

Automatic NC Part Programming Interface for a UV Laser Ablation Tool

by

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Abstract

This research project commenced in December 2001 and it is expected to be completed by December 2004. The research and experimental work are mainly carried out using the Excimer laser laboratory at IRIS. The main purpose of this research project is to improve the capability of the laser micromachining process, so that any desired 3D surface should be able to be produced by taking the 3D information from a CAD system and automatically generating the NC part programs. In addition, surface quality should be able to be controlled by specifying optimised parameters. The aim of this research project is to develop algorithms and a software system, which processes 3D geometry (STL file format) from a CAD system and produces the NC part program to mill the surface using the Excimer laser ablation process.

1. Introduction

The development of new techniques that can rapidly reduce the cost of fabrication for the most complex microstructures and at the same time reduce the product time to the market are the basis for full integration and more wider application of these structures in the micro world [1].

Excimer laser system with additional equipment of CNC-controlled handling devices is a logical step towards a more efficient and reliable system for more complex optical components [2].

Because today's CAD systems contain the complete contour information that can readily be exported in a number of different graphical file formats, this information can be used for automatic generation of data necessary for a CNC system to produce the desired structure. Hence, intelligent software as a 3D CAD-interface that can calculate the CNC-data for laser triggering, XYZ-table movements and the CNC-mask control have to be developed. This software will allow the conversion of STL-files (Stereo-Lithography file format normally used for Rapid prototyping processes) into NC code for Excimer based micro machining. With such a system micro components for MEMS and MOEMS can be manufactured without using expensive and time consuming

programming work [3]. There is no single procedure which can be established to strictly define all the important issues that need to be addressed in the use of excimer lasers for micro-engineering applications but some of the main features include; absorption of the laser wavelength by material, the resolution of features required, and issue of processing speed which may impact on the laser repetition rate [4]. The first phase of development of a CAD/CAM interface for the Excimer laser ablation tool will be limited to the step-and-repeat ablation technique. In this mode, the workpiece is moved laterally in XY after each process step and so a repetitive pattern can be built up. The advantages of step-and-repeat processing are that it is a relatively simple technique, the multiplication of repetitive features is straightforward and that complicated patterns can be produced by appropriate control of the samples [4]. The main disadvantage is that the workpiece must be stopped for exposure at each site. These disadvantages can be overcome and they will be addressed in the future work.

2. Industrial Implications

This system when fully integrated will help to simplify the processes of producing the highly accurate surfaces for high precision optics that with currently established procedures are very time consuming and operator dependent.

3. Experimental Modeling – Prototype system

3.1 STL – File format

The 3D CAD modeling process of a microstructure could be done using any commercial CAD software that has capabilities of creating a graphical output in the form of a STL file. The standard file format for rapid prototyping is called STL, where the shape of the object is defined by a mesh of tiny triangles laid over the surfaces. The triangles must meet up exactly with each other, without gaps or overlaps, if the object is to be built successfully [5]. The "slice files" which are used to build each individual layer are calculated from the STL file, and if there are any gaps between the triangles, then the edges of the slices are not properly defined.

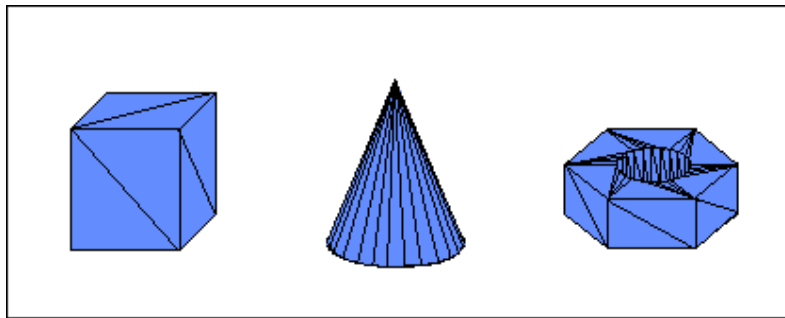


Figure 1 - Triangular mesh for different geometric shapes

3.2 SGM – File format

The STL file is used as input for the InsightV2.1™ (Stratasys, Inc.) FDM (Fused Deposition Modeling) software to create a slicing file. This SGM slicing file is created in a format that contains the original information from the CAD model and is suitable for the Excimer laser ablation process. A slice file is a collection of the 2D vertices where all vertices that belong to the same layer have the same value of Z-coordinate. Each layer represent a cross section of a 3D model.

3.3 Triangular Pocket Structure

For the development of an analytical approach to this problem we will consider first the simple case such as a triangular structure 3D model and examine it's STL file structure. The 3D model of a triangular structure is shown on the Figure 2. This model is created using SolidWorks® (SolidWorks Corporation) CAD package which has the option to export this model as an STL graphics file format (ASCII or Binary).

