

Dental materials processing with PicoSpark

Summary :

Compact Microchip lasers have proven to be suitable for the removal of tooth (dentin), ivory and ceramics:

- no burning of the material
- sharp edges with steep walls in ivory and ceramics
- good ablation rate

Furthermore, investment cost is only a fraction of a non microchip-ps-laser, wall-plug-efficiency and reliability fairly high, providing an excellent ROI.

Test conditions

- v Machine square cavities (1x1mm², 2x2mm²)
- v short and long irradiation time
- v Test different pulse energies

Objectives

- v Smooth and vertical cavity walls
- v High removal rate
- v No burning of the material
- v Determination of the ablation rate
- v Determination of processed cavity shape

Experimental setup

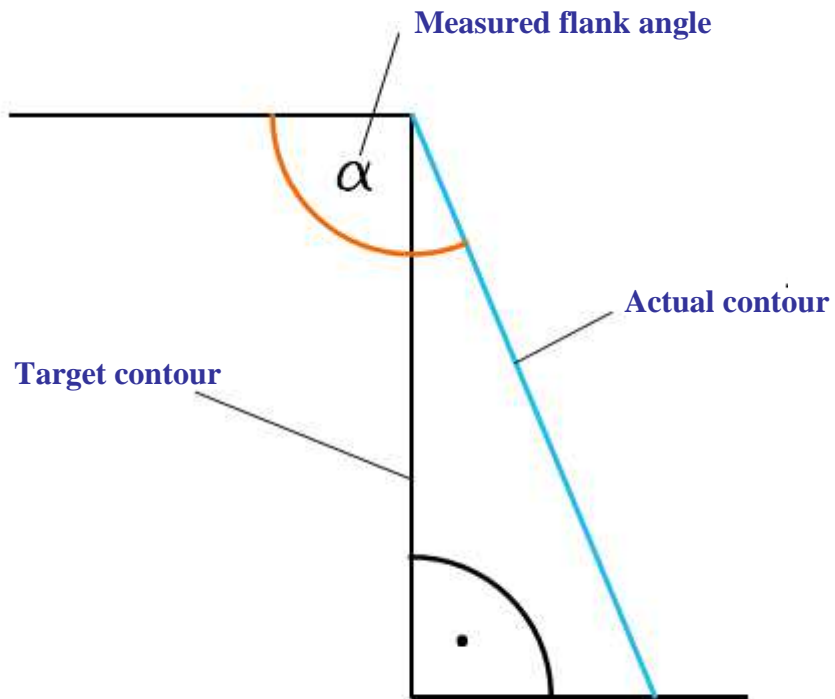
- v PicoSpark
 - wavelength 532 nm
 - 610 ps pulse duration
 - repetition rate from 20 to 40 kHz
 - pulse energy up to 100μJ
- v Galvano and linear axes
- v F-Theta lens
- v Focal length 100 mm



Figure 1 : PicoSpark laser

Definitions

The measured flank angle α is defined as follows:



Test results

Ivory samples – Process I

Parameters

- v Short irradiation time
- v 600 ps pulse duration
- v 38 kHz repetition rate
- v pulse energy 29 μJ per pulse
- v hatching disposed vertically and orthogonal (right picture)

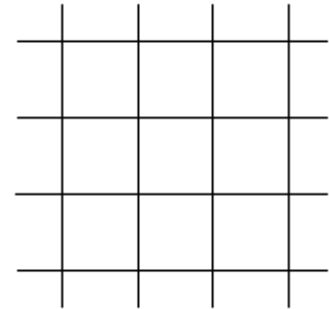


Figure 2 : Hatching strategy sketch

Results Ivory I – 2x2mm²

- v Processing time for the entire field: 26.6 s
- v Depth: 59 microns
- v Steep, clearly defined edges possible
- v flank angle 108 °

Results: Ivory I - 1 x 1 mm²

- v depth of about 65 microns
- v flank angle 102 °
- v processing time for the entire field: 7.3 s

