Polymers processing with sub-ns pulses

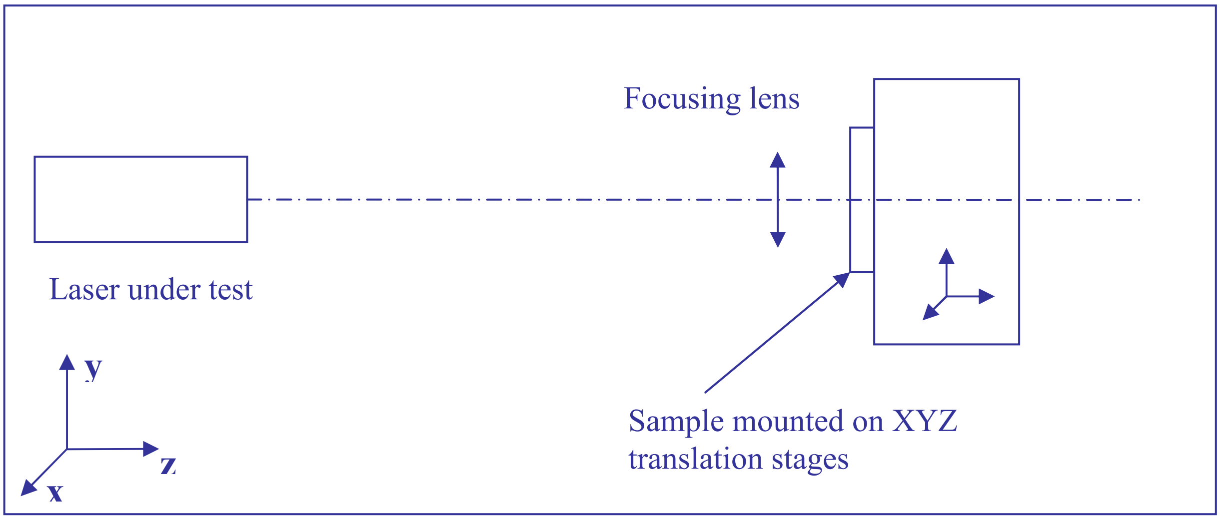
Summary :

- **transparent polymers can be surface and bulk marked without µcracks by 532nm or 355nm Powerchip thanks to its high peak power and beam quality. The marks are round and well contrasted.**
- **266nm Powerchip can scribe and mark virtually all polymers with strong contrast and low µm-scale chipping**
- **polymers can be machined with high power laser PicoSpark to increase process speed, while maintening a very good process quality (low heat-affected-zone, sharp edges, no burrs,..) thanks to the short sub-ns pulses.**

These processing capabilities make Teem Photonics lasers well-suited to a wide variety of expanding markets, like eye glass traceability/anti-counterfeit marking, hand-held devices processing or flexible electronics prototyping.

Marking polymers with 532nm and 355nm

Experimental setup schematics



Lasers under test

532nm Powerchip (PNG)

