The production of micron scale square mass limited high power laser targets

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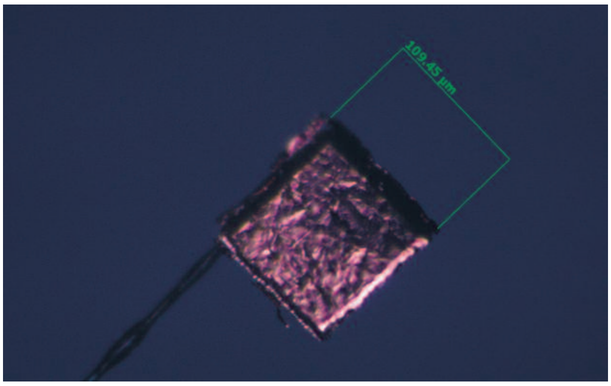
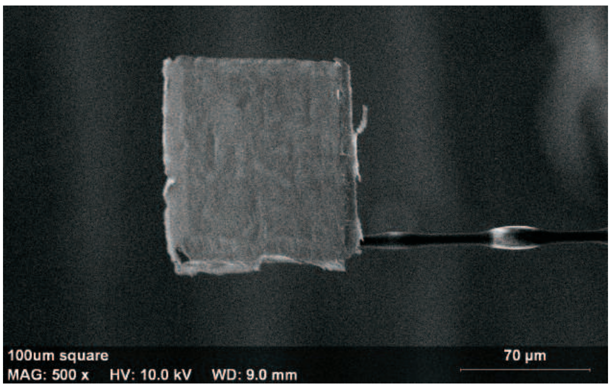
Introduction

Several experiments at RAL over the last few years have shot 'mass limited' targets. These targets are usually circular or square targets of the order of a few 100 µm in diameter or side length by a few microns thick. These targets have been historically produced by punching (the disks) or cutting the squares by hand from sheets of metallic foil and in the latter case achieving roughly 80 to 100 micron squares. A new fabrication method has been trialed where 20 µm × 20 µm metallic limited-mass scale targets have been produced for extremely low cost. The newly developed technique may ensure that the production of accurate limited mass targets will be sufficient to supply the numbers required for high rep rate laser systems.

Previous production method

As mentioned the limited mass targets have previously been fabricated using methods of production where they were simply cut by hand from a piece of foil using a new blade for each cut to ensure the neatest edges possible. When cutting an eyepiece graticule was used to measure the dimension of foil whilst being cut. The targets were then characterised when mounted onto 7 µm carbon fibres to ensure they were within specification. Some examples are shown in figures 1 and 2.





Figures 1 and 2. An optical and SEM image of a typical square limited mass target.

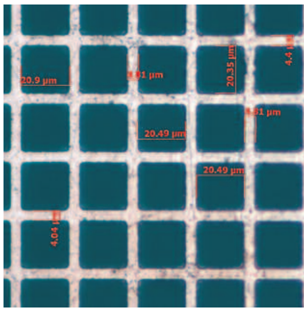


Figure 3. The grid with 20 µm square voids.

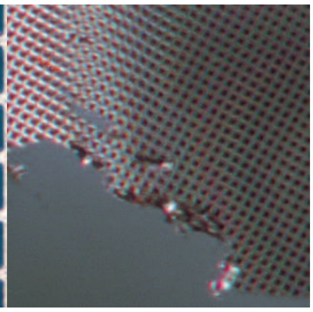


Figure 4. The Cu squares produced on a substrate.

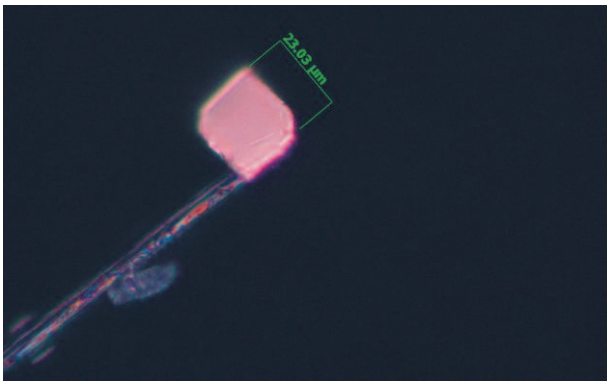
It can be seen that the squares are approximately 100 µm × 100 µm (+/- 10%).

