AWE NUCLEAR SECURITY TECHNOLOGIES

AWE Target Fabrication: Impedance Match and Hohlraum Development

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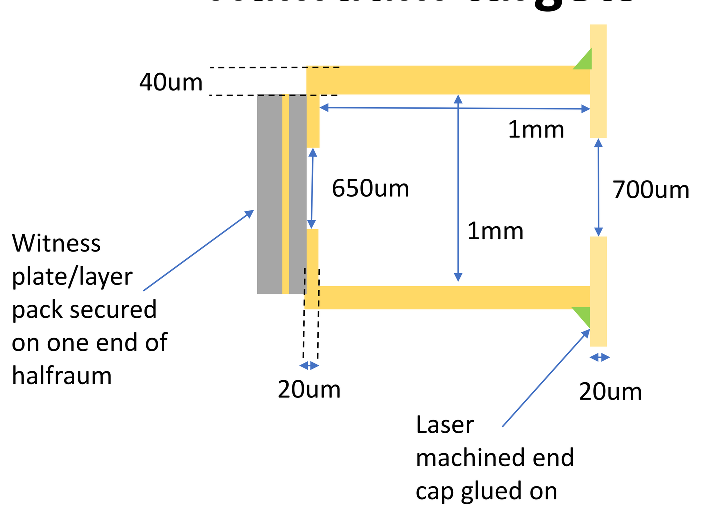
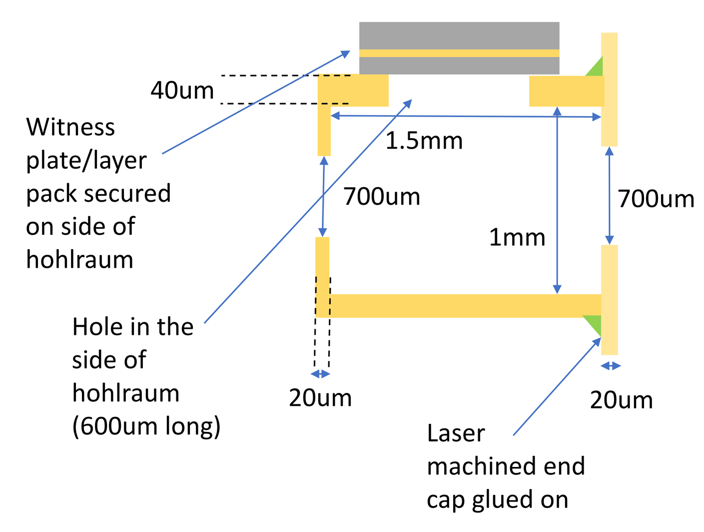
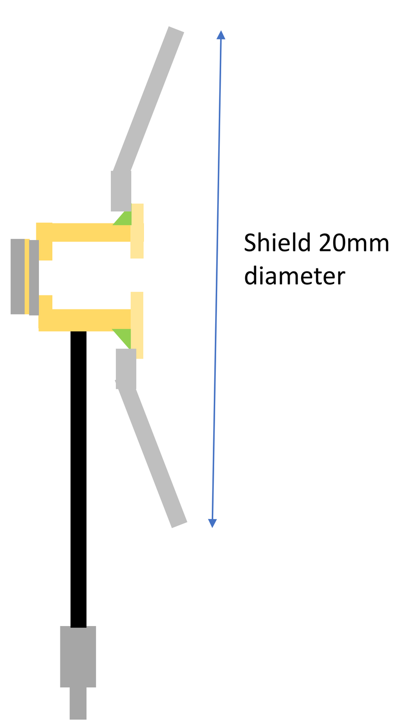
Target requirements

