# Transparent media semi-invisible marking with sub-ns pulses

**Summary :**

- **Transparent glass, crystals or polymer materials can be bulk marked without µcracks by 355nm Powerchip thanks to its high peak power and beam quality. The marks are round, repeatable and well contrasted.**
- **Marking onto the surface of polymers was also demonstrated with 532nm or 355nm Powerchip.**
- **266nm Powerchip can scribe and mark virtually all polymers with strong contrast and low µm-scale chipping.**

**These processing capabilities make Teem Photonics lasers well-suited to a wide variety of expanding markets like eye glass traceability marking, glass watch anti-counterfeit marking, or high-end cosmetic marking.**

## *Note concerning sub-ns marking features*

The type of marking reported in this note – whether it be bulk or surface marking - is generally referred to as “semi-invisible marking”. It means that the individual marks are hardly visible to the naked eye but easily detected with standard visualization equipment (microscope, industrial camera,..).

It is intrinsically well adapted to anti-counterfeit or traceability applications, where the manufacturer wants to store information that is not intended to be seen – by customers or eventual counterfeiter - but needs to be analyzed easily on the production line or during custom inspection.

Bulk marking is long lasting as it cannot be damaged by external stress – scratches, environment – and it does not generate any debris, making it ideal for clean room environment.

Additionally, the absence of micro-cracking is critical to preserve the integrity of the marked part, whether it be for obvious mechanical strength reasons or to maintain a homogeneous and controlled population of marks in your sample.

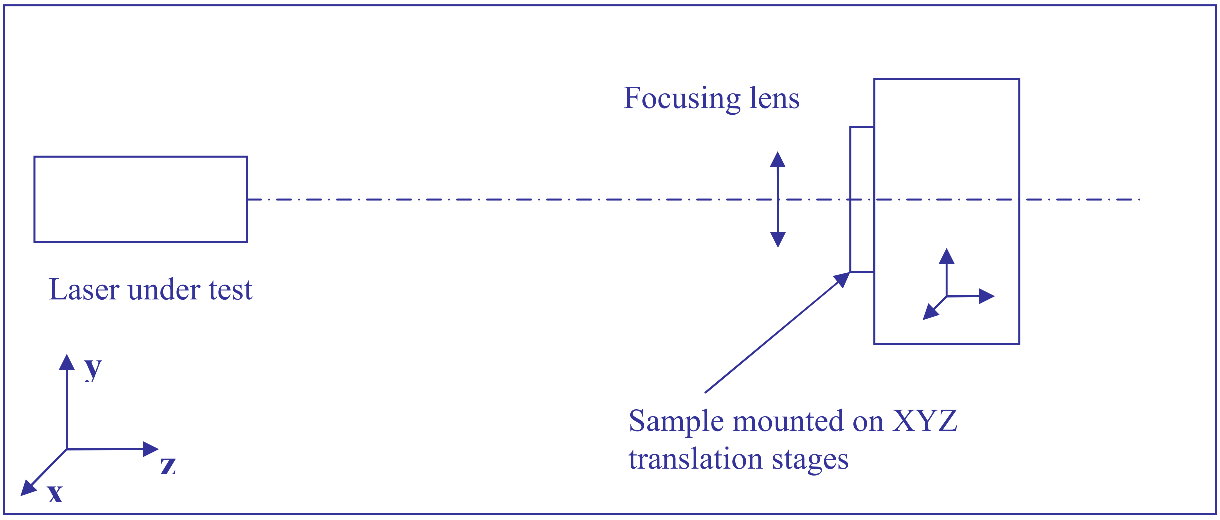
But “semi-invisible” marking doesn’t mean the pattern you generate will be necessarily unseen from your customers.

For cosmetic or identification applications, the dots density will be directly related to the actual visibility and contrast of your pattern. Semi-invisible marks are smaller and diffuse visible light in a more homogeneous manner than a crack would, providing finer control over you pattern contrast and controlled appearance whatever the observation angle is.

