

# Optec ProcessPower & CAD Conversion

A frequent question is, 'Can the MicroMaster/ProMaster handle CAD files?' The quick answer,- 'YES',- hides some complexity.

Many first-time users are thinking of laser cutting systems where the combination of efficient material processing with high rep.rate or CW beam lends itself to contour tracking using the laser focal point. The MicroMaster, as an excimer micromachining system working on the principle of pattern projection, can also be used as a contour tracking system, as above. However, because of the limited rep. rate of excimer lasers, and the small amount of material removed with each shot(which is responsible for the excellent depth resolution of the technique), such contour tracking is rarely the most efficient use of the system, and other approaches must be used.

## ProcessPower Command Structure

Optec MicroMaster & ProMaster are laser processing systems based on mask projection of relatively simple motifs, and suitable for composing more complex patterns by combination of primitive motifs on a mask selector. Standard systems use an Oregon MicroSystems(OMS) 8-axis motion controller housed in an industrial PC. Files ready for execution by the motion controller carry an extension .oms, and are written using the proprietary OMS instructions. They contain instructions for X,Y part position, laser firing T(as far as the motion controller is concerned the laser is just another axis)- and possibly mask motif selection R. The MicroMaster also accepts commands U & V for the axes controlling demag.(M) and Z focus(P), plus Z(energy level), and S(rotary axis) where appropriate, though these are more often fixed parameters within a processing sequence.

## Basic Notions,- Point to Point vs Tracking

For example, an .oms file could contain the instructions:-

- ❖ Move axes  $X_1, Y_1$  - i.e. move positioning stages so many motor steps from the start position. The move can be specified in relative or absolute coordinates, with linear or cosine acceleration ramps etc., and as either uncoordinated moves in X,Y or interpolated moves, so that the trajectory inbetween points is a straight line or circular arc.

...then:-

- ❖ Move axis T - fire the laser so many shots, i.e. steps.

At the position  $X_1, Y_1$  the fixed motif selected on the mask (for e.g. a simple hole) is milled into the part at demag. selected by M & P settings.

- ❖ Repeat this sequence as required, for other X,Y positions.

This procedure would drill an array of identical holes, on centres fixed by the X,Y coordinate set, and is a common application. Typically the hole size and processing parameters (energy and shot dose) are fixed by the operator during set-up, but both can be controlled by the PC, and included in the .oms file, provided the relevant motorized mechanical mask selector unit etc. are mounted. In the MicroMaster, AT4020 motorized energy control (axis Z) is standard, different types of motorized mask selectors(R) on option.

Thus the structure of an .oms file to drill different dia. holes, with different shot No and/or laser energy, in different X,Y locations, is not complicated, though could become cumbersome when the number of holes is large. Generally the choice of strategy, for e.g. to drill all holes of the same size sequentially or take them strictly in order of position,- is that of the operator.

ProcessPower includes a 'traveling salesman' routine for minimizing the time taken to drill a large number of such holes, by optimizing the sequence in which they are drilled, which can result in spectacular savings in processing time.

We will see later how standard industry formats can be used for point-to-point applications.

## Motif Tracking

An .oms file can also request that the moves above of X,Y, and T be performed synchronously. In that case, the number of laser shots requested will be distributed evenly along the controlled X,Y trajectory, milling a slot or trench, or, at high enough shot dose, cutting through a part. Of course, in writing the program the laser energy and rep. rate must be set to provide the correct average shot dose along the trajectory, bearing in mind the processing parameters, and the width of the motif in the tracking direction.

The motif selected will also determine the track width, which will be different in different scan directions if the motif is asymmetric. Note that *only* a circular motif allows tracking in any direction without affecting track width or depth, but leads to a higher average shot No on the track centre than at the edges, and therefore rounded depth profiles. Thus, milling depth depend in a complex way on materials data vs laser energy, laser rep.rate vs tracking speed, motif size and shape, and tracking direction.

At its simplest, tracking of a very small motif is similar to contour tracking/focal point processing, though generally an inefficient approach at the lower rep. rates associated with excimer lasers, compared for e.g. with Q-switch Nd-YAG, where rep. rates are typically more than two orders of magnitude greater.

An important point to note is that if the same process file is run again on the same part then the track will be deeper. This is a fundamentally different behaviour to a mechanical miller, and thus milling depth cannot be controlled in a simply analogous way to a mechanical milling station. Note that this is not a limitation of the MicroMaster/ProMaster, but of laser micromachining in general. A related problem arises at the extreme end of a track, which will receive a lower shot dose over part of the track corresponding to the motif length.