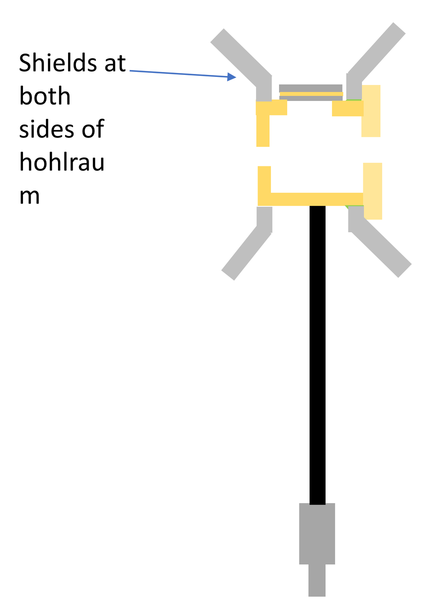
Halfraum targets



Hohlraum targets

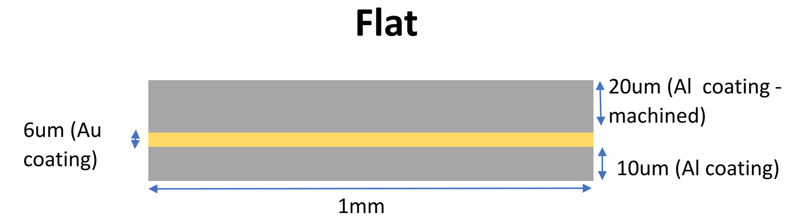




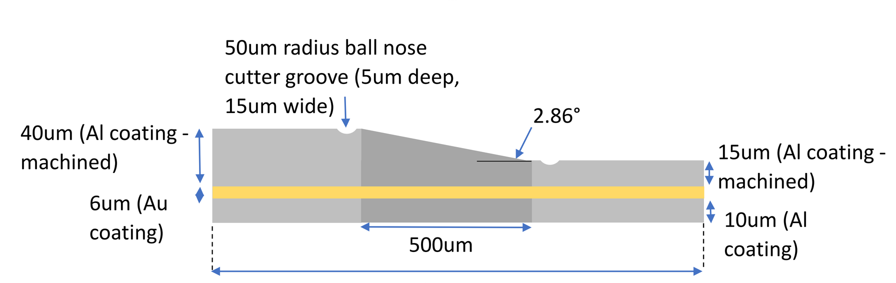


Layer pack variants

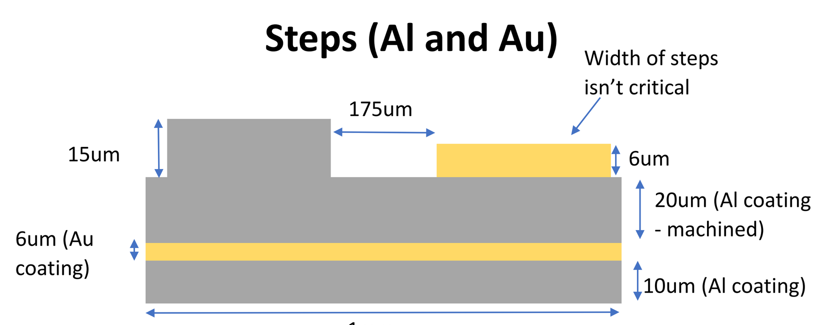
Flat



Wedge



Steps (Al and Au)

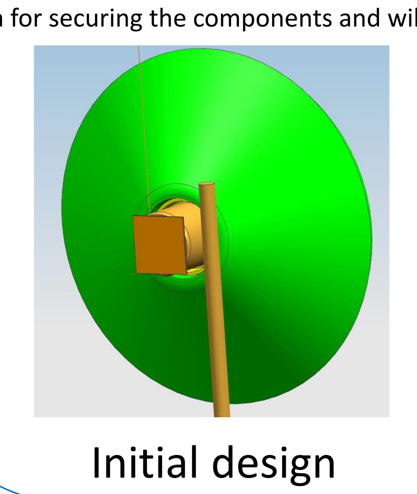


Target key requirements
- 0.05um Ra surface finish on thicker Al layers
- Alignment of hohlraum holes (+/-15um)
- No bondlines between layers (Except step components)
- Low thickness variation

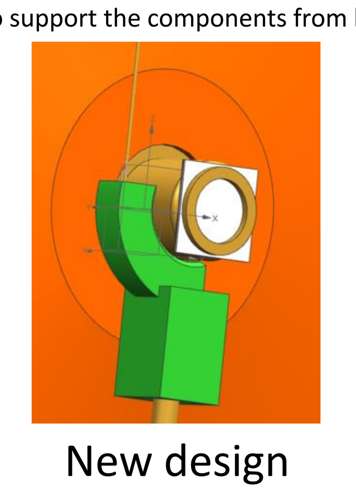
Challenges/developments

Components falling off stalks

Previous targets of a similar design experienced issues with the components falling apart from the stalks. This could have been due to the mass of the components.
To prevent this occurring, an additively manufactured mount is being used to support the halfraum/hohlraum and other components as opposed to mounting the stalk directly onto the fragile components. The mount will provide a larger surface area for securing the components and will also support the components from below.



