Stainless Steel Laser Marking with ps-Lasers

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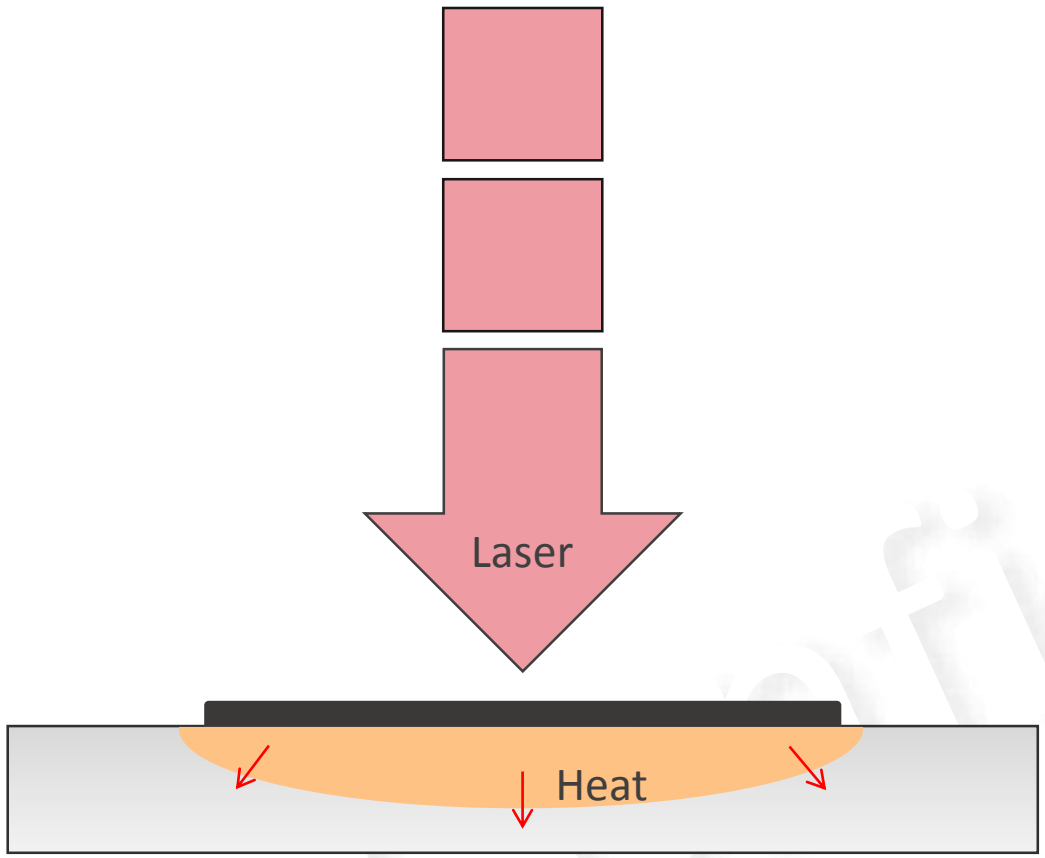
Manager Application Development

ns-Laser process description



- Heat input via laser
- Creation of liquid metal phase
- Diffusion of Chrome
- Oxidation of Cr and Fe at surface
- Formation of different Cr-oxides and Fe-oxides
- Changes in metal alloy structure
- Demixing of alloy elements

Advantages

- Robust and reliable laser technology
- Economically reasonable solution

Disadvantages

- Small process window (material and surface finish sensitive)
- Limited corrosion resistance properties
- Thermal stress limits workpiece geometrie (e.g. deformation of thin sheets, tubes, etc.)
- Mark sensitive to angle of view, color change to red/brown/blue is commonly observed

ns-laser application results

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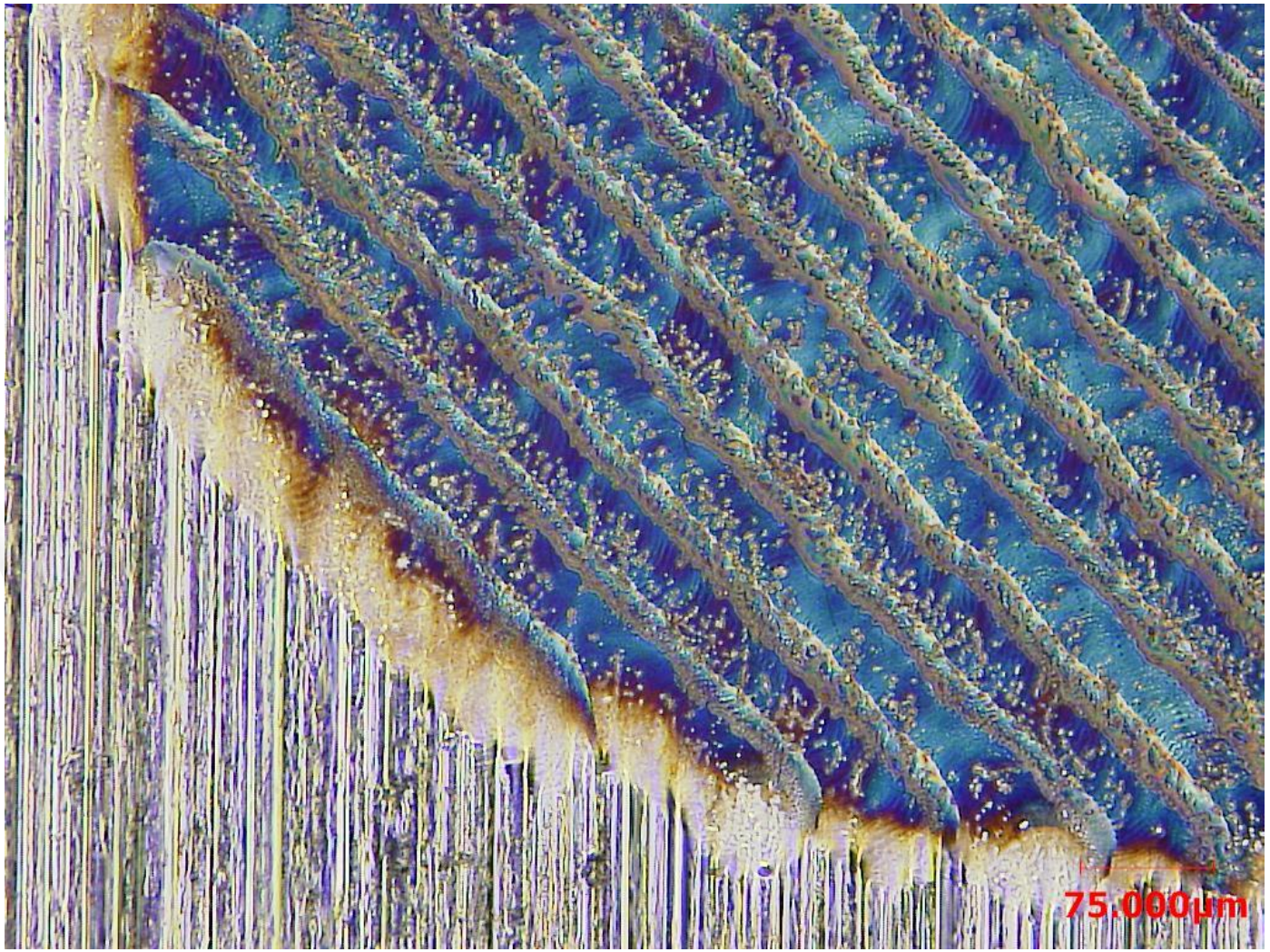
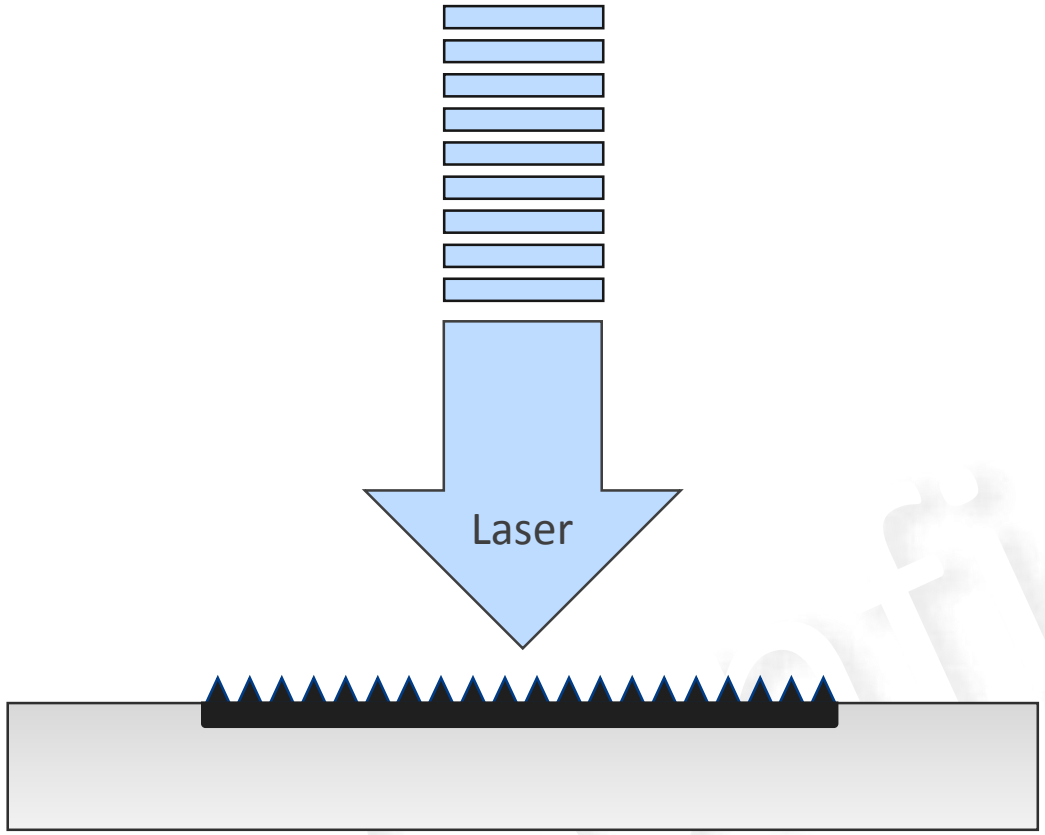


