

Comparative study of various material scribing with 532nm sub-ns laser pulses

Summary : different types of material (Silicon, ceramic, metals) were machined using the same Teem Photonics HNG laser source and the same process.

All samples – including hard materials like tungsten or ceramics - could be processed with moderate focusing conditions, demonstrating the intrinsic ablation capacity expected from such high peak power pulses.

The majority of the grooves exhibit $>150\mu\text{m}$ depth, and quasi-vertical walls ($<3^\circ$), after 200 passes with no thorough process optimization.

There is no visible heat-affected-zone on the side of the groove, even for the 3 metals considered.

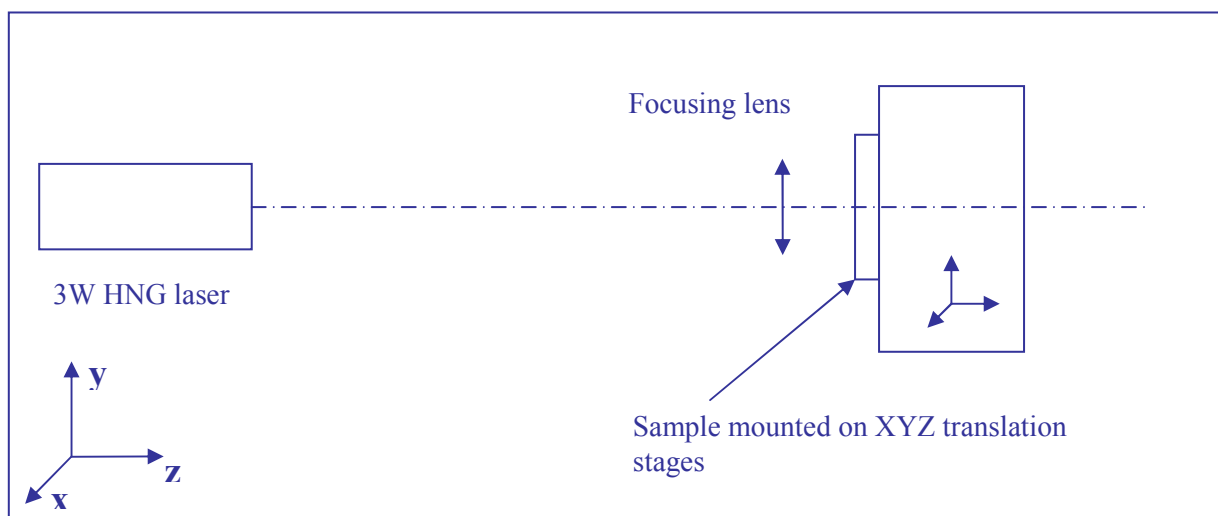
List of samples tested

- Ceramics : alumina ceramic
- Metals : aluminium, stainless-steel, tungsten
- Silicon

Process setup and conditions

All materials listed above were machined using the same process, so as to extract a first insight of the laser/matter interaction material-wise :

- Laser specifications : $\lambda = 532\text{nm}$; Freq=36.2kHz ; $E_p = 83\mu\text{J}$; $T_p = 650\text{ps}$ (HNG)
- Focusing conditions : average NA= 0.026, compatible with scanner heads
- Waist on the sample = $9\mu\text{m}$ \Leftrightarrow Fluence $\approx 32\text{J}/\text{cm}^2$ and Irradiance $\approx 50\text{GW}/\text{cm}^2$
- Translation stages feed rate : $V = 25\text{mm}/\text{s}$ \Leftrightarrow horizontal overlap = 96%
- Process : 200 passes on the same line with $\Delta z = 5\mu\text{m}$ longitudinal shift after each displacement





Results

For each sample, the following parameter were measured :

- Groove width : this is the kerf of the groove.
- Groove depth
- Groove side slopes : this is the angle from the effective groove side to the ideal vertical plan.

Material	Groove width (µm)	Groove depth (µm)	Groove sides slope
Ceramics : Alumina	86	155	1.5°
Metal : Aluminium	45	137	7°/3°
Metal : Hardened steel	71	251	3°
Metal : Tungsten	37	75	11°
Silicon	60	219	3°