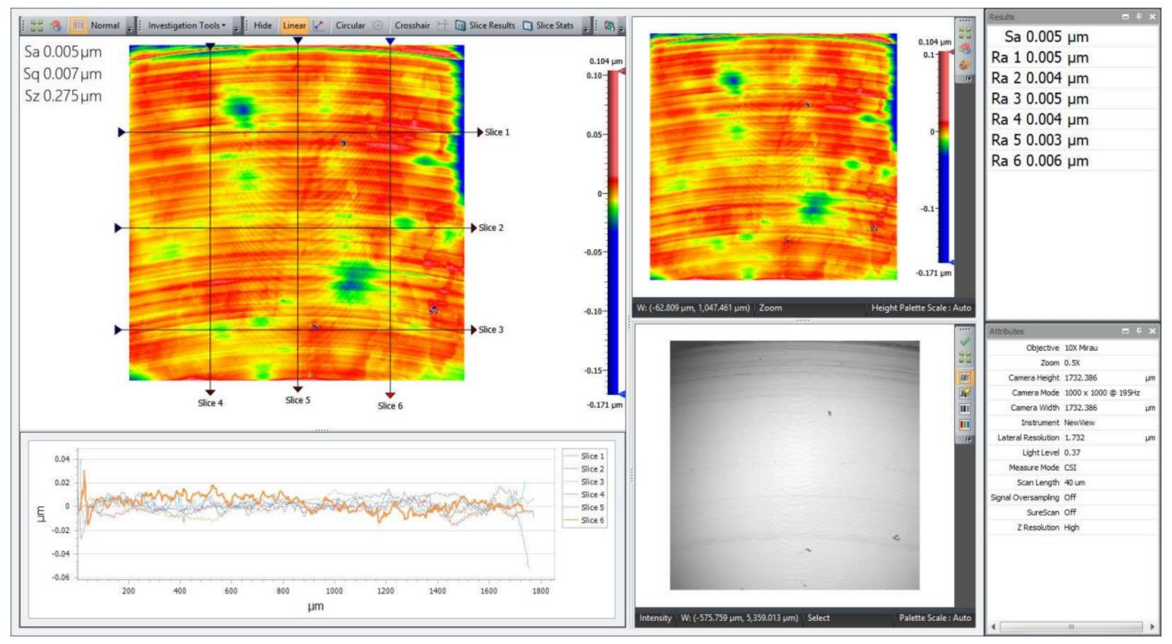
Initial design



New design

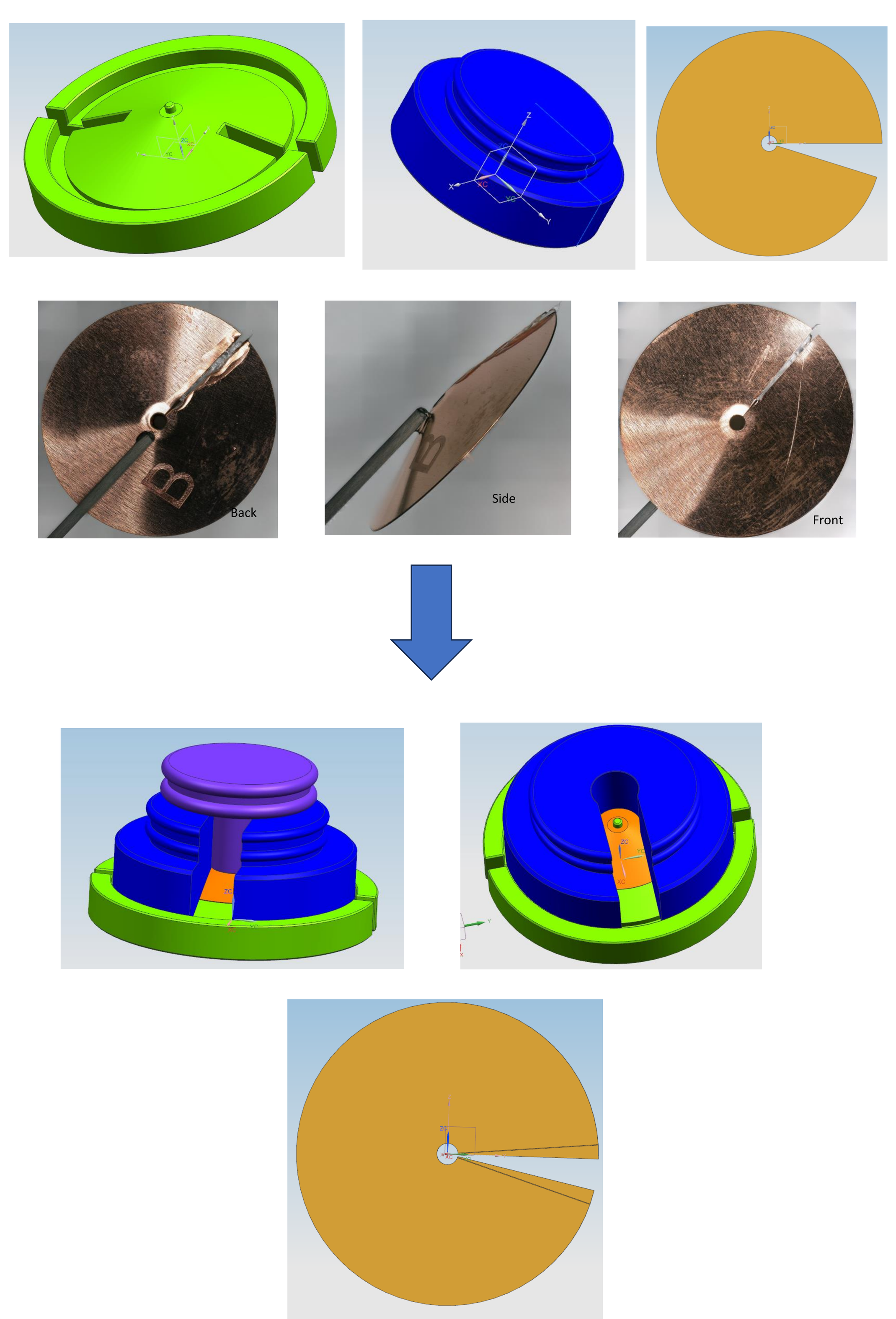
Surface finish and thickness uniformity requirements

There are requirements for a high-quality surface finish (<0.05um Ra) and low thickness variation for the layer packs. Previously these layer packs were made by machining an Aluminium foil to create the thicker 20um Al layer and then coating the other layers (6um Au and 10um Al). A bespoke vacuum fixture was made using a porous aluminium composite which supported the foils during diamond turning on the Precitech lathe.
The surface finish requirement was met, however there were uncertainties with the thickness variation of the foil. The thickness could not be accurately measured. Attempts were made to measure the thickness of the machined foil using a Zygo (Optical profiler,) however it produced varying thickness results – It was uncertain whether this was due to thickness variation in the foil, the flatness of the foil or the surface the foil was sitting on (as well as small contaminants etc).
Therefore, moving forward coatings will be used to create all the layers. The final coated layer will then be machined to meet surface finish requirements and achieve the required thickness and form. The coating thickness can be accurately measured using representative witness slides.