- Ep = 40µJ
- Tp = 350ps typ.
- M² =1.05
- Focusing : NA= 0.09

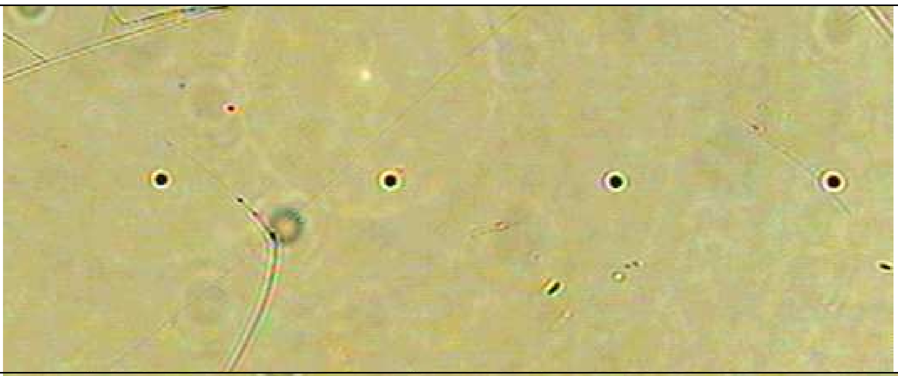
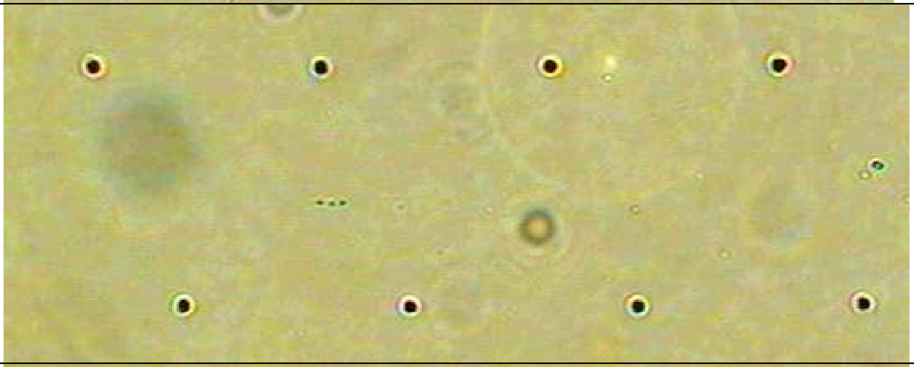
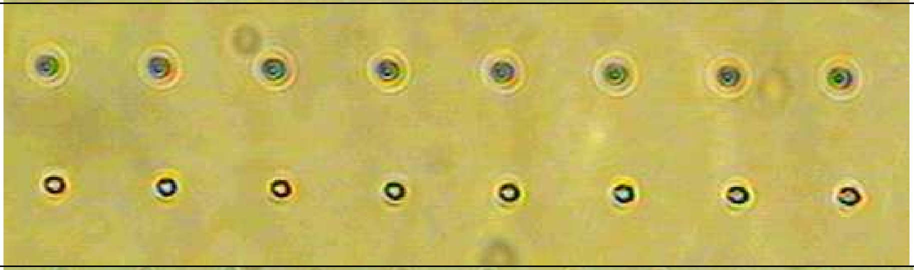
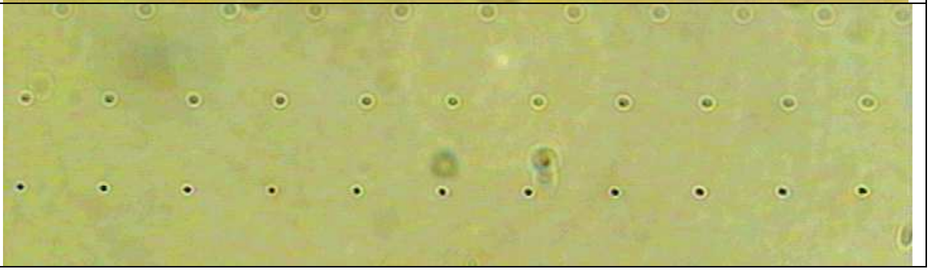
355nm Powerchip (PNV)

- Ep = 25µJ
- Tp = 350ps typ.
- M² =1.05
- Focusing : NA=0.10

Tested materials include polycarbonate (PC), high index polymer (1.67) or CR39.

