



# Fiber Laser Marking - Colour Marking

## Introduction:

The use of lasers for colour marking is not new as the technique has been known for over 10 years. This technique was identified as a viable process for use on craft metal work and jewellery. However, the process has had very little commercial impact in the intervening years. There is now a greater interest in this process as manufacturers of consumer goods are looking for new techniques and finishes to provide product differentiation.

There is a wide range of materials that are known to be colour mark-able including: stainless steels, titanium, chrome plate and transition metals. The specific material grades and surface finishes can have an impact on the marking process as can the thickness of the material.



**Figure 1: Colour marking, on titanium, showing colour variation based on changing marking speed.**



**Figure 2: Colour swatches, on stainless steel, made at 125 kHz showing the effect of scan speed and average power – marked with an SPI fiber laser.**

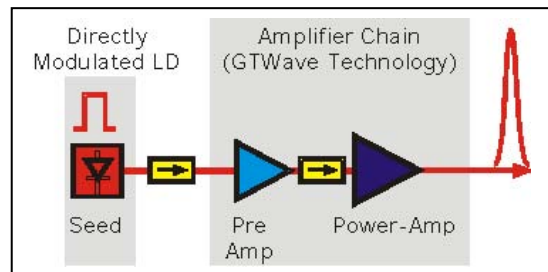
Brushed surfaces are more difficult to mark with a consistent colour mark due to the magnitude of the roughness in terms of peak to trough being significantly larger than the depth of oxides being generated. In these cases the grain of the material can still be seen in the mark. Polished surfaces have been found to be far more consistent in terms of colour. In this case the grain of the mark is more aligned with the marking direction.

## Benefits of Laser Marking:

Lasers offer some clear advantages over alternative technologies as they provide a non-contact, consistent marking process that produces indelible marks. Marking systems are easy to operate with no tooling requirements. All of the marks are software programmed and typically made with CNC controlled scanner mirrors that are capable of line marking speeds up to 6m/s, which equates to nearly 1,000 characters per second. The beam is focused onto the surface of the material to be marked with an F-theta lens which ensures the beam is consistently focused over a working marking area. The spot size of the beam can be as narrow as 25 microns and moved with micron precision.

The key is the uniquely high repetition rate capability for the SPI pulse laser at full laser power; no q-switching means no Q-switch limitation. The unique structure of the fiber laser and direct modulation via pump diodes means that the full 20W average power of the laser is maintained all the way up to 500kHz, there are no dead zones in the way that there are with some other competing laser technologies. At 500 kHz, 40  $\mu$ J is still available and this has direct benefit to colour marking as only low pulse energies and very high spot overlaps are required to allow multiple temperature excursions of each part of the substrate. In this way surface oxides are enhanced and modified to produce the range of optical and surface chemistry effects that make up laser colour marking.

## SPI Lasers' MOPA Fiber Laser:



**Figure 3: Basic MOPA system architecture**

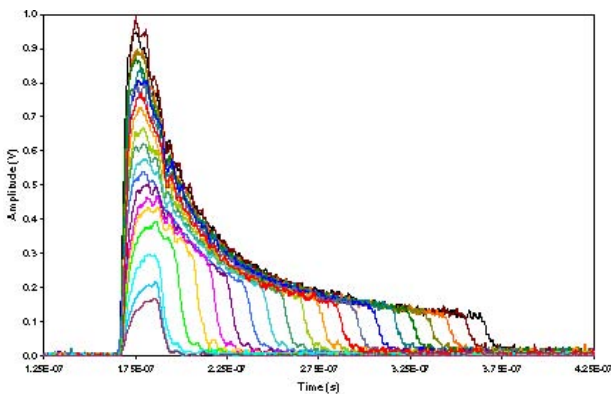
The recently introduced pulsed fiber laser uses a MOPA (Master Oscillator Power Amplifier) architecture, (Fig. 1), which uses a directly modulated seed laser that is amplified using a proprietary fiber laser based amplifier chain. This in turn allows the pulse parameters to be more



effectively controlled.

This design enables high peak powers that are not achieved with standard modulation. Peak pulse powers in excess of 14kW can be achieved at 25 kHz with an average output power of 20W. The unit also has a high pulsing frequency range from 1-500 kHz and with pulse widths in the 10-200ns range. The laser is also capable of working in continuous wave (CW) mode.

The MOPA arrangement allows control of the pulse shape, duration using a range of preset pulse waveforms are available as shown (Fig. 2) below. This flexible control over pulse width and peak power with the *PulseTune* function enables very high repetition rates whilst maintaining relatively high peak powers.

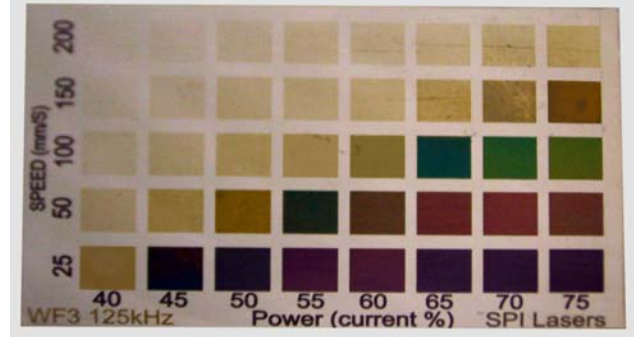


**Figure 4: Pulse wave forms showing range of pulse energies 0.04mJ – 0.8mJ**

### Parameters for the SPI Fiber Laser:

To achieve a specific colour, the SPI fiber laser must be set at a specific speed (mm/s) and at a specific percentage power, processed at the same frequency (125 kHz, Waveform 3).

See Figure 5, a close-up picture of Figure 2, for more details about the parameters used.



**Figure 5: The combination of specific percentage power and marking speed at 125 kHz**

### Benefits of SPI's Fiber Lasers:

- Significant improvement in the quality of the mark due to the stability and controllability of the laser source.
- Beam intensity and spot size enable the use of small mark widths.
- Output power stability over time enables complex mark patterns without power fluctuations - no weld defects.
- High power density allows large marking areas to be processed rapidly.
- Maintenance free (no replaceable parts).
- 3-Dimensional marking can be easily achieved.
- High repetition rate is achievable.
- Low frequency (<20 kHz) – control of heat input; processing of thermally sensitive plastic can be controlled (increase in heat might cause the plastic to melt).
- Low M<sup>2</sup> - the depth of field is high.

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**20W Pulsed SPI Fiber Laser**

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