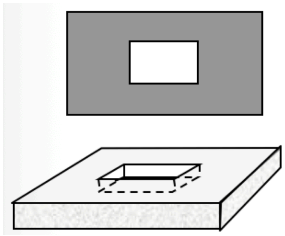
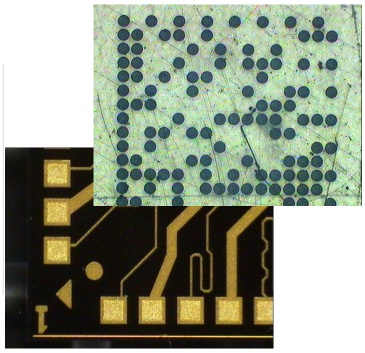
Mask Options for Excimer Laser Micromachining

Excimer laser micromachining is mask-based; different techniques require different mask options & motorization.

Simple Masks

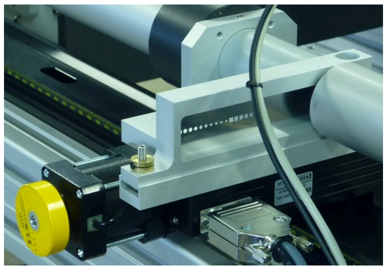
a) The simplest case is the use of a fixed mask motif to machine a primitive feature,- for e.g. a circle, or rectangle as here, to milll a hole of the same shape. The mask material is typically 0,1mm thick s/s shimstock, either chemically etched or more commonly these days laser cut. The beam completely fills the motif; rectangles & triangles are just as easy as circles.

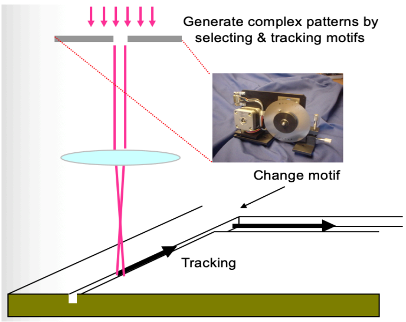




b) Obviously, the motif can be repeated as desired, combined with part motion.

c) Next step up in complexity is to have a motif selector, with N such different primitive motifs arranged either in a line or on the perimeter of a circle, with a motorized axis to select motif, which can also include alphabetic...

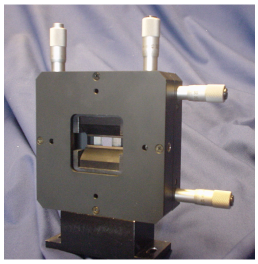




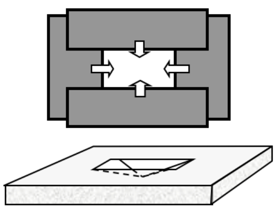
For small laser systems, many Optec machines use a selector with 32 such motifs, we have also used similar rotary selectors. The mask plate is easily changed to allow a different set of motifs, with appropriate file selected in ProcessPower control software. The combination of selected motifs with part motion allows complex patterns to be built up; in a .dxf file, the different motifs are associated with pen colour. Firing the laser ***during*** part motion leads to groove formation; depth is proportional to shot dose.

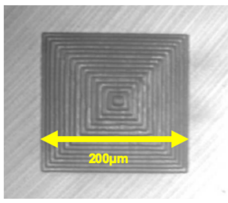
d) RA (2 axis rectangular aperture) can generate a rectangle of any size/shape, but not for e.g. a circle. MRA is the motorized version

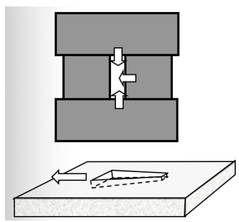
e) The combination of linear mask selector and MRA as a 3 axis 'Intelligent Aperture' allows not only the full range of both rectangles and other primitive motifs (circles, triangles..) but also combination motifs, for e.g. a half circle, which can be stored in PC memory as a 'virtual motif'.



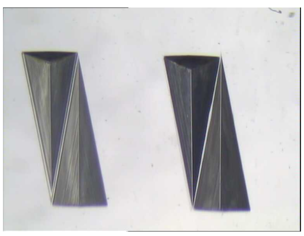
f) MRA can also be used as a dynamic mask, synchronized to part motion/laser firing, to generate by contour sectioning (CS) a range of structures which can be tapered in one or more axes, and can also be associated with part motion.