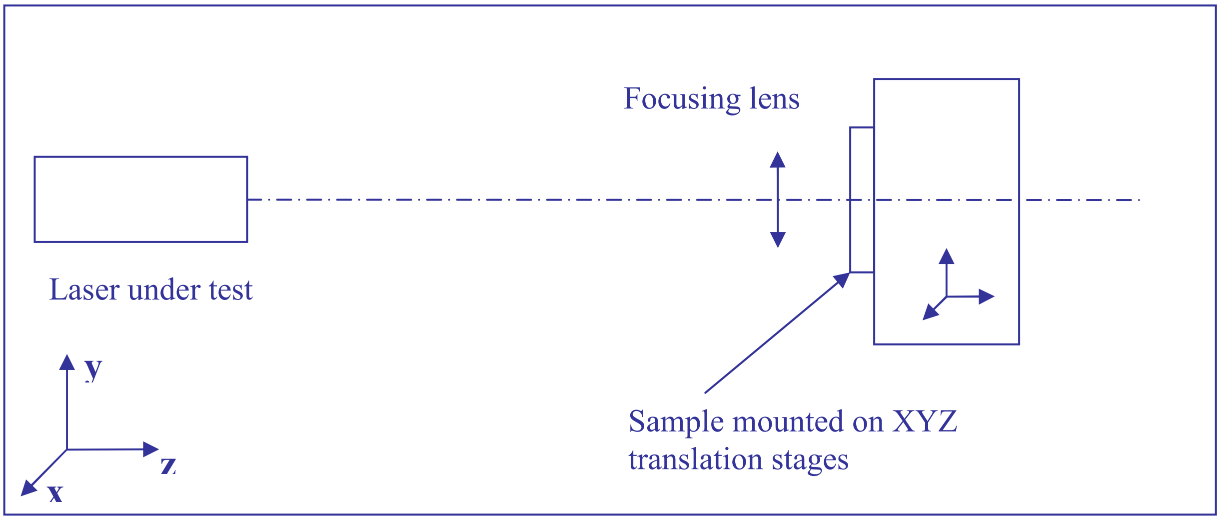
All the pictures presented below are optical microscope characterization of the marking result. There is a 100µm lateral distance between consecutives marks.
For bulk marking, consecutives lines exhibit a different thickness into the sample and are therefore out of focus compared to the observed line (100µm longitudinal shift between lines).

For 532nm and 355nm wavelength, both surface and bulk marks are rounds and nicely contrasted, repeatable, without any evidence of microcracks. The marks diameters are in the 5-15µm range depending on the wavelength and the material.
It is worth noting a similar quality marking has been obtained with 355nm Powerchip inside transparent amorphous or crystal matrix like glass or sapphire.

Laser	Marking/ Magnification	Result
PNG	Surface x20	
PNV	Surface x20	
PNG	Bulk x10	
PNV	Bulk x10	

Marking and scribing polymers with 266nm

Experimental setup schematics



Laser under test

266nm Powerchip (PNU)

- Ep = 15µJ
- Tp = 300ps typ.
- M^2 =1.2
- Collimated beam along the horizontal axis
- Focusing : different focusing were used, with focal lengths from 18mm to 50mm

All the pictures presented below are optical microscope characterization of the marking result. The lateral distance between two consecutive marks is 75µm.

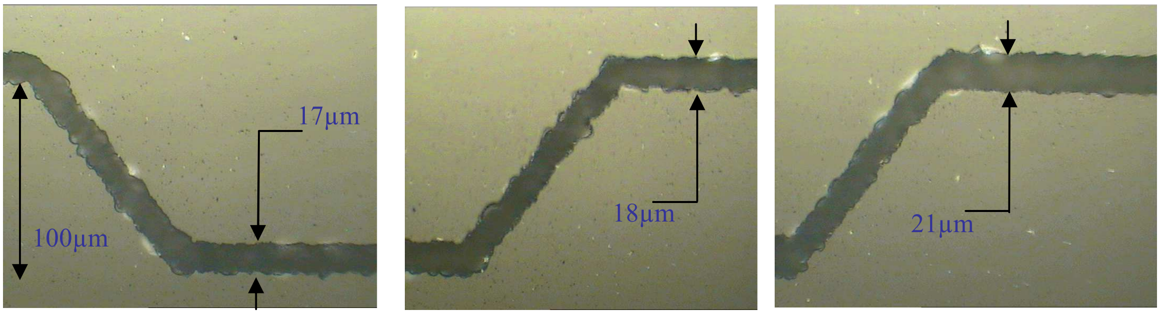
Laser	Marking/ Magnification/ Focal length	Result
PNU	Surface x20 f=18mm	
PNU	Bulk	N/A

With 266nm Powerchip, the marking is clean and contrasted, with a large average 15µm diameter. The mark shape - shown in fig.1 below – is not as round as previously but it is still nicely symmetrical.