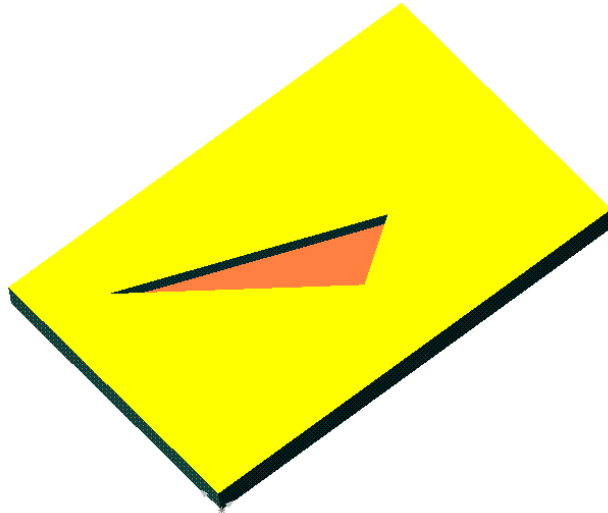


Figure 2 - 3D Model of a triangular structure on a surface

A tessellated (triangular) representation of this model is shown in the Figure 3. This figure shows that this model will have 24 facets.

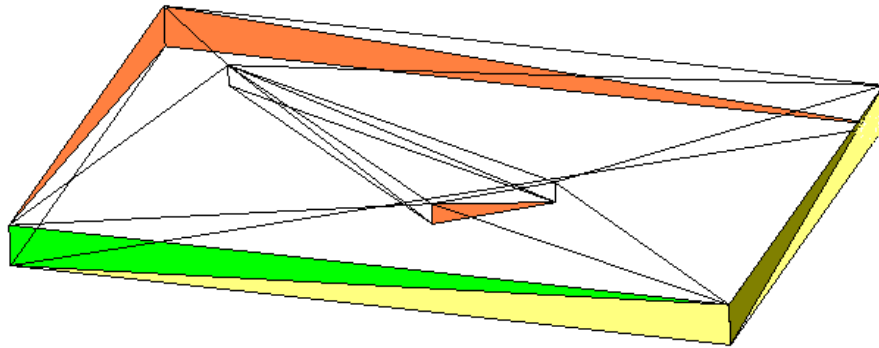


Figure 3 - Tessellated representation of a triangular structure

Representation of a 3D structure in this form is suitable for the input to the InsightV2.1™ (Stratasys Inc.) software for the slicing into layered structure.

Currently the layer thickness is limited by the diameter of the nozzle head of the FDM 3000 Modeller machine and the maximum resolution is 0.010 mm [6]. This software constraint is taken into account and our first 3D model is extruded 1.78 mm in the direction of Z-axis. Now we are able to slice this model into 10 equal layers, using the maximum precision possible by the current settings of the FDM 3000 modeller. Before we start with slice file generation we will orientate our model in such way that the 2D cross-sectional areas generated after slicing will be suitable for examination of this model. The layered structure is represented in the Figure 4.

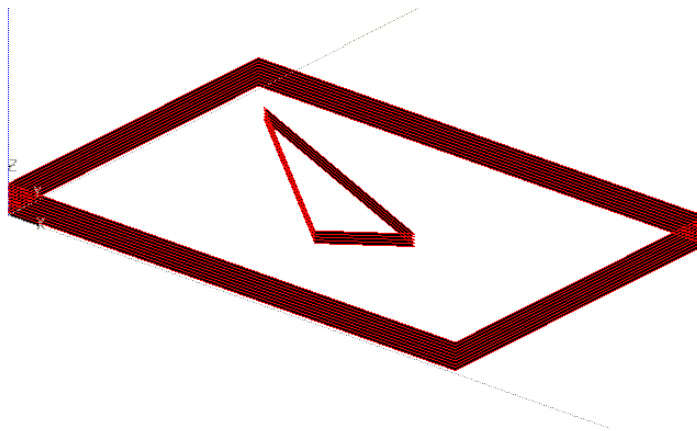


Figure 4 - Sliced 3D model of a triangular structure

After the algorithm for the single boundary case is developed it will be applicable to all other polygonal 2D cross-sectional areas with one boundary. As we can see from Figure 4 the sliced model is a collection of 2D vertices where all vertices that belong to the same layer have the same value of Z-coordinate. This layered structure will be used as an input to the Ex-Expert v1.0 software currently under development to create the proper toolpath for the Excimer laser ablation tool, and using this information automatically generate the NC code to be executed for microstructure processing. An

inside triangular boundary of a layer of the 3D model with different size masks layout is shown in the Figure 5 and is produced by the ExExpv1.0 software.