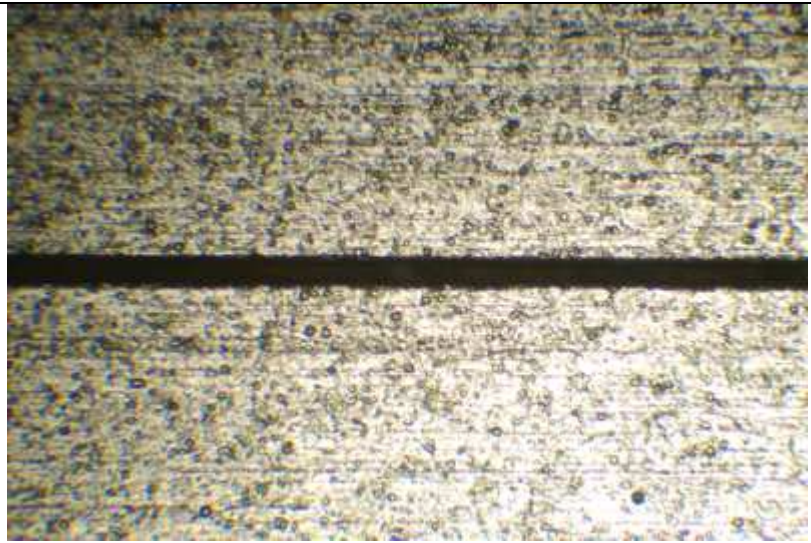
Pictures

Ceramics	
<u>Alumina ceramics</u> Top view (x5 magnification)	
<u>Alumina ceramics</u> Side view (x20 magnification)	

Metal

Aluminium

Top view (x10 magnification)



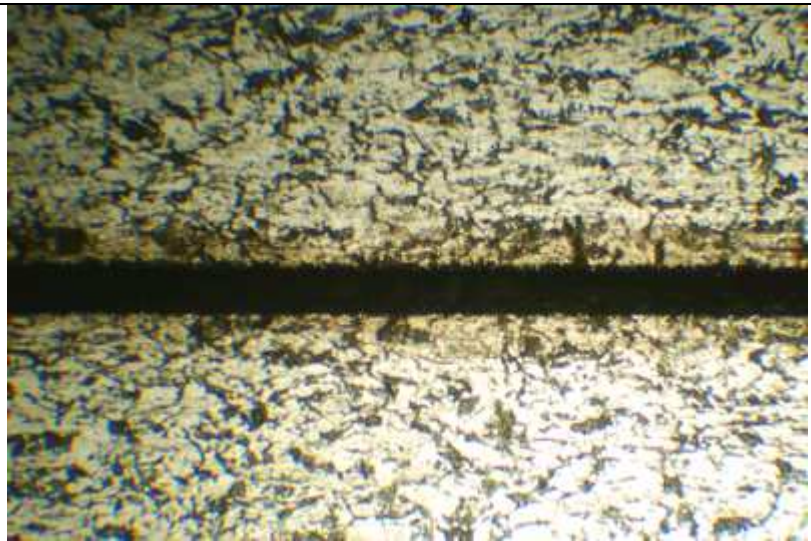
Aluminium

Side view (x20 magnification)



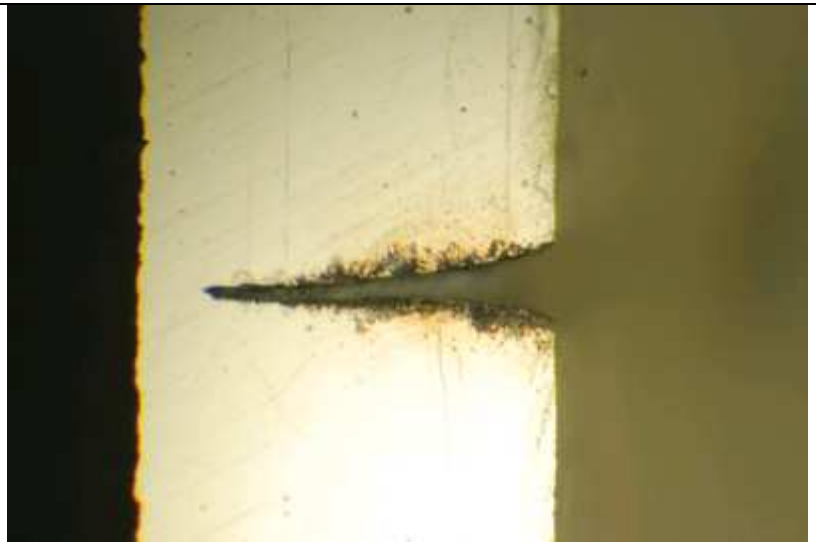
Hardened steel

Top view (x10 magnification)