ps-laser process description

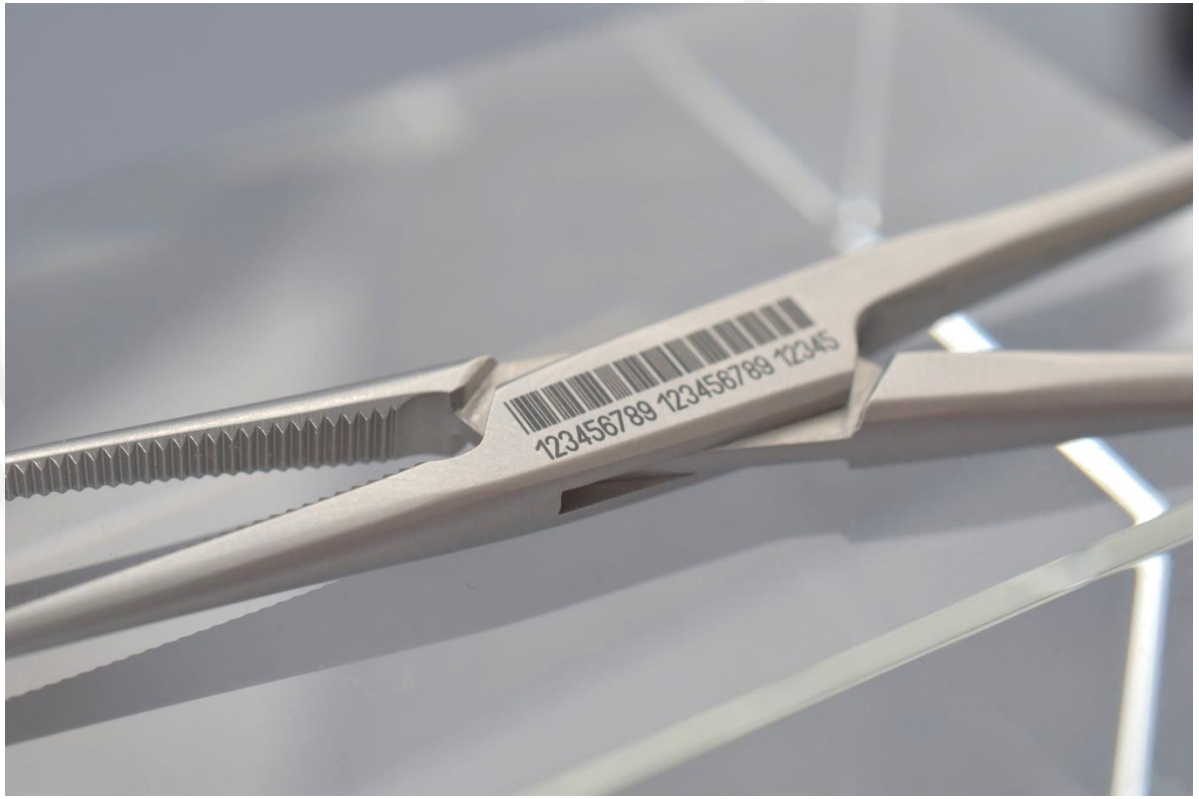


- Short pulse duration limits liquid phase
- Diffusion of elements is reduced
- Partial oxidation of Cr and Fe at surface
- Formation of nano-structure due to high peak power of ultra short laser pulses
- Changes in metal alloy structure minimized
- De-mixing of alloy elements minimized

