MEMS Fabrication of Silicon Microwire Targets

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Introduction

Some recent experiments at CLF have specified surface structures which lead to an increase in the absorption of the incident laser light. There a number of ways such a surface may be manufactured but one of the best routes is to use MEMS-based fabrication to create regular arrays of close-packed micron-scale pillars (microwires), which behave in the desired way. This manufacturing technique allows pillars, grating or similar structures to be defined over specific areas which are both highly uniform and scalable.

This paper describes the basic processes of MEMS-based fabrication and continues by outlining the process steps required to manufacture arrays of microwires over the required area. The microwire arrays were successfully created and have been used in a recent experimental campaign.

MEMS-based manufacture

MEMS-based manufacture uses technologies originally developed from those found in the semiconductor manufacturing industry. Unless requested otherwise, the substrates for this type of target fabrication are usually silicon wafers which are typically 100mm in diameter, have a thickness of 300-500 microns and are flat from edge to edge on the micron scale. MEMS microfabrication techniques are based upon the three basic processes outlined below:

Deposition

This includes sputter-coating, thermal evaporation, chemical vapour deposition, thermal oxide growth and spin/dip coating. Consequently it is possible to deposit precisely controlled films of metals, dielectrics and polymers.

Etching

This may be either dry etching or wet etching. In the former, a plasma containing highly reactive species (e.g. fluorine, chlorine) is generated which etches the substrate and/or previously deposited thin films. In the latter, the substrate and its coatings are immersed in a solution which is selected to etch the required layer, whilst leaving the other layers unaffected.

Pattern transfer

This is the key process and uses either optical or e-beams tools to pattern a thin film of photo- or e-beam sensitive material known as a resist which has previously been applied to the substrate by spin- or dip-coating. The resist film is then used as a protective stencil through which deposition or etching can take place, thereby transferring the pattern into the substrate or its coatings.

Optical lithography uses photomasks to define the patterns and comprise of an extremely flat quartz plate with the pattern defined on one side of that plate in a 100nm layer of chromium.

Electron beam lithography is utilised to define the highest resolution features and uses an e-beam tool which takes the device CAD files (converted into an appropriate format) and uses them to steer the e-beam on the surface of the resist and hence to directly write the required pattern which is then developed prior to use in the next process step.

These basic processes are repeated as often as required, and in a pre-determined order until the final structures are created.

Target Specification

Figure 1 shows the specification of the microwire target, whilst Figure 2 shows how this is realised. The target mount is a 2mm x 7mm x 350um piece of silicon with the microwire array 2mm from the end. The trench around the target allows it to be separated from the silicon wafer as it is only secured with a small tab at the end of fabrication.

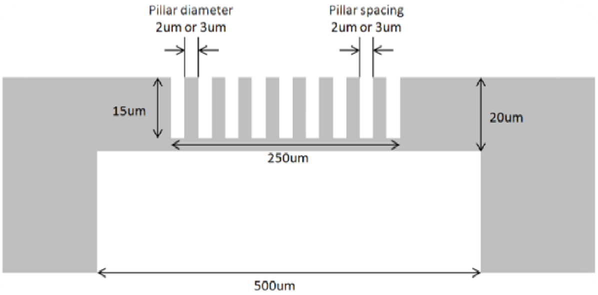

Figure 1. Basic target specification.

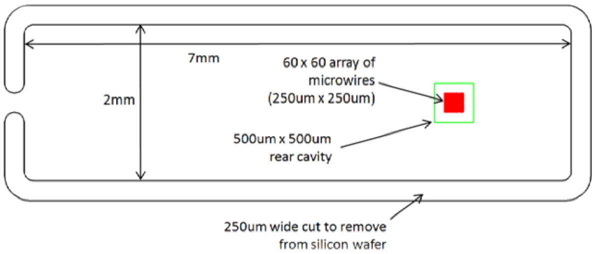

Figure 2. Microwire array as realised in a 2mm x 7mm silicon

Fabrication

Figure 3 shows the microfabrication steps using a silicon-on-insulator (SOI) wafer. This wafer has a 20um thick device layer and a 325um thick handle (support) layer, separated by a 1um oxide layer, which acts as an etch-stop layer during the processing. Optical lithography is used throughout to define the structures which have a minimum feature size of 2um.