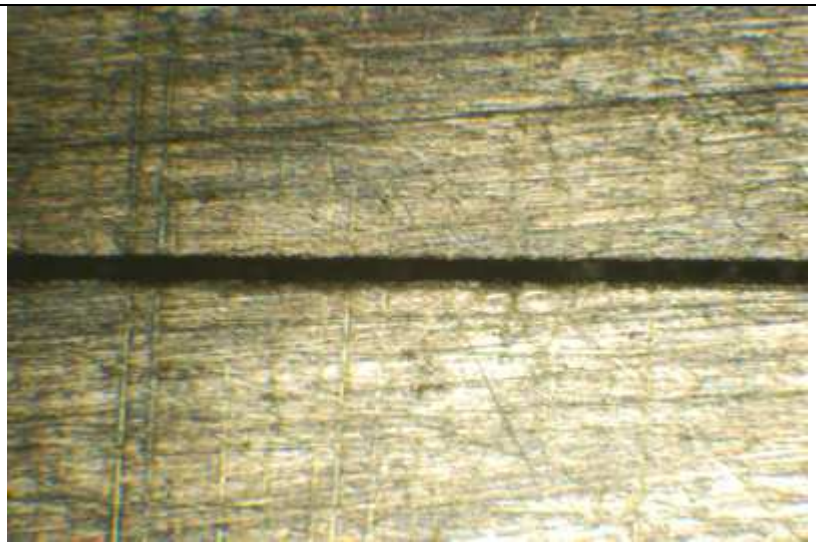
Hardened steel

Side view (x20 magnification)



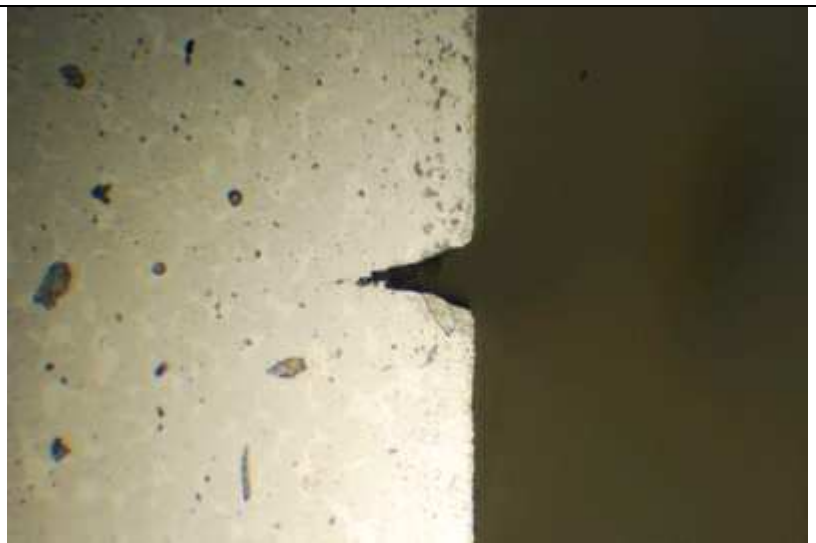
Tungsten

Top view (x10 magnification)



Tungsten

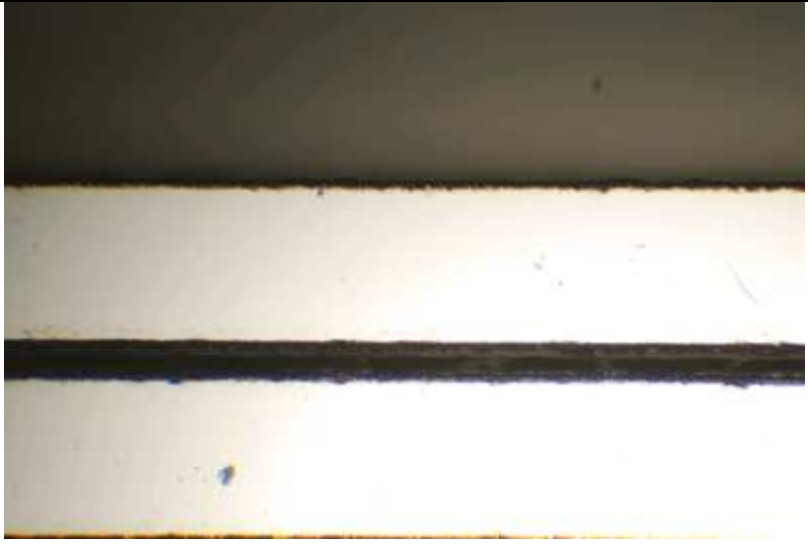
Side view (x20 magnification)



Silicon

Silicon

Top view (x10 magnification)



Silicon

Side view (x20 magnification)