Ivory samples – Process II

Parameter

- v Long irradiation time
- v 600 ps pulse duration
- v 38 kHz repetition rate
- v Pulse energy 32 μJ per pulse
- v Hatching disposed vertically and orthogonal

Results Ivory II – 2x2mm²

- v Processing time for the entire field: 19.4 s
- v Depth: 79 microns
- v Steep, clearly defined edges possible
- v Flank angle of 97 °

Results Ivory II – 1x1mm²

- v Depth of about 62 microns
- v Flank angle 102 °
- v Reduced ablation rate at startup
- v Processing time for the entire field: 5.6 s

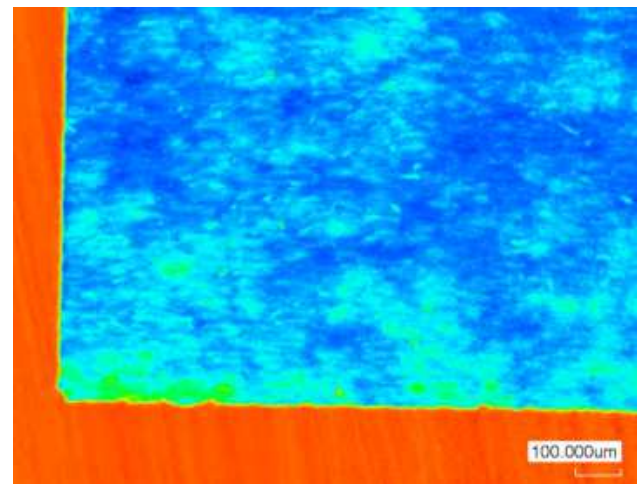


Figure 3 : 3D profile with Laser Scanning Microscope

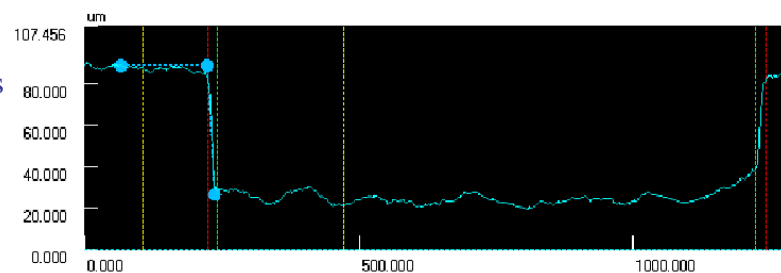


Figure 4 : 2D profile with profilometer

Ceramics samples – Process I**Parameters**

- v Long irradiation time
- v 600 ps pulse duration
- v 38 kHz repetition rate
- v Pulse energy 43 μJ per pulse
- v Hatching disposed vertically and orthogonal

Results Ceramics I – 2x2mm²

- v Depth of 110 microns
- v Processing time for the entire field: 22.2 s
- v Flank angle approximately 113 °
- v Rounded removal profile

Results Ceramics I – 1x1mm²

- v Depth 108 microns
- v Processing time for the entire field: 6.2 s
- v Rounded removal profile
- v Flank angle approximately 123 °

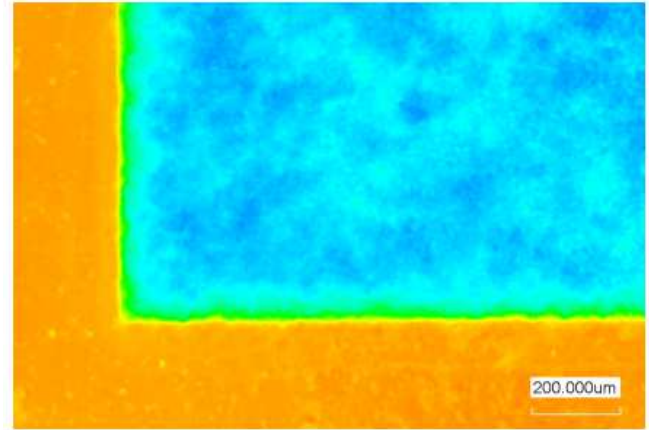


Figure 5 : 3D profile with Laser Scanning Microscope

Ceramics samples – Process II**Parameters**

- v Short irradiation time
- v 600 ps pulse duration
- v 38 kHz repetition rate
- v Pulse energy 55 μJ per pulse
- v Hatching disposed vertically and orthogonal