It should be fitting the majority of marking applications quality-wise, even "cosmetic" marking as long as a macroscopic visual effect is expected.

Figure 1: 266nm mark on the sample surface - x100 magnification, f=18mm

Fig.2 presents some scribing tests results with PNU on the same polymer, with different focusing. As expected, the line width increases with increasing focusing length. The scribed line appears well defined and homogeneous, with µm-scale chipping on the edge.



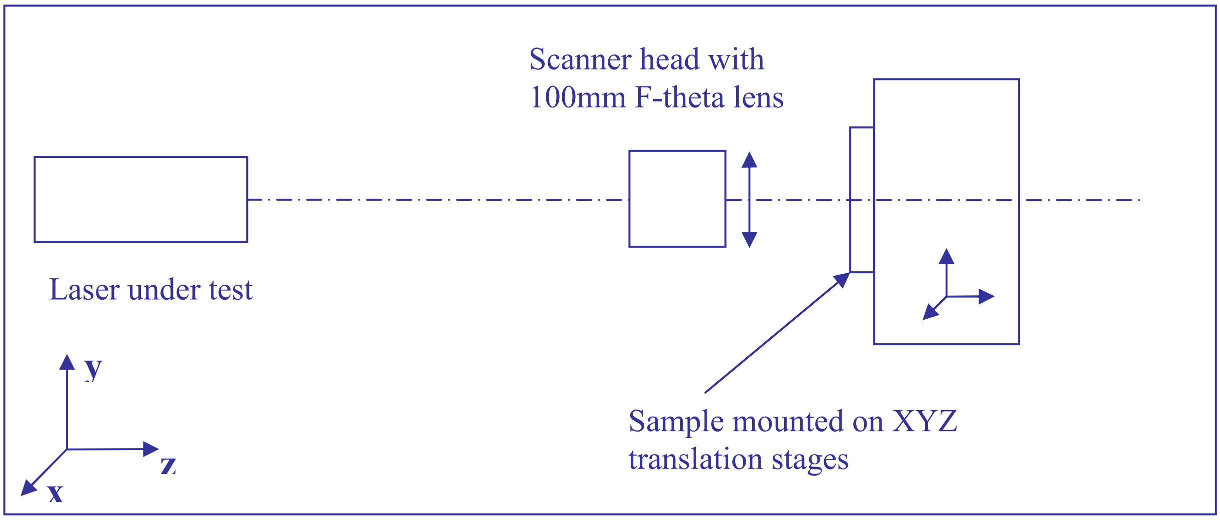
(a) (b) (c)

Figure 2 : x50 magnification, V=1mm/s , f=18mm (a), f=30mm (b), f=50mm (c)

It is worth noting that the PNU laser can be an interesting option for customers wanting to reduce cost of their actual excimer laser based processes. Added to its technology inherent cost effectiveness, this laser has a quasi-null cost of ownership over its whole lifetime.

Machining polymers with high-power laser PicoSpark

Experimental setup schematics



Laser under test

532nm PicoSpark laser (HNG)

- P=3.3W with Frep = 40kHz
- Tp = 600ps typ.
- M^2 =1.05
- Collimated beam
- Focusing : 100mm F-theta lens on scanner head, NA=0.2

1- Cutting PCB Flex

The sample exhibits a three layer structure : polymid, copper and a polymer top layer.
Target is to cut through all 3 layers with minimal heat effects.
Cutting is performed from the backside (starting with polymid layer).