However, sometimes samples often consist of easy-to-ablate layers on a hard-to-ablate substrate, where the material selectivity provides a natural control over the ablation depth (e.g. Kapton on Cu), thin metal films on ceramics, and in those cases the machining strategy is much simplified. The same applies to machining through a thin free-standing part.

## Area Ablation

Using large motifs, tracked in two dimensions in a regular fashion, larger areas can be ablated, essentially by making parallel and overlapping tracks, and techniques exist for ensuring uniform shot dose over the area. As in 1-D tracking, the materials data vs laser energy, laser rep.rate vs tracking speed, motif size and shape, and tracking direction interact in a complex way to affect milling depth.

However, where material selectivity exists, or for through machining, complex shapes can be ablated using a combination of tracking and area ablation with different selected mask motifs.

## Industry & CAD Files & File Conversions

A number of formats are in common use, usually originally developed with some particular process in mind, and therefore best adapted to that process. Typically, such a file contains coordinate data, and maybe other attributes,- e.g. line type, width or colour. There is NO format which can be directly input to the MicroMaster/ProMaster(or any other similar machine), for the simple reason that these formats contain no provision for coding the motif size, energy density, laser firing etc., nor the materials processing characteristics. These have to be entered somehow by the user.

ProcessPower eases the task by taking geometric data in standard industry formats, and converting this for use in excimer ablation.

ProcessPower supports the following:-

### ASCII

X,Y coordinates for point to point hole drilling applications are supplied in ASCII code; selecting that option within ProcessPower will use that data, plus laser firing data to be entered by the user, to automatically generate the requisite .oms instruction file.

### Excellon

These are industry standard via drilling file formats, containing coordinate information. Selecting that option in ProcessPower allows the operator to set the hole drilling parameters of hole size, shot No etc., and then merge this data with the Excellon coordinate data to generate a complete .oms file, which can then be used by the MicroMaster. The

operator must indicate to the conversion routine the place in the Excellon file from where the data is to be extracted, and often such files contain a header and tailer which must be deleted by the user to avoid confusion.

For both ASCII and Excellon i/p format, the path optimizing routine can be used to reduce processing time, by a significant factor.

## Gerber - Drilling

Gerber code (there are actually a number of different, but related, formats, which are not fully compatible even between different Gerber machines) is a format developed for photoplotters, the nearest functional equivalent to an excimer laser ablation tool, and therefore it is no surprise to find that this format is probably the most readily adapted to excimer ablation. Gerber files contain coordinate data, mask selection data, and exposure commands, essentially 'lamp on', 'lamp off', and 'flash'.

A Gerber point-to-point or drilling file moves the part to a specific location, selects a mask motif, then flashes the lamp to expose the resist. ProcessPower contains a routine to generate .oms drilling files using the Gerber coordinate data as starting point. We use the lamp flash signal to initiate a laser firing burst defined by the operator as i/p to the file conversion process.

The full motif selection attributes of Gerber can also be used, provided of course that there exists a motorized mask selector. That motif set must be defined by a TOOLSn.PRO file, providing the essential 1:1 correspondence between motif and selector drive; a very common user problem is failure to correctly define that file.

## Gerber - Motif Tracking

These combine the data as above, but allow track writing using different motifs by using 'lamp on' and 'lamp off' signals to initiate and terminate a move. Note that the i/p Gerber files contain no notion of the calculation of laser rep. rate/motion speed vs shot dose in order to ablate a track uniformly, since the lamp is a photoplotter CW device. In addition, the exposure sensitivity range of resists means that 'double' exposure presents no problem, and there is not the complex interaction between motif size, rep. rate and tracking speed which exists in laser processing.

The ProcessPower conversion routine takes into account the dimension of each motif in the tracking direction (defined in the matching TOOLSn.PRO file) in order to calculate an the appropriate tracking speed for constant average shot dose, and generates an .oms tracking file accordingly.

However, that conversion can never alter those aspects of the depth of processing by scanning non-rectangular motifs, since this is a fundamental physical feature of the process, only absent where strong material selectivity exists.

## CAD

A typical CAD system uses .dxf as an interchange format and .plt as an output format. However, many plotter/CAD combinations do not use the HPGL circular arc commands but instead approximate the arc by straight line segments. For this reason ProcessPower uses the .dxf format, though does not attempt to replace the CAD system; where further modification is to be made to the Dwg. is required Optec simply bundles AutoCAD Lt with the ProcessPower s/w.

