Laboratory

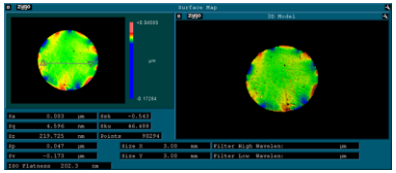
- Specifically built to determine ρ and quality of foam samples
- Demonstrated accuracy of ρ measurement to 1%.
- Produces monochromatic x-rays
  - Good contrast
  - Density determination
- Good spatial resolution (13μm) – identify small artifacts
- Illuminate several samples at a time under vacuum
  - multiple simultaneous measurements
  - sample measurements under same conditions as experiment
- Currently under assembly and test at LANL. Expected at AWE late May.



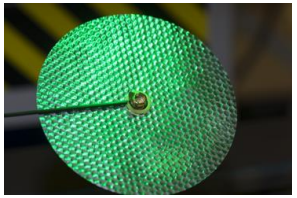
Highlights – targets delivered in 2018/19

AWE TF notable successes in the past year (*more detail in other presentations this week*)

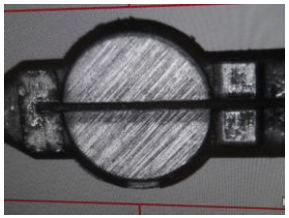
- Aug 2018 - Further quality improvements in ultra-thin bondlines in diamond/copper layer targets for material strength campaign.



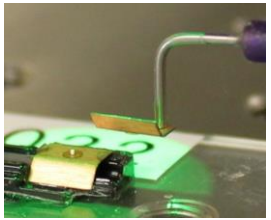
- Oct/Nov 2018 - First complete targets for a NIF campaign, assembled to NIF spec at AWE (*Martin et al - oral*).



- Nov/Dec 2018 - Targets for Warm Dense Matter campaign incorporating boron strip samples for the first time (*Sadler et al - poster*)



- Mar 2019 - Complex double-ended chlorinated foam target design for charged particle stopping campaign. *(Merritt et al - poster)*



Challenges for the future

- Campaign requirements are increasingly challenging
- Increased interest in hohlraums and other gold components – in the process of reinstating AWE's gold electroplating capability.
- Continuing to develop ability to assemble targets for NIF campaigns – purchased second NIF-spec OGP to help streamline assembly and metrology.
- New materials –
  - iron aerogel for campaigns on Orion and NIF
  - Higher density tantala aerogel and lower density CRF for RadT
  - Potential to tighten uniformity specs on copper foam and tantala aerogel
  - Micro-bubble backlighters

Prototype FeO aerogel sample

Conclusion

- AWE Target Fabrication has moved to new laboratories
- Co-located with Orion – our main customer
- Major equipment in place, some recommissioned, first return to ops imminent
- Investment delivered in new equipment – machining & characterisation
- Facing new challenges – hohlraum manufacture, new materials, further improvements in characterisation

Acknowledgements

- Thanks are due to many people
  - All the staff in AWE Target Fabrication for their efforts in supporting the move to our new laboratories whilst still delivering targets for campaigns.
  - AWE's project team for the relocation.
  - Our colleagues in Orion for helping facilitate the move.
  - Our collaborators at LLNL, LANL, LLE and RAL/STFC.