Producing large conical shields while minimising mass

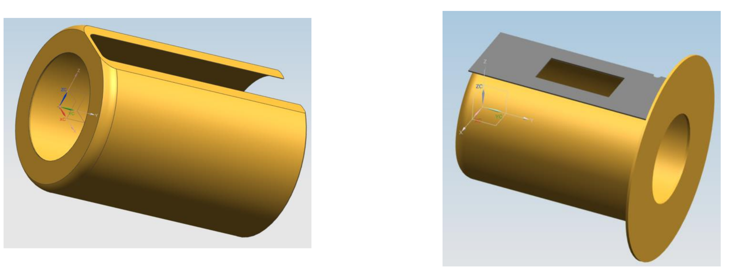
Due to ease of manufacture, conical shields are typically 3D printed then flash coated with Aluminium. The issue with this process is the mass of the component due to size limitations of what can be printed (shields are printed with substantial wall thickness). For this campaign, a large 20mm diameter conical shield is required for some target designs. In order to minimise the mass, R&D is being carried out to press conical shields from a foil. This involves a multiple part jig which has been developed and adapted during the R&D process and the blank material which has also changed:



A combination of forming the shield in place and securing the ends of the shield blank together with glue was used to produce the conical shield components.

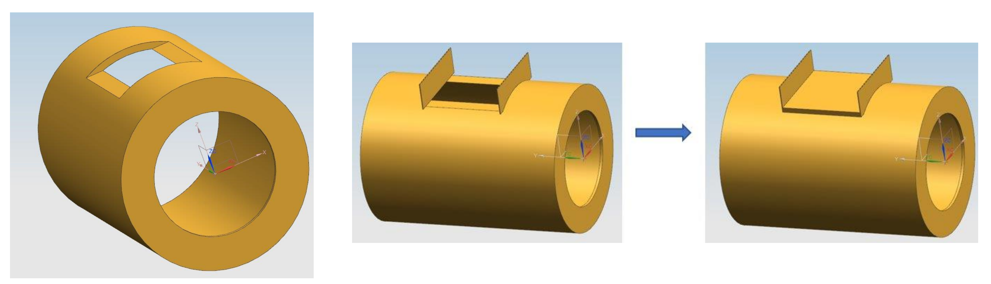
Producing side hole in hohlraum (New design/concept)

The design of producing a hole in the side of a hohlraum for the layer pack to be positioned was a new requirement for AWE Target Fab. There were multiple proposed designs however the following was selected (due to the reduced machining and assembly which is required):



The hohlraum body will be produced using standard manufacturing processes with an additional machining stage to produce the slot along the length of the component. The flat foil with a square hole and the end cap will be laser machined and then assembled to the hohlraum body. This is being trialled as part of R&D ahead of final target production to prove out the manufacturing process (Machining and assembly).

An alternative design was proposed; however, it was not favoured due to the tight tolerances/fits which would be required to assemble the layer pack in the correct position. This design included the use of foils positioned at either end of the layer pack:



Delamination during coating deposition

Coatings were carried out externally due to the thicknesses required and capability of external partner (MMU – Manchester Metropolitan University). The coatings were deposited onto a NaCl substrate (50mm dia, 3mm thick), this would allow the coatings to be removed from the substrate by dissolving the NaCl in water once deposited and machined. These substrates were supported in a bespoke fixture.
For the initial trials there were issues with the coatings delaminating from the substrate and one another.

A Ti interlayer 50nm thick was used between the coatings to act as a keying layer. This was successful and prevented the merging of the layers. However, during coating the substrate cracked and the coatings delaminated from the substrate.

The next trial looked at using an initial Ti layer on the substrate to prevent the layers from delaminating. This produced the same result with the coatings delaminating from the substrate after venting. It was believed that this was due to the top layer of the NaCl substrate reacting with moisture and causing the coated layers to delaminate.

After several coating runs a successful coated layer pack was produced which hadn't delaminated after removing it from the coating machine.
The coated layers had begun coming away from the centre of the substrate but remained intact. This allowed the coating to be analysed for surface finish and flatness and then decide the best way to progress in terms of either machining or re-securing the coated layers somehow. This was not ideal as it is important the coated layers are secured to a flat surface before machining (to prevent tearing and ensure they are machined flat), but it was a good advancement in achieving this requirement.

Once this coated layer had been achieved there were further coatings done onto glass slides. This was to check if the issue of delamination was due to the substrate. However, the coatings applied to the glass slide still delaminated. There was also residual glass on the undersurface of the initial coated layer – So although the glass slide didn't crack, the point of failure was within the glass surface.