ProcessPower accepts .dxf input, with user-added laser data to create the .oms process file. Note that the order of the lines/curves in the .dxf file is the order in which they were created by the draughtsman, and this order is retained in machining. During the file translation, the user can select which layers/calcs to machine.

Note that for .dxf input, the coordinate data in the file is the locus of the CENTRE of the mask motif as it will be tracked across the part (as with all other approaches). The selection of that motif is indicated by the line colour, but the representation of the limits of the track width on the CAD screen must be performed by the designer/operator, usually in an overlayer which is NOT processed. Similarly, it is up to the user to calculate the ablation effects which will be created by tracking a given motif at operating rep.rate, with particular attention to the extremities of lines etc.

Area ablation, as an extension of tracking, can also be performed in this way, with comments as already noted.

## General Area Processing

For some applications, say stripping of thin films, there may exist a CAD file containing line data which marks the external outline of the area to be ablated. For such applications, a *desirable* feature might be a routine which allowed

automatic stripping of that complete area by laser ablation, without any operator intervention. However desirable, this does not exist on any machine, and is not likely to in the short term, for the reasons below:-

## Contouring

Feeding the line data to ProcessPower will cause that outline to be interpreted as the centre track. If a very small motif is selected MM will cut out the contour of the motif, as in cutting laser systems using focal point processing. In a free-standing film this will cause the cut out area to detach, achieving the desired result, albeit at low speed, because of the small motif/low rep. rate.

## Rastering

One way to approach the problem would be to scan the complete complex area with a small motif, toggling the laser on/off as appropriate. From a programming point of view this may not be too complicated. However, from a physical point of view the finest feature to be reproduced in an arbitrary shape requires the choice of a small motif (which then sets the resolution), whilst a large area to be scanned would then require an unacceptably long time to process at practicable rep.rates, certainly longer than contouring, and quite possibly even exceeding the shot lifetime of the laser. Note that a similar feature IS available on some Nd-YAG marking systems,- where the available rep.rate is orders of magnitude higher,- and also as a standard resist exposure tool, where required photon doses are MUCH lower, and allow rapid scanning with a CW laser.

## Patching

From the above, it is clear that acceptable processing times of large complex file i/p motifs with high resolution in laser ablation (at the limited rep. rate which this implies), can only be achieved by using the full power of the MM system to *change* motifs,- i.e. using a small tool for the fine work/high resolution, and a larger tool for the larger areas. Most users do this regularly on a manual basis to construct more complicated shapes,- the challenge is to automate the process, or at least to speed it up.

Changing tools in a reproducible manner implies a motorized mask selector, with appropriate choice of motifs, and the .oms file to be constructed will enable the MM to coordinate motif selection with positional data etc. However the *strategy* to be adopted to use the available motif set in the most efficient way to produce the complete pattern,- i.e. the fitting and overlapping of these shapes to produce the complex final shape desired,- is a human-brain type of activity,- which can of course benefit from a CAD environment where the user can plot the tracks of the centers of selected motifs. Typically therefore, the user uses an overlayer to construct the centre tracks of parts of the complex pattern, using either existing motifs or specifying new ones, and indicating this by the colour of the centre track, until the complete complex pattern is recreated. Issues of milling depth/overlap etc depend on material characteristics, and a foreknowledge of these.

Once the selection of appropriate motifs and centre tracks is defined by the user, the conversion routine assists the user is calculating possible rep rate. tracking speed combinations,- depending on motif size and desired shot dose,- and automatically,- constructs the appropriate .oms file.

## VAPE/MRA Patching

VAPE is a Gerber term used to describe a 2-axes Motorized Rectangular Aperture (MRA) functionally identical to the Optec 2xMA15P/M, and which can be used for patching with an infinitely variable motif of rectangular form. This motorized unit can be piloted from the spare axes and PS slots in the MicroMaster, and by .oms files.

From a programming standpoint, the Gerber software used to drive the VAPE is *not* currently supported directly by MM, since the selection, and insertion into the routine, of appropriate rep.rates etc. for the particular machining application and material remains, as above, a user-driven operation. In applications we have treated to date, the adjustment of the rectangular motif, and the tracking data are treated as separate issues. The most common application of VAPE patching is to compensate for the end-of-line effect by reducing the motif in sychronization with laser firing/part motion,- an operation called 'stitching', when used to link segments together, and which can be automated.

## OMS File Edits

The .oms files generated as above can of course be edited as necessary within ProcessPower, using the usual cut & copy routines. Sometimes this is the quickest way to eliminate/correct anomalies arising as above.