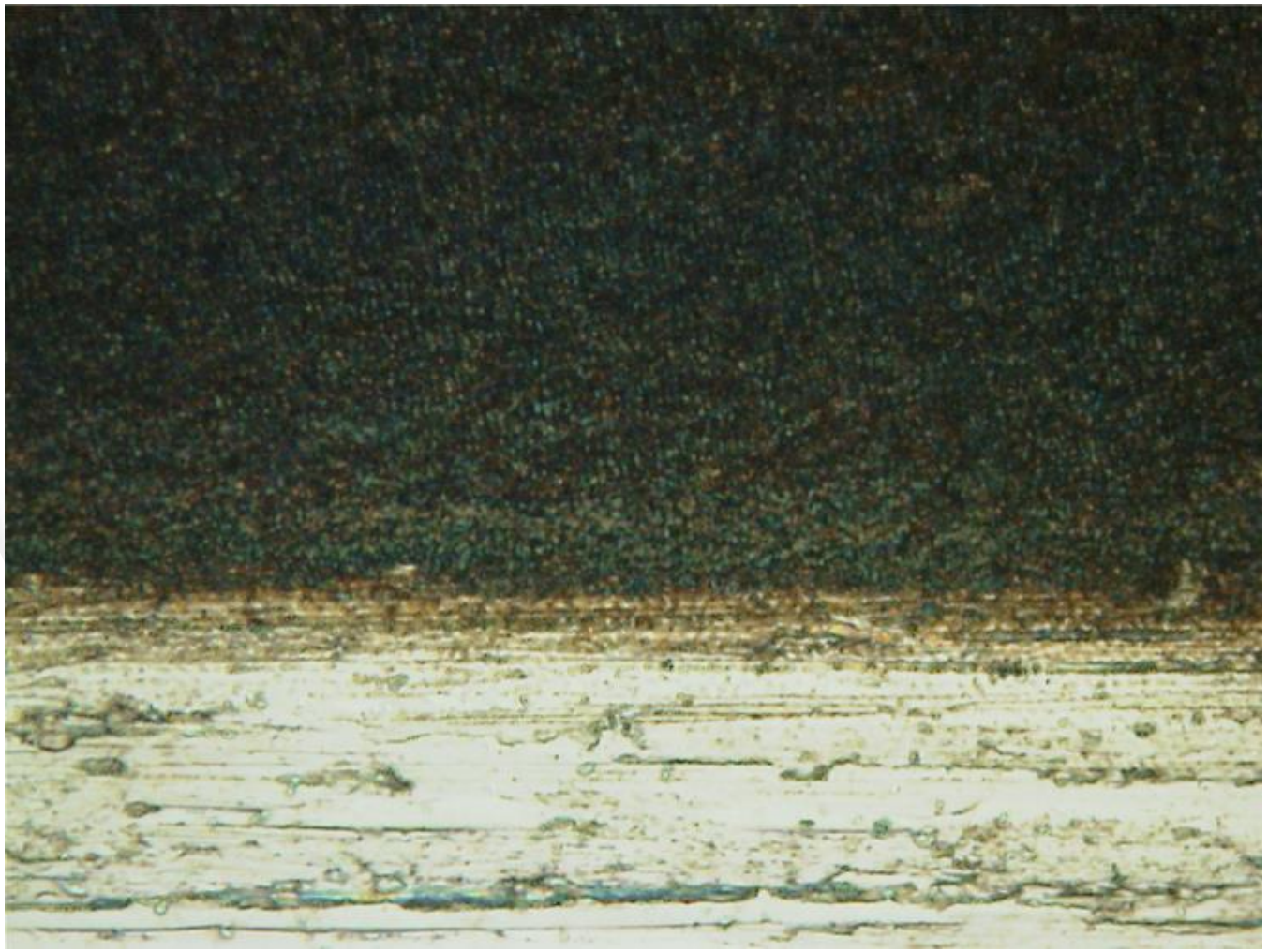
Advantages

- Higher contrast achievable (dark black)
- Nano-structure enhances contrast, allows angle independent color
- Broad process window (almost independent from material and surface finish, increases flexibility and reduces initial setup time)
- Greatly improved corrosion properties
- Minimized thermal stress extends field of application (wires, tubes, implants etc.)
- Mark not sensitive to angle of view, no color change to is observed