# Processing polymers with 532nm, 355nm and 266nm

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

## *Experimental setup schematics*




## *Comparison of surface and bulk marking at 532nm and 355nm*

**Lasers under test :**

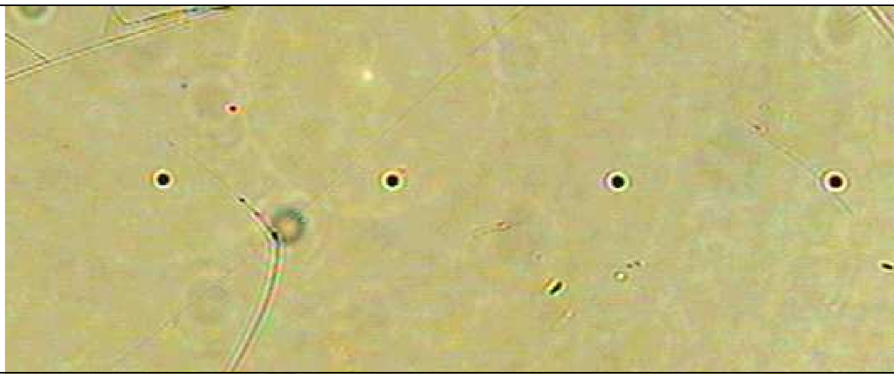
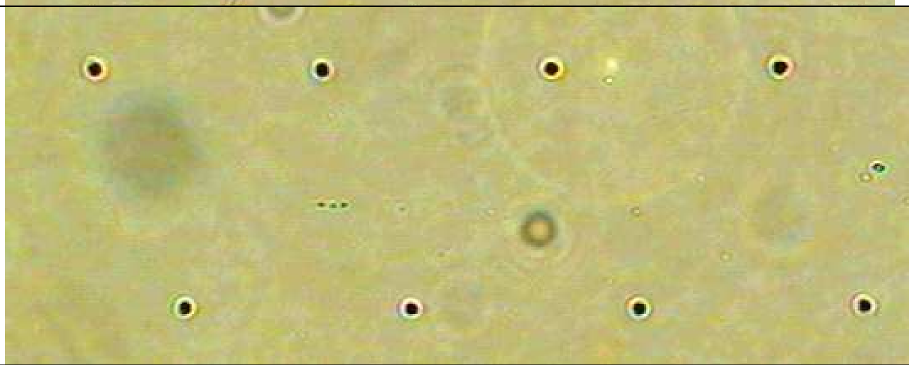
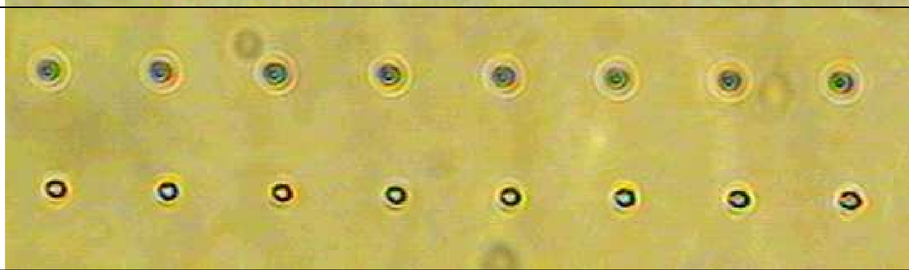
<u>532nm Powerchip (PNG)</u>

- Ep = 40µJ
- Tp = 350ps typ.
- $M^2$ =1.05
- Focusing : NA= 0.09

<u>355nm Powerchip (PNV)</u>

- Ep = 25µJ
- Tp = 350ps typ.
- $M^2$ =1.05
- Focusing : NA=0.10

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).

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

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.

## Marking and scribing with 266nm

### 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.

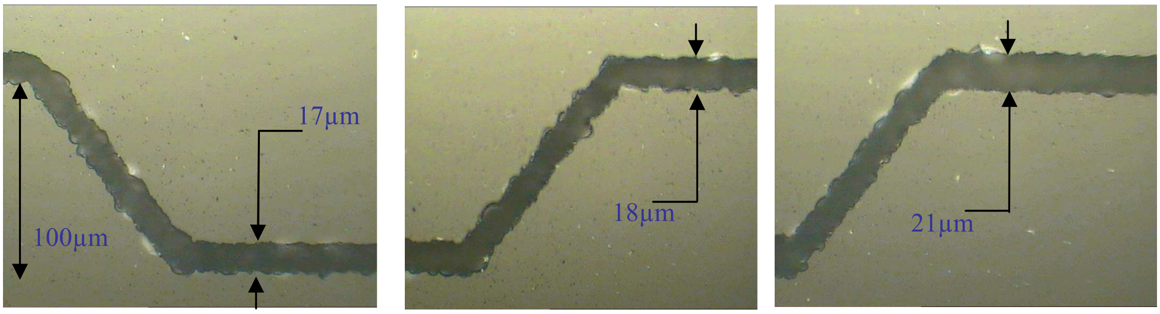
| Laser | Marking/ Magnification/ Focal length | Result |
|---|---|---|
| PNU | Surface<br>x20<br>f=18mm |  |
| PNU | Bulk | N/A |

With 266nm Powerchip, the marking is clean and contrasted, with an average 15µm diameter. The mark shape - shown in fig.2 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.3 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.



