

Application Note #02

Further Improvements to Nanosecond Pulsed Lasers

Introduction

IPG Photonics strives for continuous product improvement and is known within the laser industry for scaling laser power to levels previously thought unachievable. Although 500 W average power q-switched lasers are now available, the most popular models are those up to 50 W average power. This application note presents an upgrade to the laser that has extended the repetition rate capability to 200 kHz for this range. This has extended their processing capabilities for some specific applications.

General Purpose Marking

Laser parameters of 20 kHz, 1 mJ (20 W output) are the most widely used laser parameters for general purpose marking applications. Many marks on metals are produced using a single line high speed font and in this case, at a scan speed of ~2 m/s using parameters of 20 kHz and 1 mJ a mark visible to the unaided eye is produced. This is due to the fact that at this speed and repetition rate combination, consecutive laser spots are almost touching and a quasi-continuous scribe line is produced. IPG produces a YLP laser (Figure 1, Right) with 1 mJ at 50 kHz capability that allows for rapid metal removal at this power level.

High Repetition Rate Applications

For some applications using metals and non-metals, a repetition rate > 100 kHz is required. It must be remembered that:

$$\text{Average power (W)} = \text{Pulse energy (J)} \times \text{Repetition rate (Hz)}.$$

MARKING APPLICATION



Figure 1: Standard YLP Series Laser

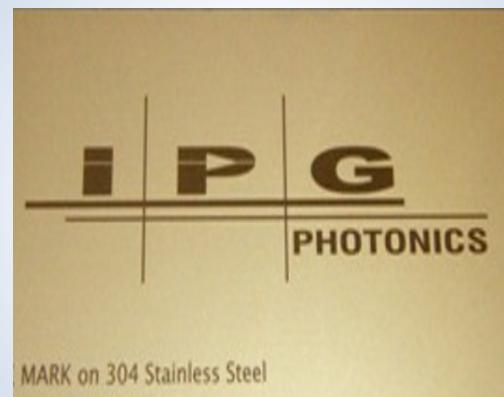


Figure 2: Smooth Corrosion Resistant Mark Produced at 200 kHz

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As repetition rate is increased, pulse energy, peak power and peak power density (in W/cm²) drops to the point at which material removal from metals is minimal: at 100 kHz and 20 W only 0.2 mJ is available. If standard off the shelf optics are used at this pulse energy level, very little metal will be melted and hence little ablation or material removal occurs. If the repetition rate is increased to 200 kHz, now available from the YLP range, the time between pulses, the pulse period, is reduced to 5 µs. The surface of the material sees an almost continuous beam due to complex interactions between the beam and the vapour and the localized surface temperature does not drop significantly between pulses.

This regime is used for metals where only very light surface treatment processes are required. In the scanning speed range of 0.1-2 m/s, a high laser spot overlap also occurs. This enables low energy pulses to interact with metal surfaces in a very subtle manner, especially if heat input to the component is kept low by high scan speed. The result is that the surface temperature of metals can be raised locally in a highly controllable manner and although many different phenomena may be produced by this heating, we will discuss two that are of commercial interest for laser marking.

1. Smoothing surface asperities: laser polishing
In this regime, only small surface asperities are removed which reduces the surface roughness of the component.

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In a few cases, this technique may produce enough visible contrast for a satisfactory mark.

2. Growing surface oxides: color or dark marking
This technique can also generate enough contrast (depending on the condition of the metal surface) to produce a satisfactory mark visible to the unaided eye. If heat input to the target surface is carefully controlled by choosing power density, process speed and laser power it is possible to heat the target surface evenly. For stainless steels in particular, the very thin native oxide layer is enhanced locally at these elevated temperatures. As the thickness of these surface oxides increases, a range of colors are observed at first due to incremental numbers of extinctions of reflected light from the surface. As the thickness increases above 200-300 nm, this mark appears dark to the naked eye, Figure 2.

Contact

IPG Photonics' Application Facilities will work with end users and systems integration partners from proof-of-concept through process development for all materials processing applications. Contact any of IPG's worldwide application facilities to arrange complimentary sample processing, evaluation and project planning or go to www.ipgphotonics.com for more information.