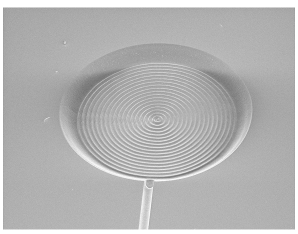


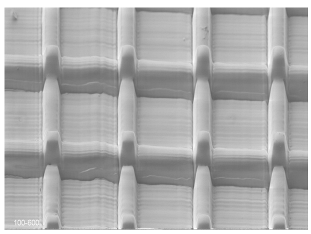


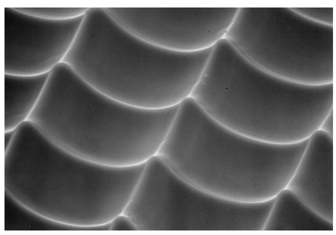


g) Taking these basic ideas further, with sufficient ingenuity, any non re-entrant 3D shape can be milled; can you figure out how these were done?

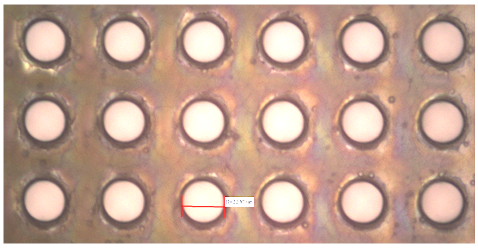








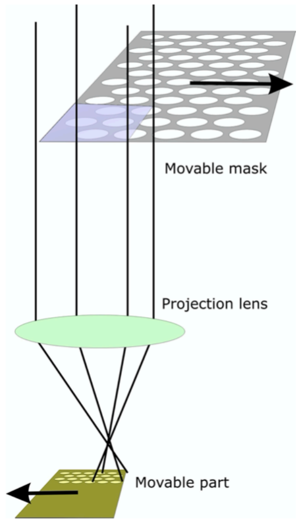
Complex Masks

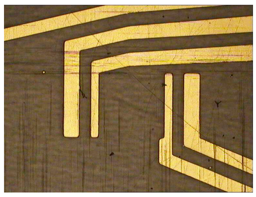


h) So far, the idea has been to build up the target pattern by combining smaller primitive motifs. Particularly where larger lasers are used & mostly for 2,5D patterning, the alternative is to have the complete pattern on the mask. At right is part of an array of 900 identical holes drilled simultaneously, in this case through a glass substrate.

i) In this case, the complete double OPTEC motif was machined in a single operation.

Mask Scanning & OCM



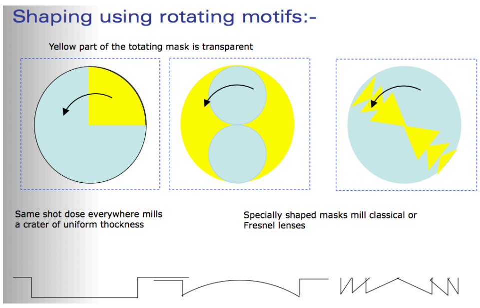


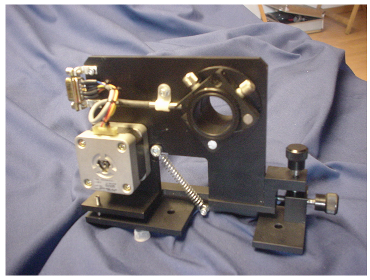
j) Sometimes the pattern on a complex mask is larger than the laser beam; this is just a small part of a much larger & complicated electrode pattern that was generated by stripping away unwanted parts of a thin gold layer on a polycarbonate substrate.

In this case we can scan the beam across the mask, or use Opposed Coordinate Motion (OCM), in which both part and mask are mounted on translation stages & moved in opposite directions (image inversion) by the ratio of demag.

Rotating Masks

k) Rotationally symmetric forms can be generated by using a rotating mask.

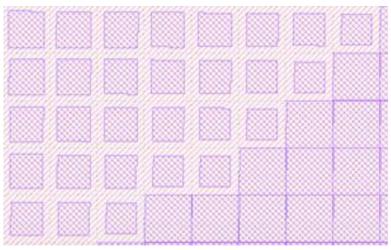




M/FS & Grey Scale Masks

l) Stencil masks are limited to motifs that are simply connected. Where more complex motifs are required, such as a letter 'O' or when greater precision is needed, then Cr/UVFS masks can be used. N.B. Cr is only about 50% reflective at 248nm, protected Al/Cr/UVFS is a better choice for higher rep. rates, which is why we refer to them as Metal on fused silica or M/FS.

m) In some cases, it is advantageous to have a soft edge to the motif, using a M/FS mask with grey scale. This is achieved not by varying the optical density of the metal layer but by blocking or deviating part of the beam using structures that are below the optical resolution of the imaging lens & therefore not reproduced on the part.. In general there are two approaches i/ use random structures to block part of the beam ii/ use periodic structures to diffract part of the beam outside of the imaging lens aperture;- r.h. example courtesy of Philips Innovation Services,- experts in this technology, with whom Optec has close collaborative projects.



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