Results

60 x 60 arrays of 2um and 3um microwires were successfully manufactured. Figures 4 – 6 show the microwire arrays during fabrication and inspection.

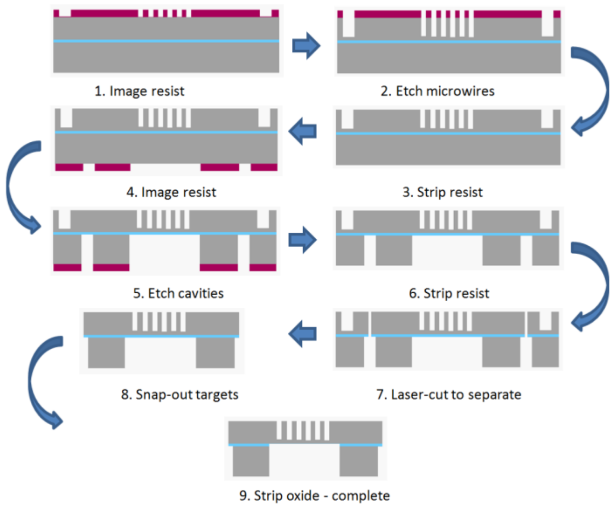

Figure 3. Basic MEMS-based process steps for the fabrication of Micro-wire backlighter targets.

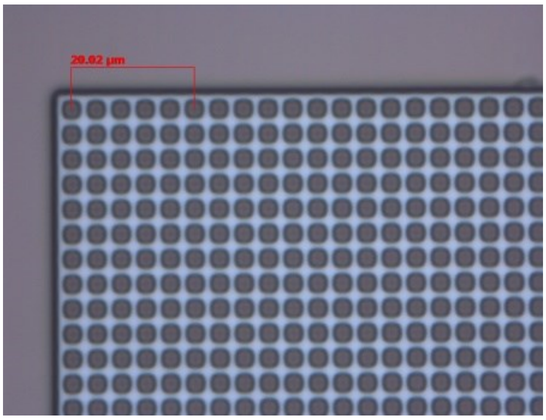

Figure 4. Optical image of the photoresist image before etch.

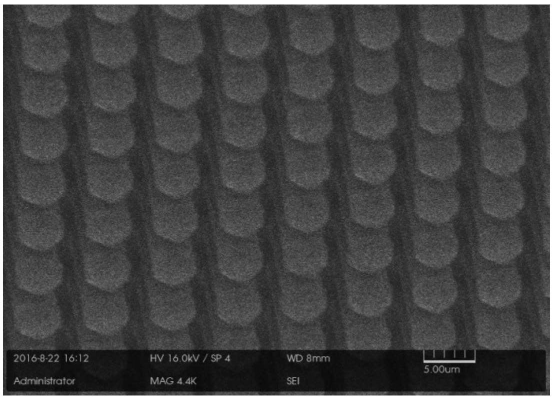

Figure 5. SEM image of 3um pillars after etch.

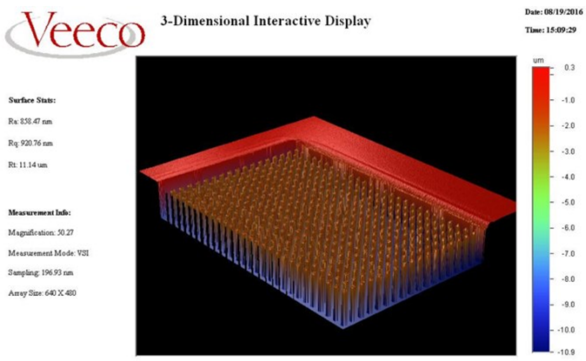

Figure 6. Wyko white light interferometer scan of the 2um microwire arrays.

Conclusion

We have demonstrated the successful manufacture of microwire targets with both 3um and 2um critical dimensions. Both types have now been used in a recent experimental campaign. Variations on these design are now being investigated for future applications.