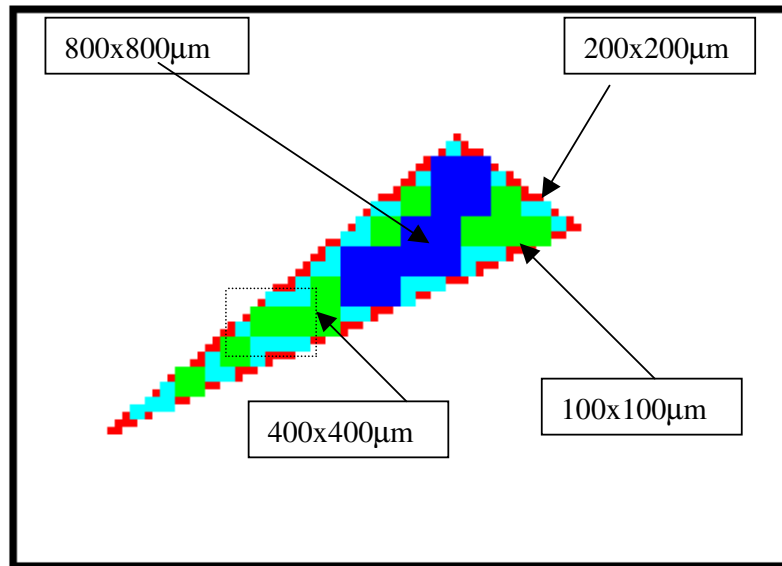


Figure 5 - Masks Layout for triangular structure – Layer 5 produced by ExExpv1.0

After all 2D cross sectional areas are defined by the software we will be able to automatically extract the G-Code for the Excimer Laser (Aerotech Inc. – Unidex 500 Controller) tool. A sample of the NC code file structure automatically created by the ExExp v1.0 software is shown in the Figure 6.

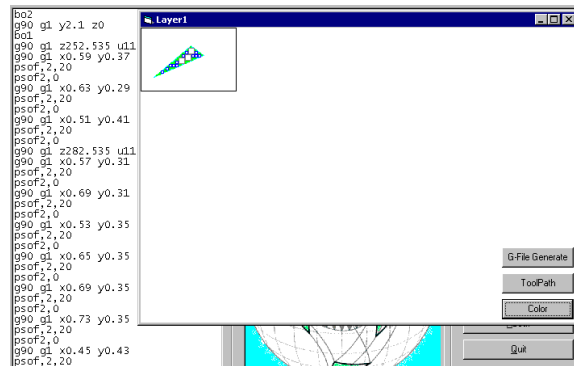


Figure 6 - G-Code automatically generated by ExExpv1.0

3.4 Experimental Results

The next step is to verify that the G-code created by the ExExpv1.0 software (under development for this project) is correct and matches the results produced by the actual machining of this channel structure by the excimer laser (Exitech Ltd.Series 8000). For the purpose of this experiment the laser head fires a fixed number of shots (50) and the workpiece is moved a certain step size and the process is repeated. The mask position is fixed and we are using a range of square masks (100x100 μm , 200x200 μm , 400x400 μm , 800x800 μm projected on the workpiece after 10x demagnification). Other settings are: numerical aperture 0.3, 5 Hz repetition rate, fluence at the workpiece 850 mJ/cm² (\pm 10%). A sample of actual machining using the G-Code produced by ExExpv1.0 is shown in the Figure 7. The actual image is produced by confocal microscope (Olympus OLS-1100).

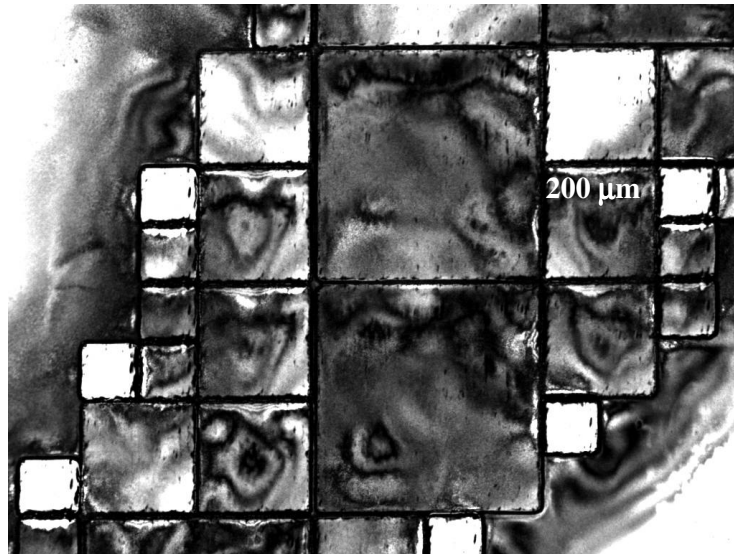


Figure 7 - Part of the machined structure highlighted in the Figure 5

3.5 Future activities

More complex geometry shapes with more than one boundary will be generated to prove that algorithms are working properly. The algorithms will be extended to mask dragging and synchronized scanning techniques to achieve higher surface accuracy and smoothness within the sub-micron range. The next stage would be to continue with GUI interface development and layout development of the materials data base.

4. Conclusions

This research explores the development of a novel system for Excimer laser ablation process that implements the existing knowledge of various parameters that influence and specifically determine this unique process, to automatically derive a precise NC part program for the Excimer laser machine. The research also further extends the industrial application area of this machining process especially for the optics industry.

5. Acknowledgments

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6. References

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