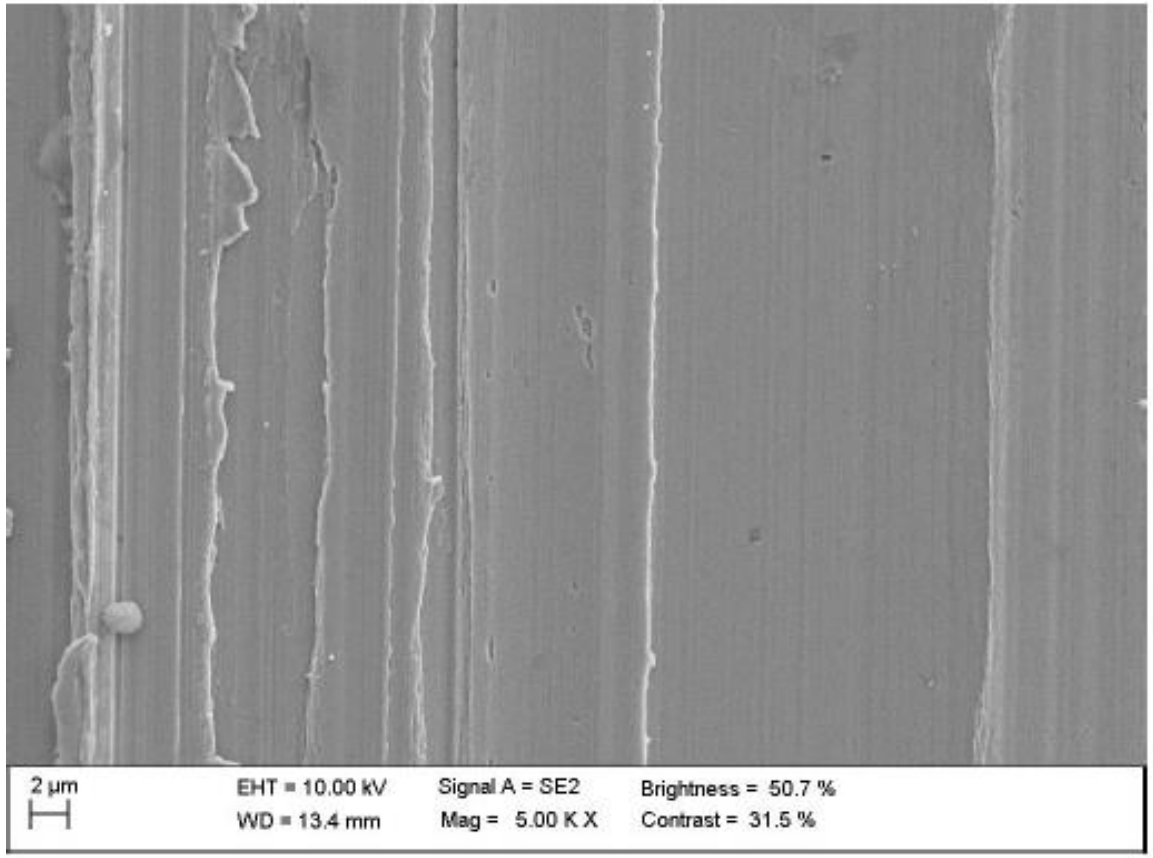
ps-laser application results

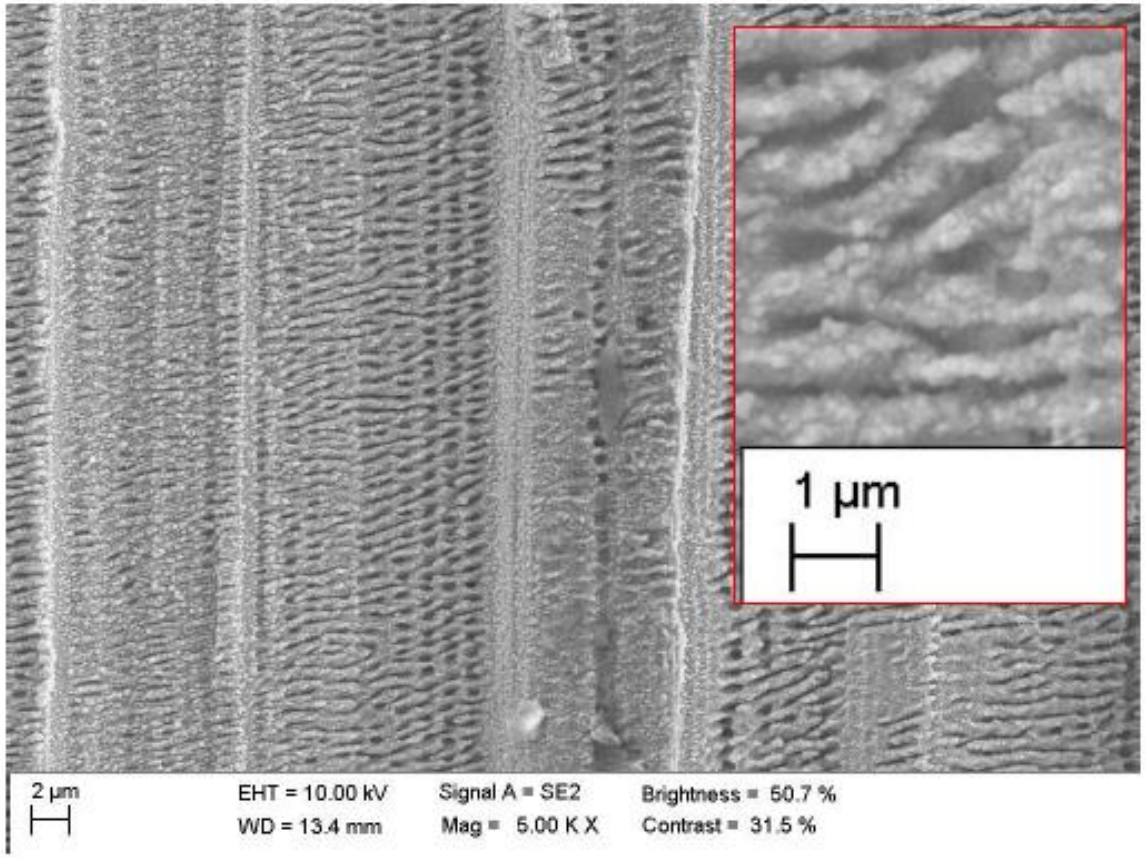


ps-laser application results



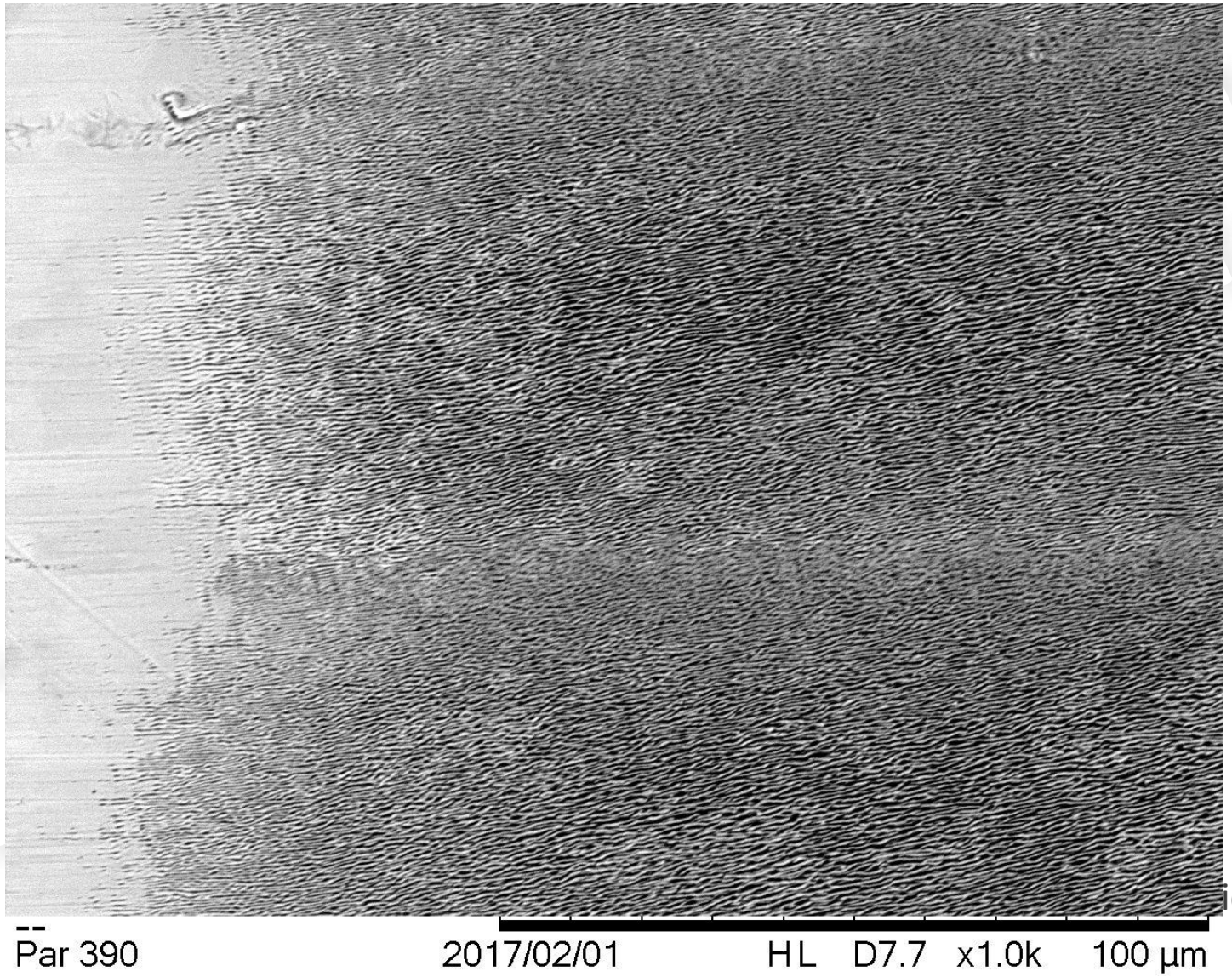
Surface observation by SEM





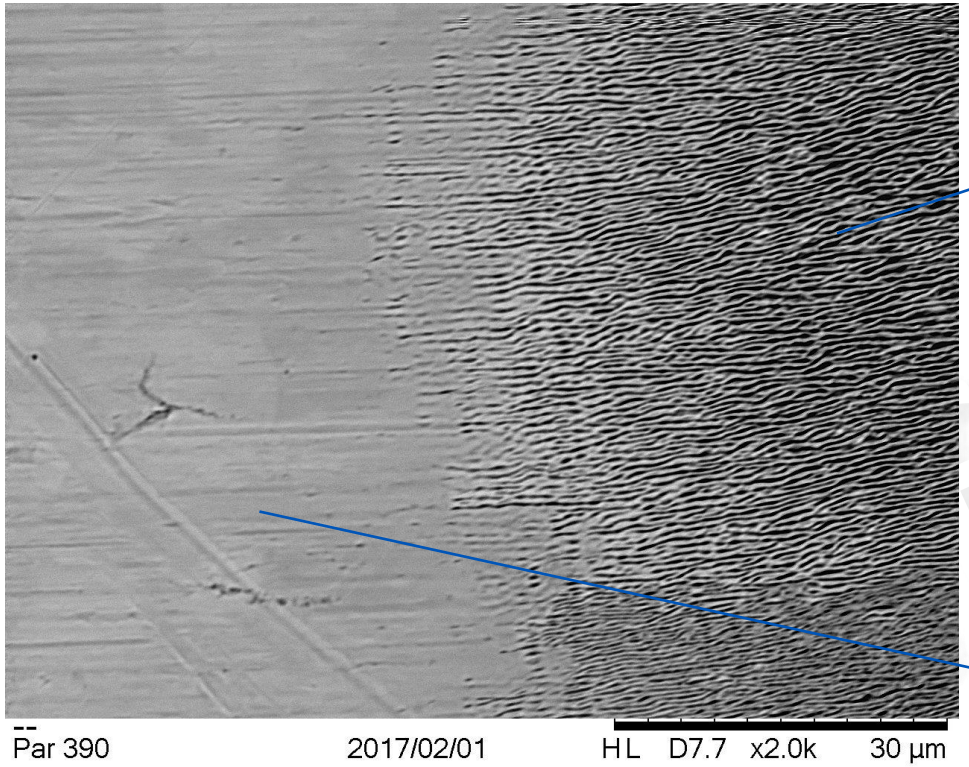
Laser marked area features micro/nano structures