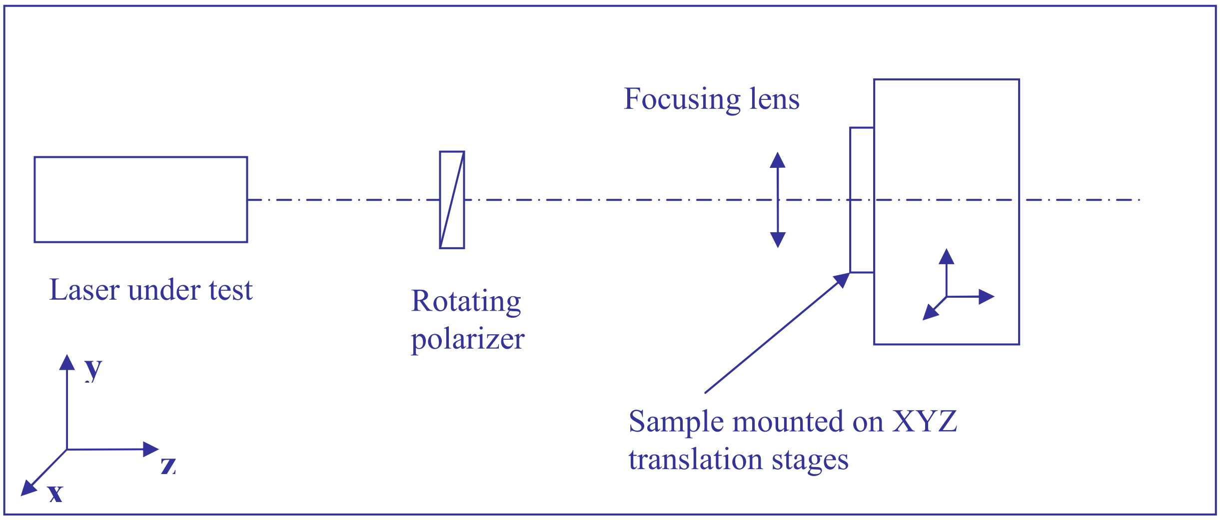

(a) (b) (c)

**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.

# Bulk marking glass or sapphire with 355nm

## Experimental setup schematics




In this experiment, a rotating polarizer is used to adjust the incident energy level on the sample.

## Laser under test :

<u>355nm Powerchip (PNV)</u>

- Ep = 25µJ
- Tp = 350ps typ.
- $M^2$ =1.05
- Focusing : NA=0.1 or NA=0.225

It is worth noting high quality marking has also been obtained with 355nm Powerchip inside transparent amorphous or crystal matrix like glass, coloured glass or sapphire.

Marking with 532nm generally leads here to micro-cracking and thus visible marks, similar to what can be achieved with standard nanosecond lasers.

However, marking with 355nm leads to controlled and repeatable process for numerical aperture as low as low as NA = 0.1 and energy in the [20;25]µJ@355nm range, compatible with commercial scanner head specifications.

In order to reduce the marks longitudinal extension (<30µm) to get higher 3D marking density, another process point using a high aperture NA=0.225 was found, with corresponding energy level ≈[5;10]µJ@355nm.

The figure 1 below illustrates the difference of longitudinal extension within the same sample, for the 2 setup considered (NA=0.1 and NA=0.225). With higher NA, the dot is more confined and do not exhibit a volume with affected optical properties downstream.