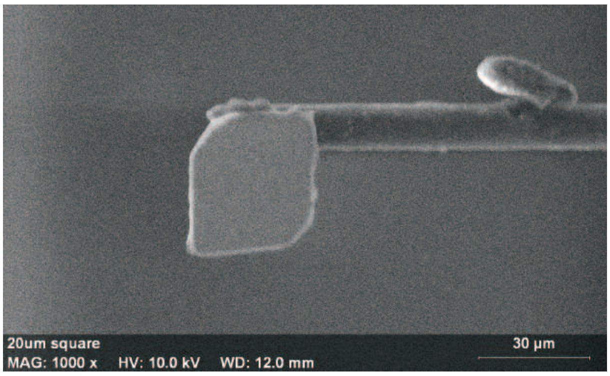
New method of production

The new method used to produce the targets is a simple yet very effective way of producing targets on a mass production scale. We used several 1000 LPI copper meshes (20 µm square void size) shown in figure 3 secured to a glass microscope slide. The slide was then coated with 5 µm of copper in the electron beam thin film coating plant in the Target Fabrication Laboratory. The material coats through the meshes to leave 20 µm × 20 µm Cu squares.

Once the squares have been coated and the mesh has been removed the squares are simply lifted away from the glass slide using a fine paint brush. Cu squares on a substrate are shown in figure 4. A 7 µm carbon fibre with a small layer of glue on the tip of the fiber is used to mount the square before it is shot. One challenge we face with mounting the squares is the glue always forms in beads on the fibre so it is necessary to remove some of the glue solution until left with just the right amount to hold the square in place.

The images in figures 5 and 6 show the square after it had been mounted. The size is, as expected, in the order of 20 µm but there was significant damage to the edges and this needed to be investigated.





Figures 5 and 6. A mounted 20µm square.

Thickness investigations

The coating that was produced was 5 µm thick in bulk but it is common knowledge that when coating through an aperture there are a large amount of edge effects to take into account. Charge build up on the mesh and in the areas under the mesh contributes to a varied coating profile across the gap. This effect was investigated by scanning the coating squares on the slide with the white light interferometer that is available to the group. This gave results that can be seen in figures 7, 8 and 9.

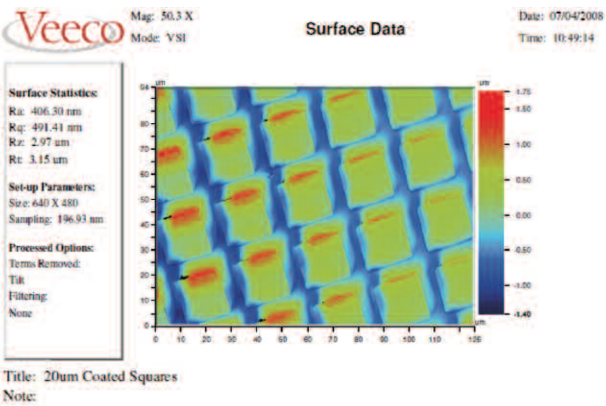


Figure 7. A height map of the squares.

The height map of the squares shows that there is definitely some discontinuity of the thickness of the coated material across the range of squares but also most obviously, across every square. There is a definite thicker area that is prominent at the top of each square. To fully understand this line-outs across the squares were taken.

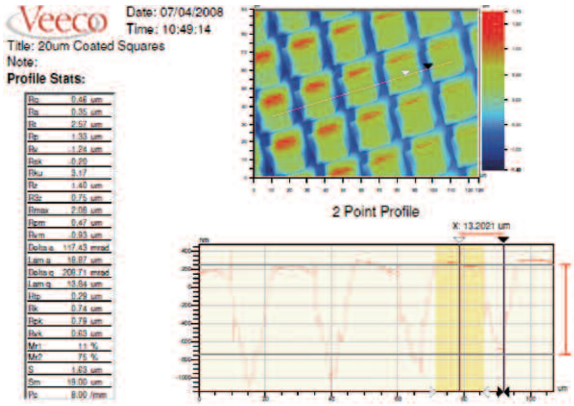


Figure 8. A line-out across the squares (parallel to ridge features).

From the line out it can be seen that the coating thickness is only about 1 µm. This is only 20% of the gross coating thickness that was produced and is a very good indicator that there are other processes that are stopping the full deposition in the squares. The width of the squares though is close to 20 µm and the edge definition is better than expected.

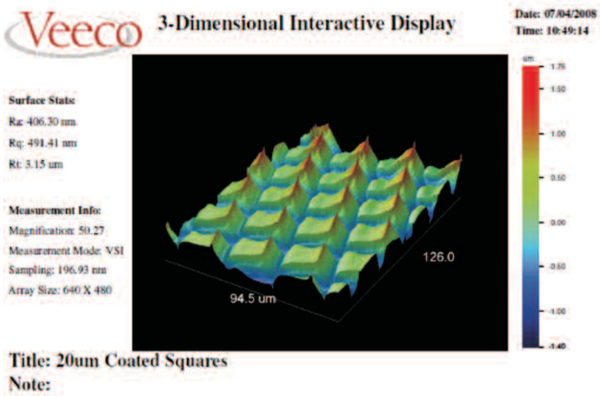


Figure 9. A 3D representation of the squares.

The final 3D representation shows very clearly how there is a buildup of coating on one side of the squares and this could be due to the geometry of the coating process.

Further work is required to study these effects and how they vary with grid size.