Surface observation by SEM

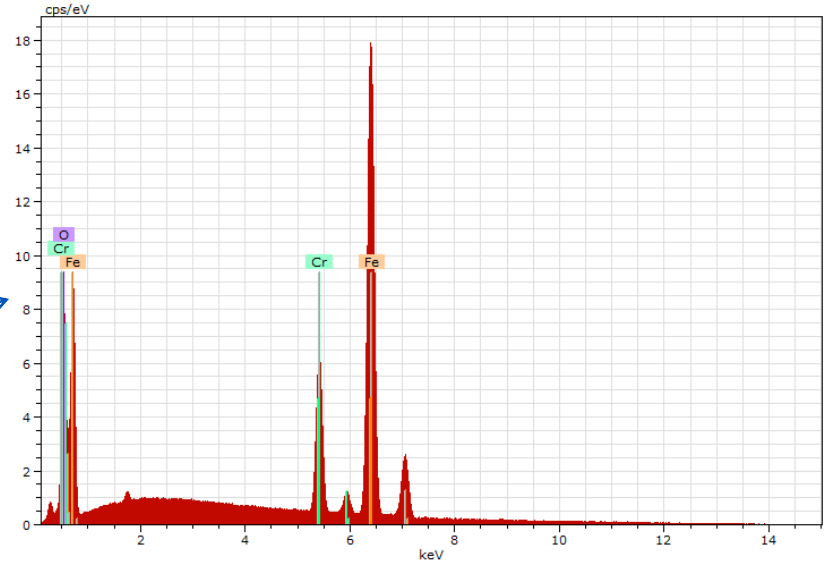


icro/nano structures

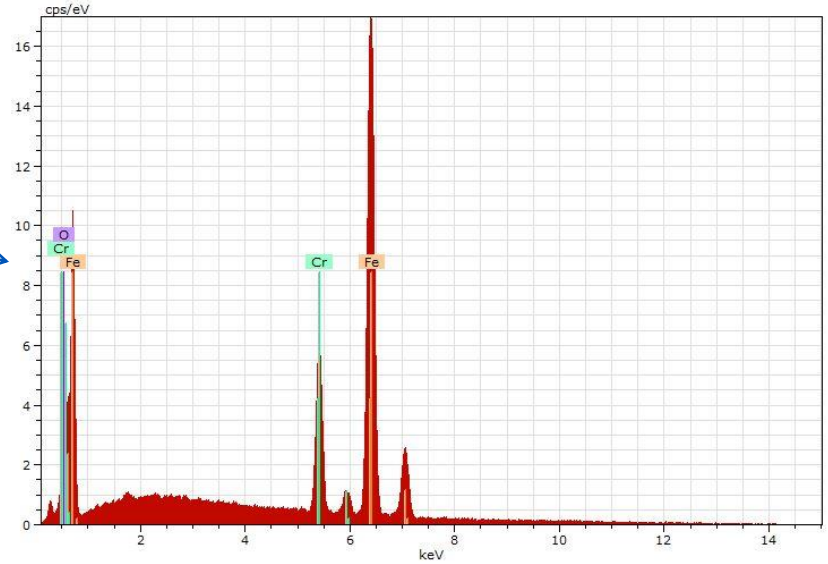
EDX ANALYSIS



2500x

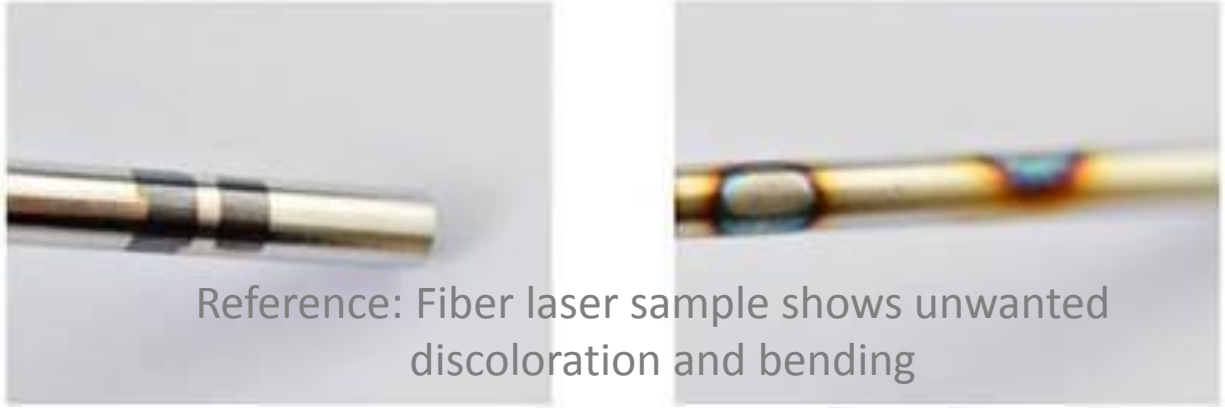


El	OZ	Serie	unn. C [Gew.%]	norm. C [Gew.%]	Atom. C [At.%]	Fehler [%]
Fe	26	K-Serie	76.85	78.89	65.18	2.3
Cr	24	K-Serie	12.71	13.05	11.58	0.4
O	8	K-Serie	7.85	8.06	23.24	0.9
Summe:			97.41	100.00	100.00	



El	OZ	Serie	unn. C [Gew.%]	norm. C [Gew.%]	Atom. C [At.%]	Fehler [%]
Fe	26	K-Serie	83.85	85.07	82.22	2.5
Cr	24	K-Serie	13.76	13.96	14.49	0.4
O	8	K-Serie	0.96	0.98	3.30	0.2
Summe:			98.57	100.00	100.00	

