Issue 02 | June 2020

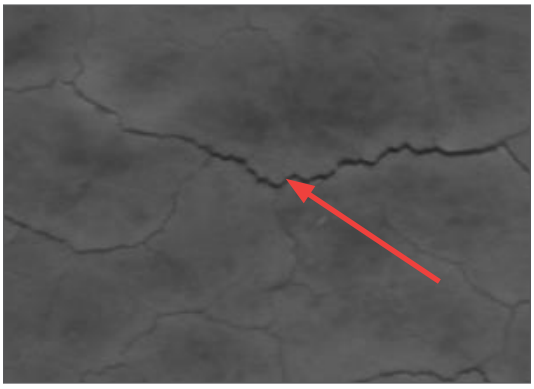
Hot Application
Picosecond Black Marking

THIS ISSUE
Picosecond Black Marking

THE CHALLENGE

Problem:
- Medical devices and tools - frequently made of stainless steel due to their low interaction with the human body - need to be marked to meet FDA requirements.
- The mark needs to be permanent, dark, and corrosion resistant.
- Some marks need to survive repeated cleaning iterations (e.g. autoclaving).

Solution:
Use a **picosecond IR laser** to make permanent, black marks without damaging the surface of the part.



Brittle oxide formed by excessive heat

Marking Medical Devices
Medical device manufacturers have been marking their parts for branding, serialization and traceability for decades. In 2015, however, the FDA mandated that implantable devices bear a specific, permanent mark called "UDI" (Unique Device Identification) on the device itself.

In 2018 UDI was extended to include reusable surgical tools and instruments that undergo autoclaving and reuse.

Typical customer key criteria states that the UDI marks must be:

- High-contrast and dark black in color
- Permanent, corrosion resistant, non-fading
- Machine readable
- Shallow surface relief so as not to retain bacteria
- Ideally, no additional passivation step required after the mark is made.

Traditional Laser Marking Methods
Medical devices are most commonly made from 300-series and 17-series stainless steels due to their inherent mechanical strength, corrosion resistance and machinability. The naturally occurring chromium oxide passive layer that forms on the surface of these steels resists corrosion during sterilization and is inert to the human body. Fiber lasers have long been the laser of choice for making crisp, clear marks on these stainless steels, but the successful processing window is extremely small and the operating wavelength tends to generate excessive heat which may damage sensitive electronics. In simpler terms, when the surface of stainless steel is heated high enough, the surface oxide layer formed can become brittle and prone to corrosion. This heat also damages the passive layer necessitating a post-process passivation step to restore it. The problem is that this passivation step has the unintended consequence of severely degrading the marks.

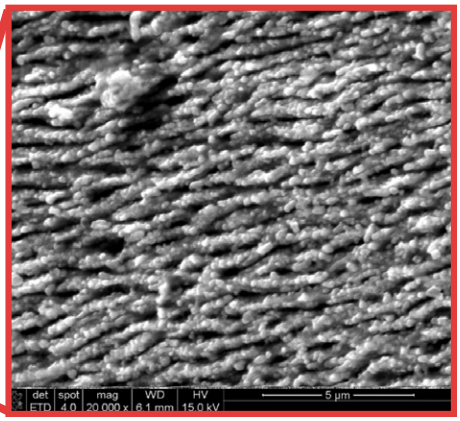
Since laser marking must take place prior to passivation in a production line, a more robust and permanent laser marking method is required.

Picosecond Black Laser Marking

Enter the picosecond IR laser. Picosecond laser pulse durations are about 10,000 times shorter than nano-second lasers and more intense than other marking lasers. The ultrashort pulse durations allow them to impart energy to the material surface with minimal thermal effects. Unlike fiber lasers which create heat-generated, layered/oxide forming, annealed marks, picosecond IR lasers create "light traps" – with anti-reflective properties making marks that appear dark black against their surroundings.

Unique to these picosecond laser marks is that they have extremely small heat-affected zones, so they don't form a brittle oxide layer and therefore remain corrosion-resistant even after passivation and repeated cycles through the autoclaving and sterilization procedures.

Picosecond black marking is also being used on other materials, like aluminum, titanium, plastics and glass with success.



Nanostructures
Viewing size shown in image - 12 µm x 10 µm

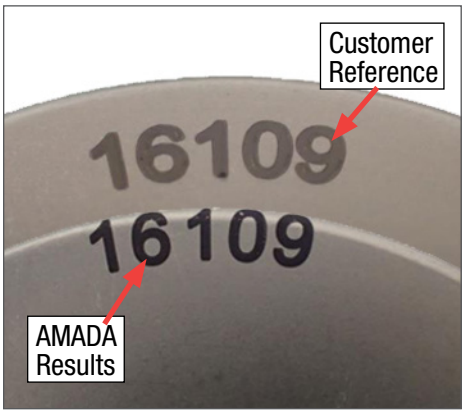
Corrosion Resistance

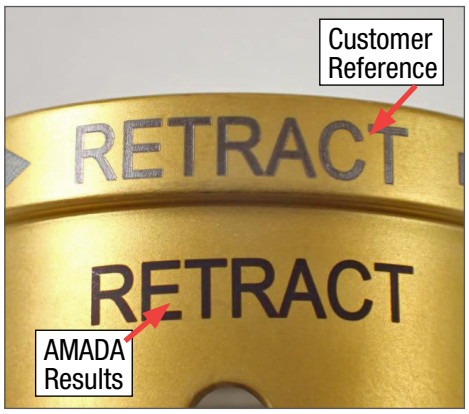
Short pulses and exposure time result in extremely small heat-affected zones preventing the formation of brittle oxide layers. Black marks remain corrosion-resistant even after passivation and repeated autoclaving/sterilization cycles.

Resistant to Bacterial Growth

Picosecond black marks are actually restructured surface material making them highly resistant to bacteria formation.

Fiber vs Picosecond IR Marks





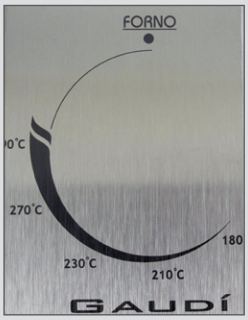
Fiber Laser - SM IR

Picosecond IR Laser

Where is Black Marking Used?

Medical Devices
- Cannulas, catheters, tubes
- Implantable devices
- Invasive tools & wires
- Operating room / surgical instruments


Home Appliances
- Cook tops
- Ovens
- Sinks
- Faucets



Automotive Components
- All safety components

Aerospace / Marine Components
- Cover plates