Results Ceramics II – 2x2mm²

- v Depth 109 microns
- v Processing time for the entire field: 12.1 s
- v Rounded removal profile
- v Flank angle approximately 108 °

Results Ceramics II – 1x1mm²

- v Depth of 110 microns
- v Processing time for the entire field: 3.6 s
- v Flank angle about 116 °
- v Rounded removal profile

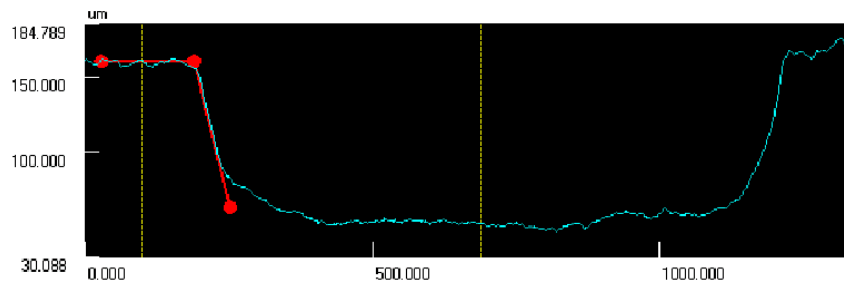


Figure 6 : 2d profile with profilometer

Tooth samples – Process I**Parameters**

- v Long irradiation time
- v 600 ps pulse duration
- v 38 kHz repetition rate
- v Pulse energy 39 μ J per pulse
- v Hatching disposed vertically and orthogonal

Results Tooth I – 2x2mm²

- v Depth of 38 microns
- v Flank angle about 136 °
- v Processing time for the entire field: 16.3 s
- v Natural tooth structure recognizable in ablated field
- v Rounded removal profile

Results Tooth I – 1x1mm²

- v Depth of 55 microns
- v Flank angle 122 °
- v Processing time for the entire field: 4.8 s
- v Natural tooth structure recognizable in ablated field
- v Rounded removal profile

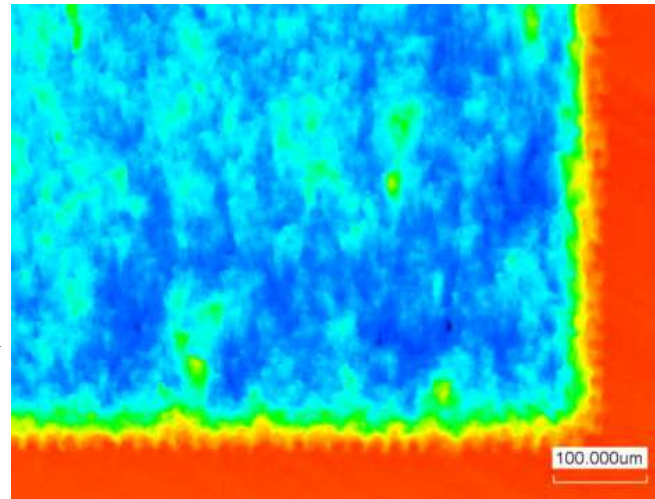


Figure 7 : 3D profile with Scanning Laser microscope

Tooth samples – Process II**Parameters**

- v Short irradiation time
- v 600 ps pulse duration
- v 38 kHz repetition rate
- v Pulse energy 39 μ J per pulse
- v Hatching disposed vertically and orthogonal

Results Tooth II – 2x2mm²

- v Depth of 60 microns
- v Flank angle 135 °
- v Processing time for the entire field: 13.0 s
- v Natural tooth structure recognizable in ablated field
- v Rounded removal profile