Minimized HAZ allows processing of fine workpieces

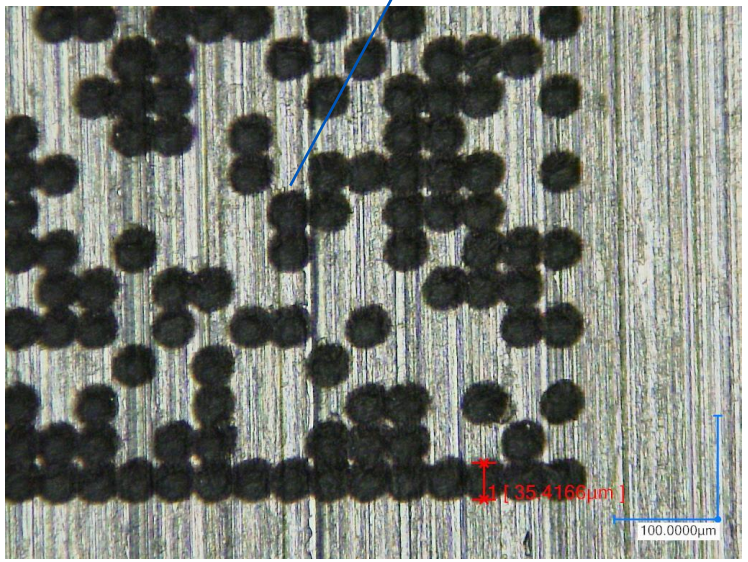


Reference: Fiber laser sample shows unwanted discoloration and bending

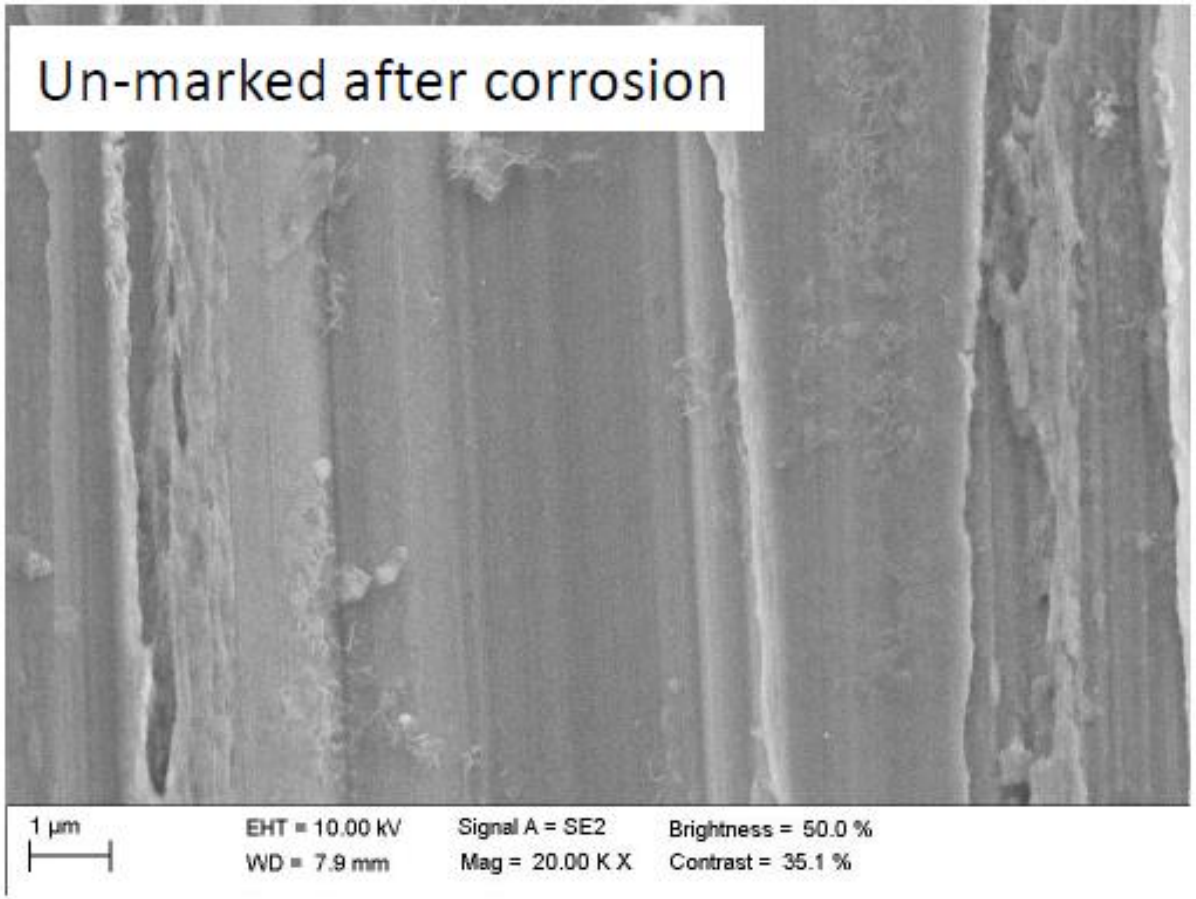
Tube diameter 0.26mm

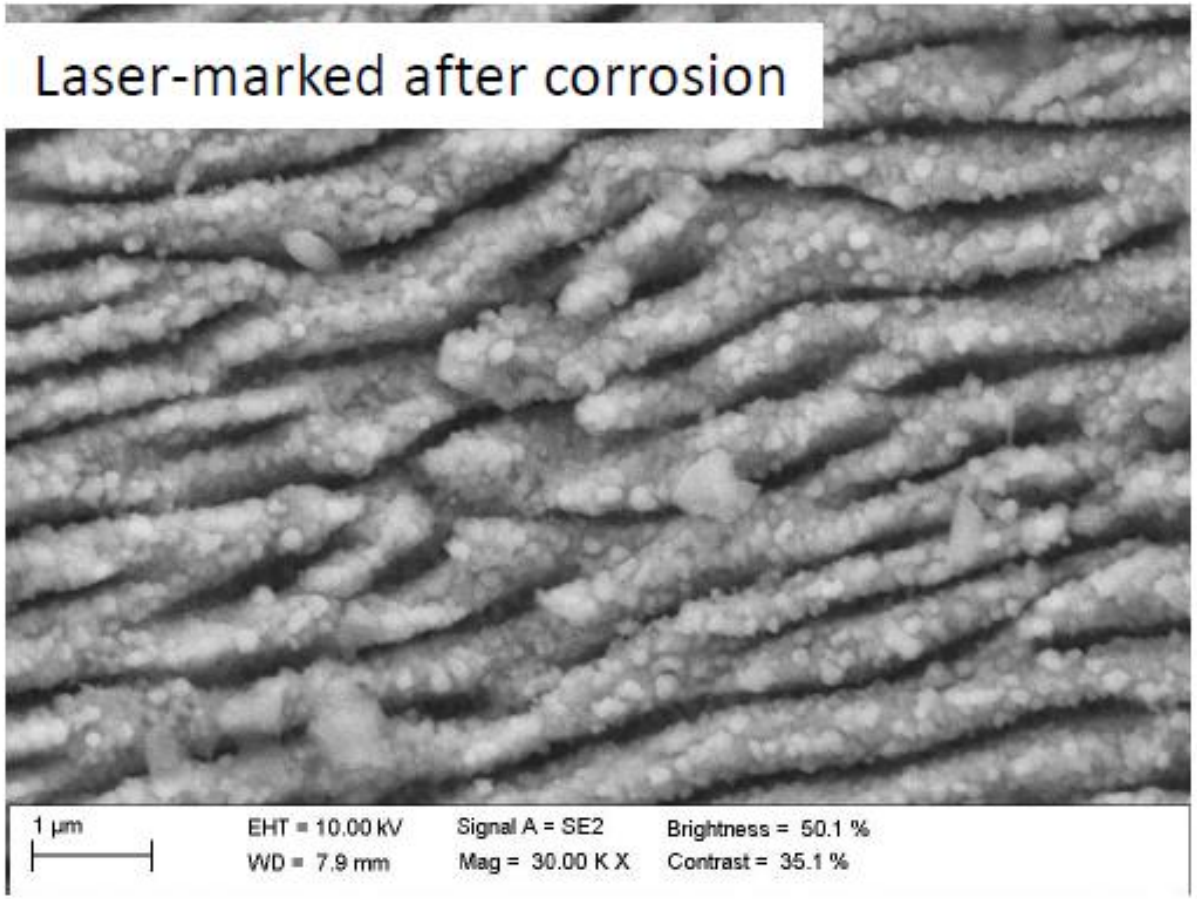
HAZ free / deformation free black marking of filigree metal parts

Cell size 35µm



Improved corrosion resistance properties





- The above samples were obtained after 23 h of SVET test.
- No obvious difference was observed between laser-marked and un-marked areas.

