IPG PHOTONICS®

Application Note #03

Dark Oxide Marking on 304 Stainless Steel

Introduction

All newer YLP fiber lasers up to 50 W average power are now capable of up to 200 kHz repetition rate and this has extended their processing capabilities for some specific applications. Compared to most laser marking techniques, a different type of mark is required for marking of medical devices. This dark oxide mark is often inaccurately referred to as ‘anneal marking’. There are three primary requirements for this type of mark (Figure 1, Right):

1. A smooth surface is necessary to avoid contamination from debris entrapment.
2. The mark must be black to make it visible to the unaided eye.
3. The mark must not corrode in service.

At these high repetition rates available in the YLP range of q-switched fiber lasers, 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 vapor. If heat input to the target surface is carefully controlled by choosing power density, process speed and laser power it is possible to grow a relatively thick surface oxide layer that appears dark to the unaided eye.

This laser marking process builds up graphics or alpha-numeric characters by a raster scanning process. It is essential that the fill or pitch of the raster lines is correctly adjusted so that an even smooth layer of oxide is built up by the laser heating process over the whole surface of the area to be marked.

MARKING APPLICATION

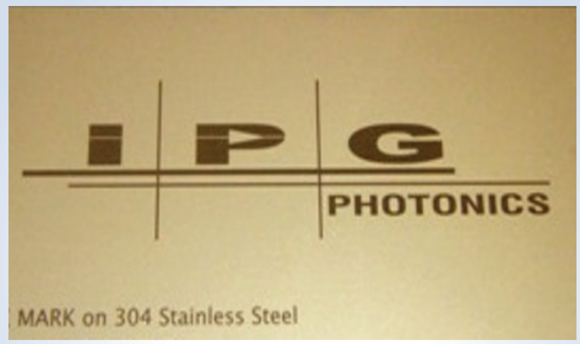

Figure 1: Showing a 50 X 90 mm Coupon of Laser Marked Type 304 Stainless Steel

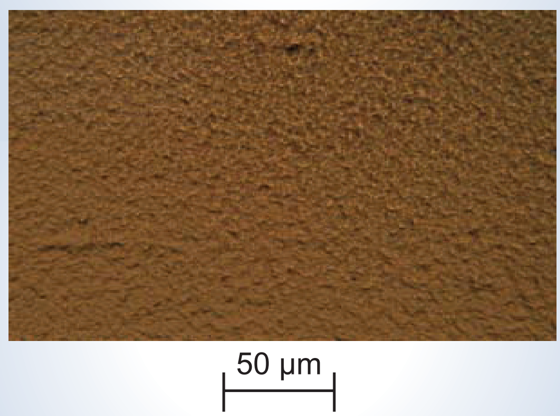

Figure 2: Showing the sub 1 µm Ra Surface of the Mark

Using off-the-shelf scanning optics with a focal length of 163 mm, a focused laser spot size on the workpiece of ~50 µm is readily achieved with the YLP laser. This gives an excellent depth of focus and hence any marking process will be tolerant to variations in the distance of the target from the lens. In this process, the actual line of oxide that is produced by laser heating on a stainless steel surface is larger than this focused spot size due to conduction effects.

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Results

An in-house development program showed t hat all of these requirements could be met on 304 stainless steel. Of key importance to the technique development was an accelerated in-house corrosion test. This procedure based on the ASTM F1089 standard enabled rapid feedback within minutes of corrosion performance.
The ultimate acceptance test for all samples was a 1 hour immersion in a concentrated saline solution at an elevated temperature. It has since been shown that these results corroborate with other corrosion tests used in the medical device industry such as multiple autoclaving cycles. In addition, many stainless steel medical devices are passivated after marking and the mark must not be removed or made illegible by this process.

Extensive use of visible light microscopy also showed how the oxide itself developed from the grain boundaries of the stainless steel as heat input was increased into the component. Of technical interest also was the excessive growth of oxide that occurred if excess heat input was supplied by the laser process. The rougher surfaces produced by this excess heat input were seen to corrode badly.

Process speeds of 50-75 mm/s are high compared to speeds used when conventional flashlamp-pumped lasers are used for this task.

It should be noted that different material compositions and different surface finishes will affect the optimum laser parameters so each mark must still be approached on a case by case basis bearing in mind the general principles laid out in this note.

Conclusion

IPG has developed guidelines for producing crack free corrosion resistant dark marks on stainless steel. Contact any of IPG's worldwide application facilities to arrange complimentary sample processing, evaluation and project planning. Go to www.ipgphotonics.com for more information on all of IPG's products.

+1 (508) 373-1100
sales.us@ipgphotonics.com
www.ipgphotonics.com