Results Tooth II – 1x1mm²

- v Depth of 36 microns
- v Flank angle 130 °
- v Processing time for the entire field: 4.0 s
- v Natural tooth structure recognizable in ablated field
- v Rounded removal profile

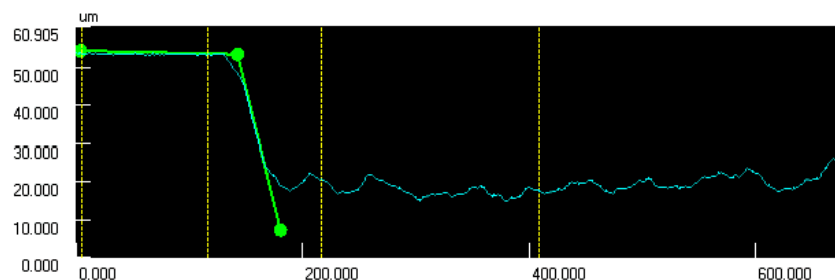
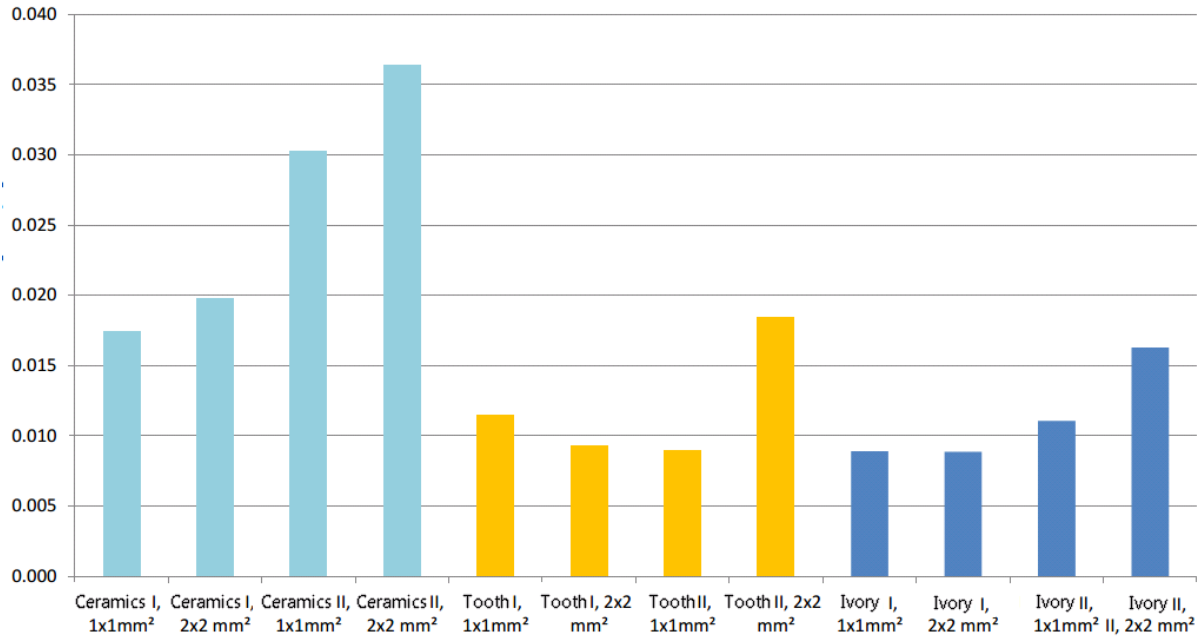


Figure 8 : 2D profile with profilometer

Summary and outlook

Ablation rate (mm³/s)



- v Ceramics can be machined twice faster than ivory or dentin
- v Ivory and dentin have a similar ablation rate
- v 1x1 [mm²] fields appear to have a lower ablation rate because of process related aspects only. It could be avoided with further development of the process.

Flank angle (°)