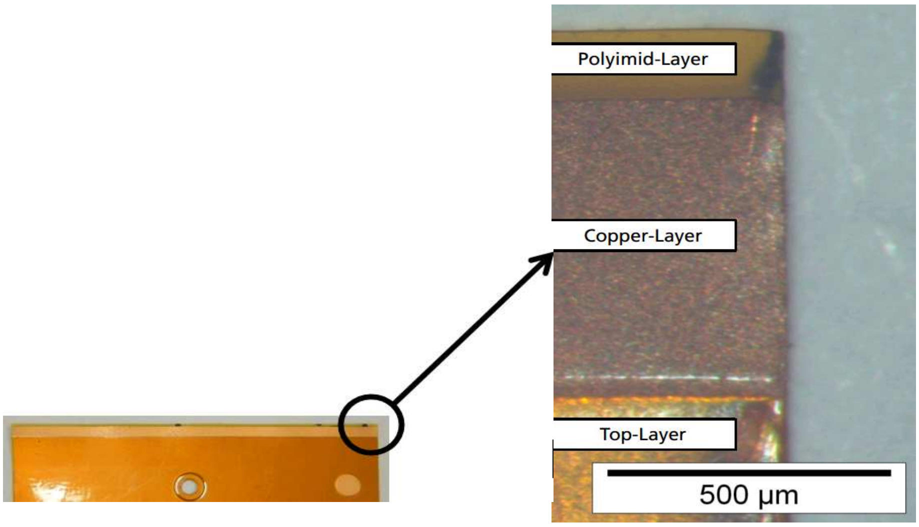


Figure 3 : sample structure

A stable and robust process has been achieved to cut through the polymer/metal/polymer, without any visible damage of the polymer layers. The cutting quality is excellent on both side of the sample, e.g for the beam entry and exit faces.
The width of the cutting kerf is 60-70µm (fig.4/5, right picture) when the darkened width is around ≈170µm (fig.4/5, left picture): the heat affected zone is thus only ≈50-60µm on each side of the groove.

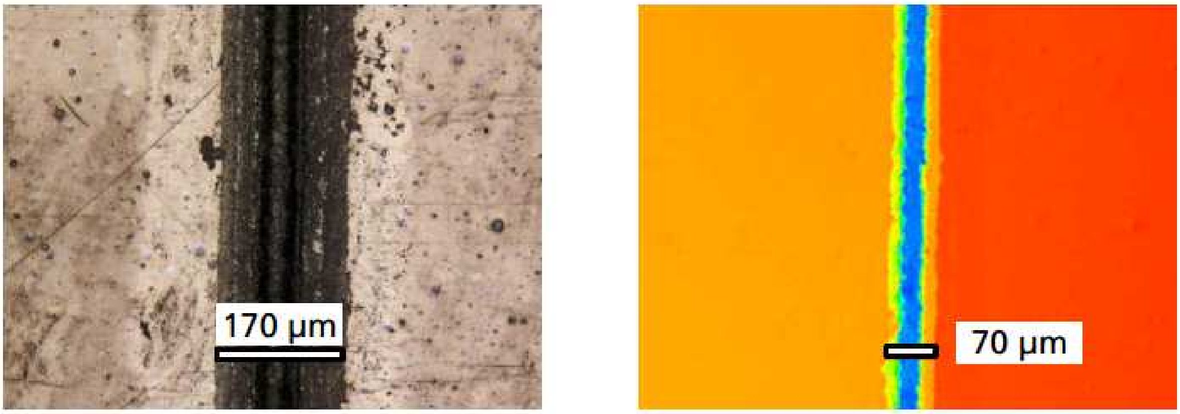


Figure 4 : backside of the sample (beam entry) : heat affected zone is only 50µm on each side of the groove