Images: University Manchester

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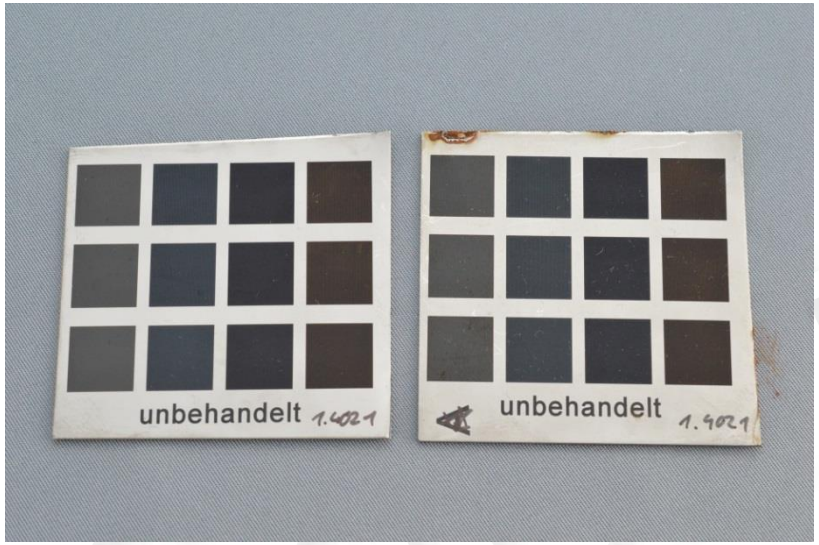
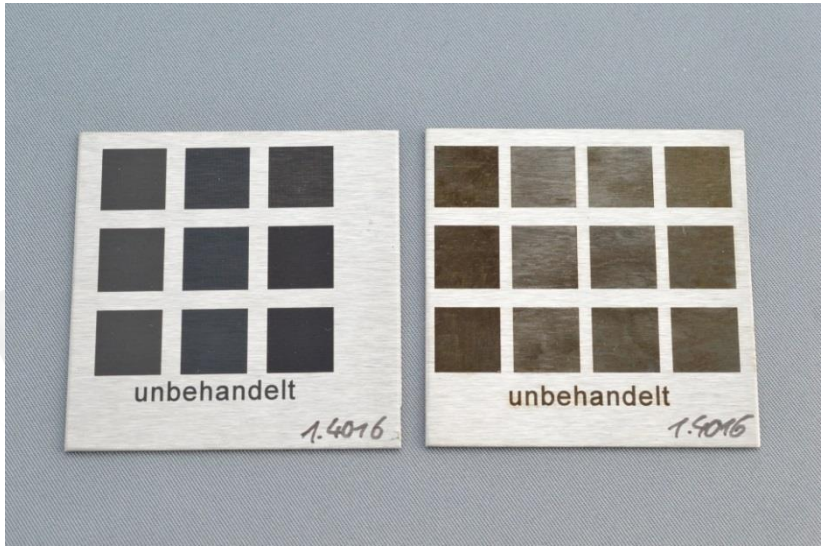
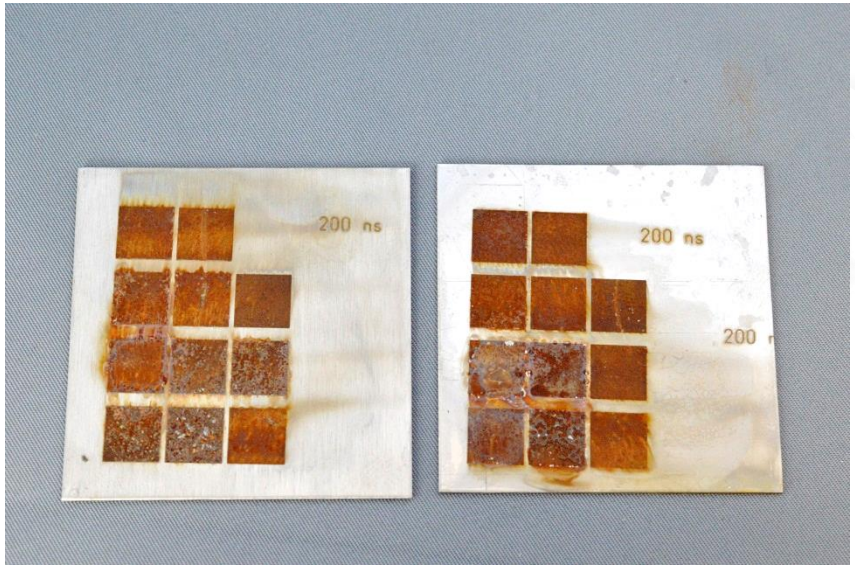
Improved corrosion resistance properties