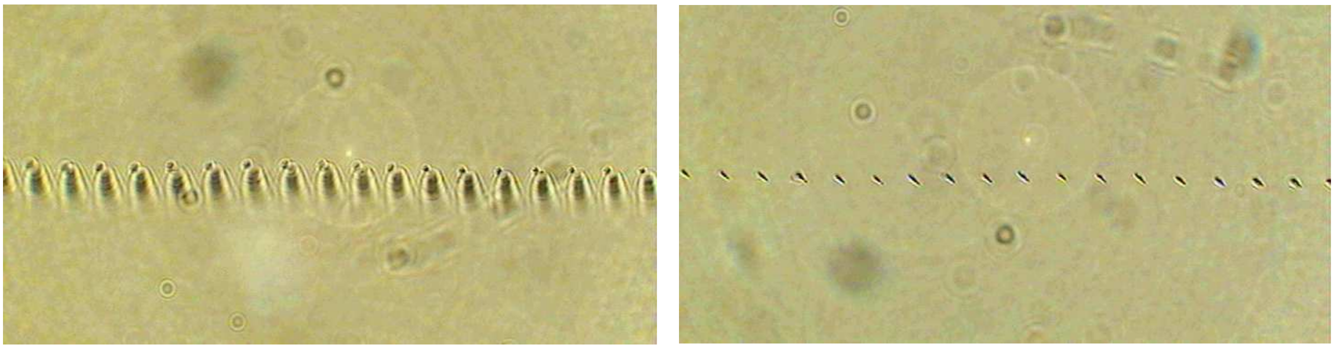
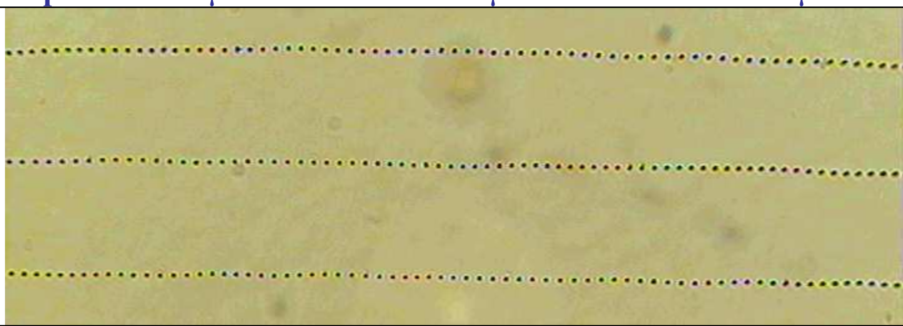
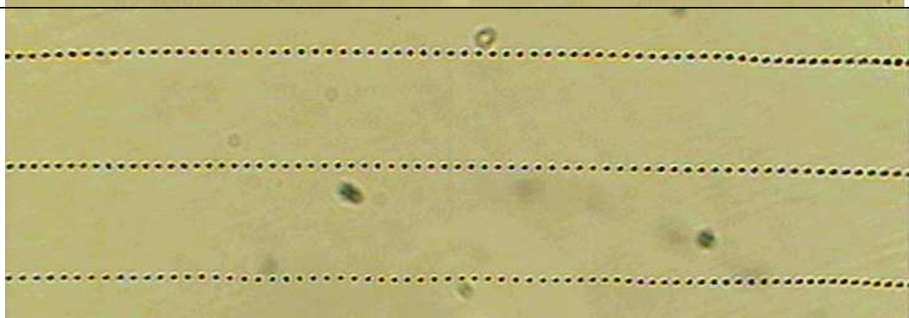
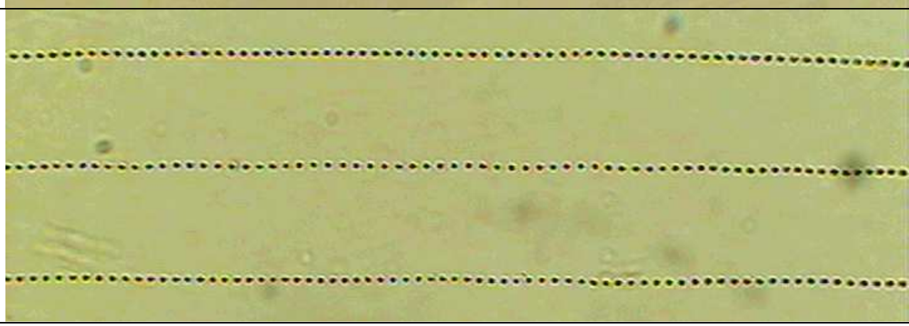


**Figure 3 : comparison of the longitudinal extension of the marks between the 2 setups considered - Same sapphire sample and observation condition (sample inclined 20°, x20 magnification)**

The pictures presented below are optical microscope characterization of the marking result.
There is a 30µm lateral distance between consecutives marks, and 500µm between lines.

| **Laser** | **Sample / Magnification** | **Bulk marking with decreasing energy**<br>**Top line = 27.5µJ / Middle line = 26µJ / Bottom line = 24.5µJ** |
|---|---|---|
| PNV | Sapphire<br>X5 |  |
| PNV | Glass<br>x20 |  |
| PNV | Coloured glass<br>x10 |  |

Here again, marks are rounds and nicely contrasted, repeatable, without any evidence of microcracks.
The dots diameter is ≈10µm with Na=0.1 and ≈5µm for NA=0.225.