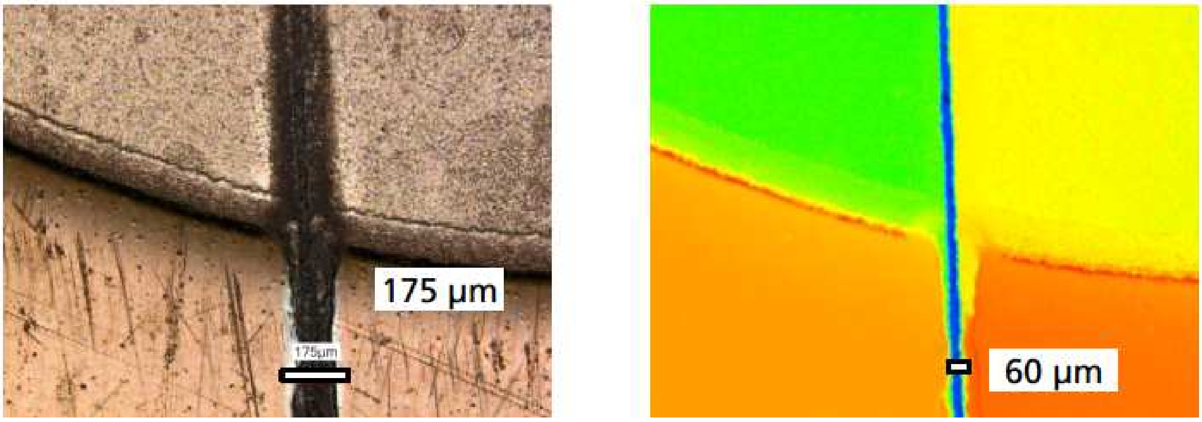


Figure 5: front side of the sample (beam exit) : heat affected zone is only 58µm on each side of the groove

The effective cutting speed is 0.75mm/s.
The cutting speed cannot be increased in a visible manner without also increasing HAZ and/or damaging the polymer. If it is acceptable quality-wise, cutting speed of several mm/s can be easily achieved.

2- Drilling holes smartphone screen black coating

The target is to drill 30-50µm diameter holes in the black thin film polymer layer coated onto the glass screen of smartphones.
Holes should be round and well defined, without heat effects or burrs on the edges.

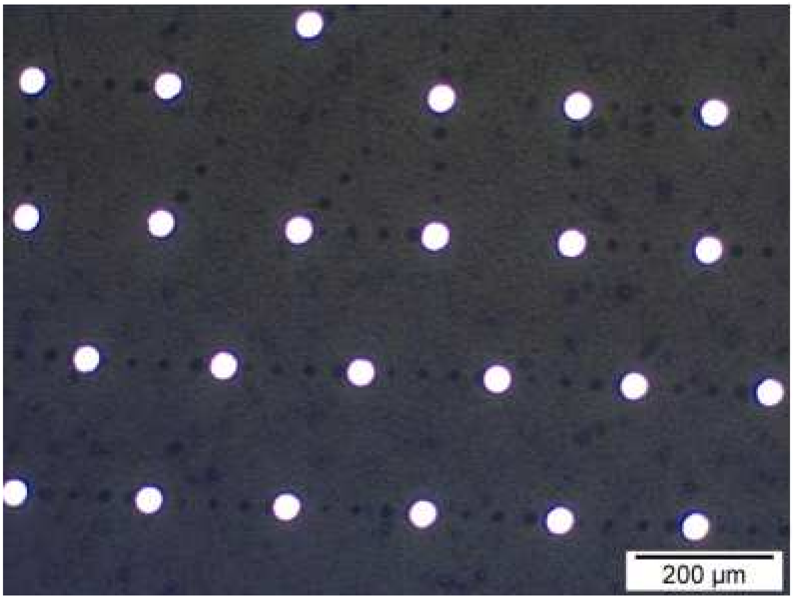


Figure 6 : drilled polymer layer with back illumination (38µm diameter holes)

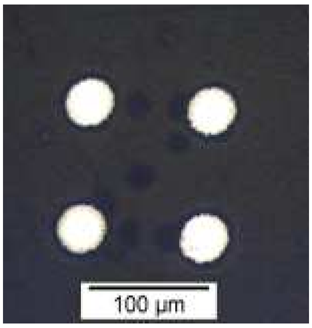


Figure 7: zoom on 38µm diameter holes

It was demonstrated that high quality holes – sharp edges, no melting or burrs on the side - can be drilled in this polymer coating when working close to the focus (fig.7).
For the considered setup, the optimal hole diameter is in the 30-40µm, and requires ≈30ms/hole.

A much shorter process time (5-10-fold decrease) is reachable by optimizing the synchronization delay between fast laser commutation and the moving devices, that would lead to a few thousands of holes per seconds drilling speed.