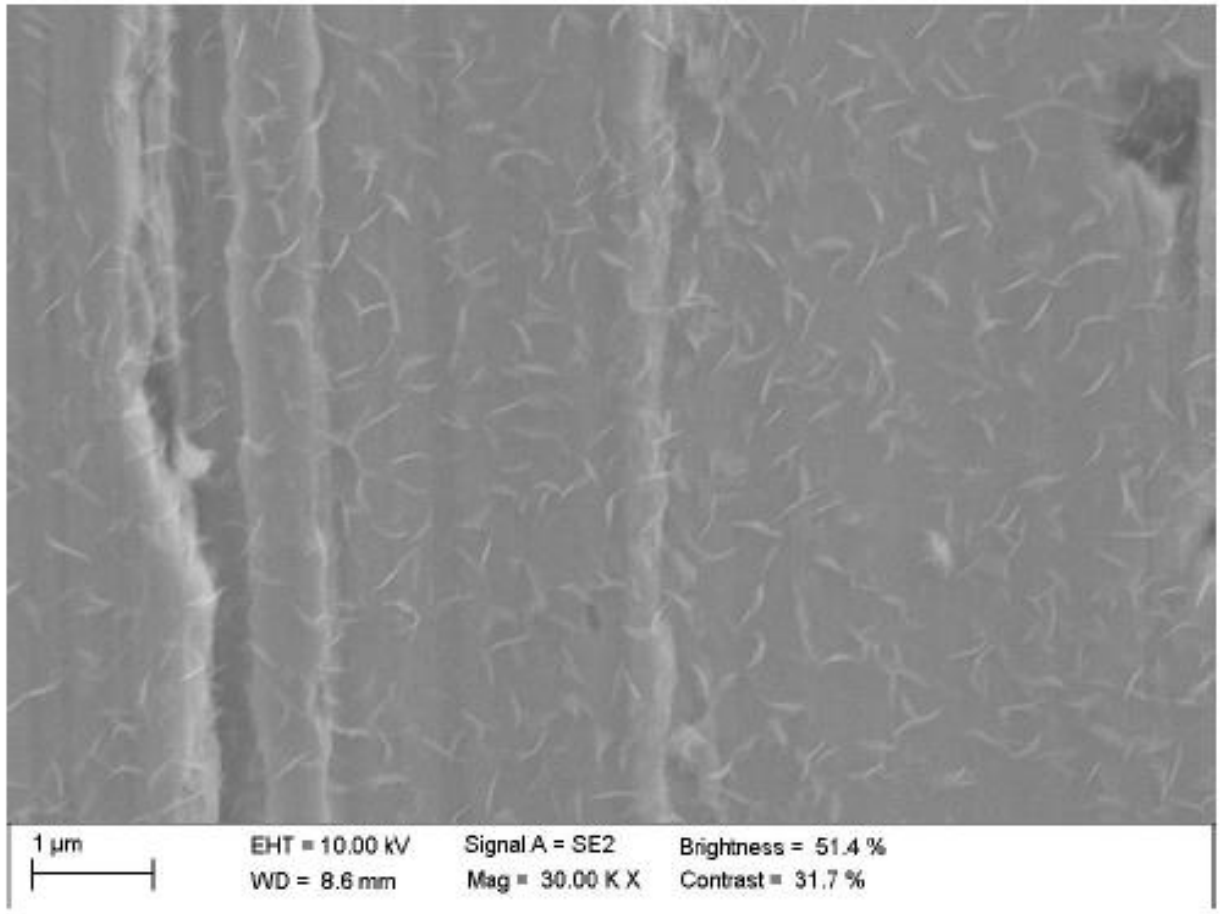


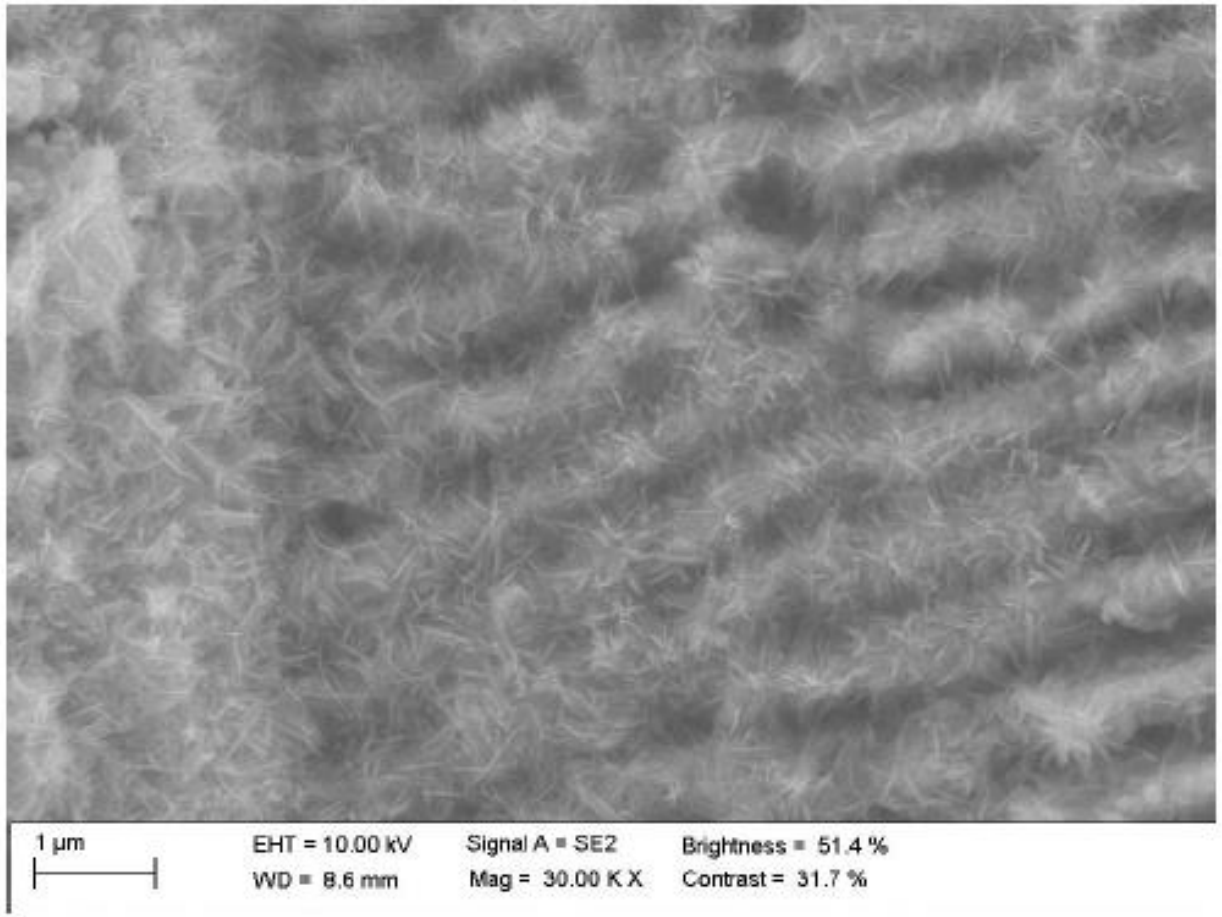


Before/After comparison of 1.4301, 1.4016 and 1.4021 steel types after 72h in 50°C warm 5% NaCl salt water spray test.

Reference: fiber laser sample after 72h

Improved corrosion resistance properties





Images: University Manchester

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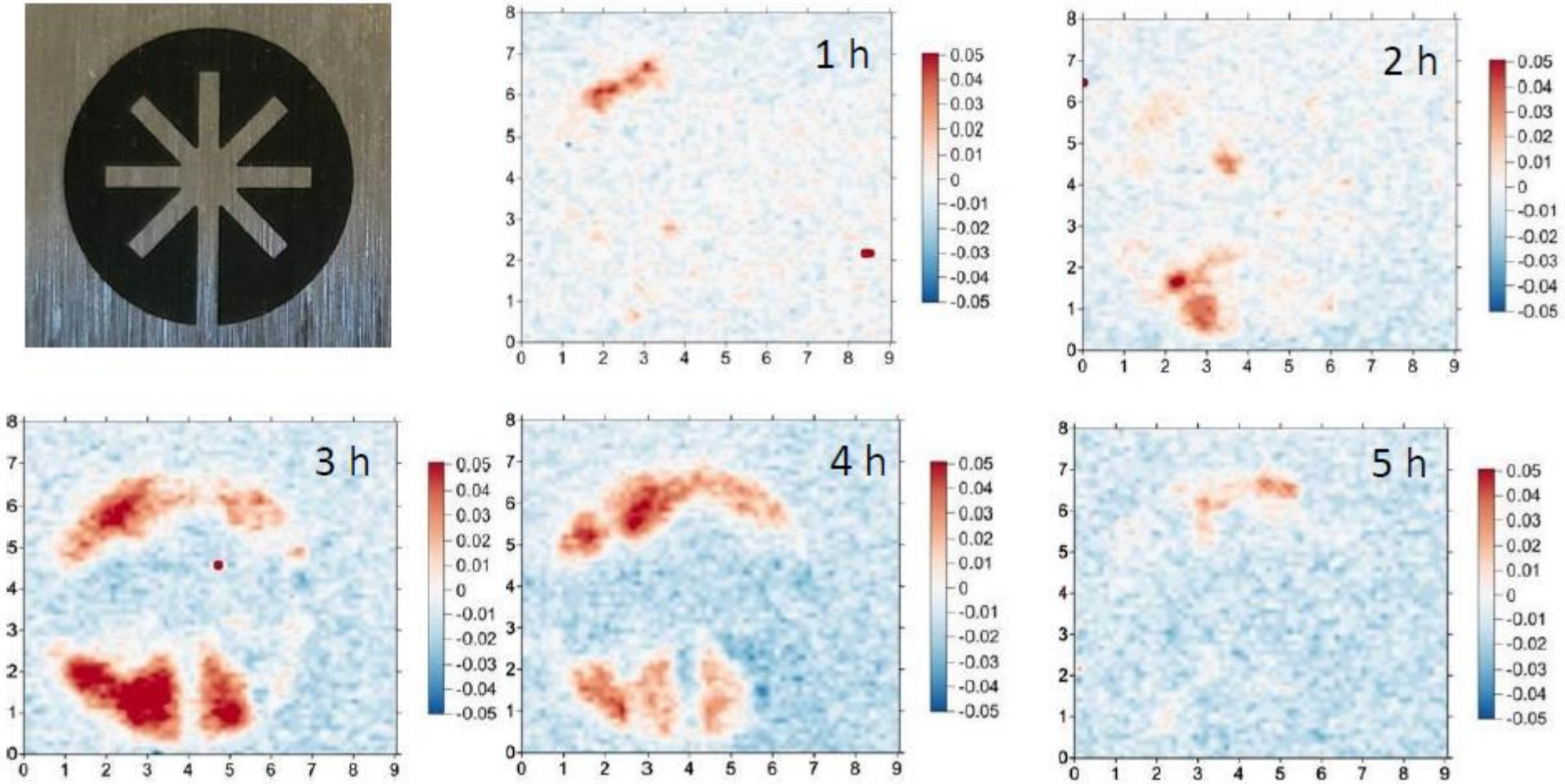

SVET analysis: Possible formation of Fe3O4 – then dissolve and reform Cr2O3.

Images: University Manchester

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