



SURFACE FUNCTIONALIZATION

USING DIRECT LASER INTERFERENCE PATTERNING

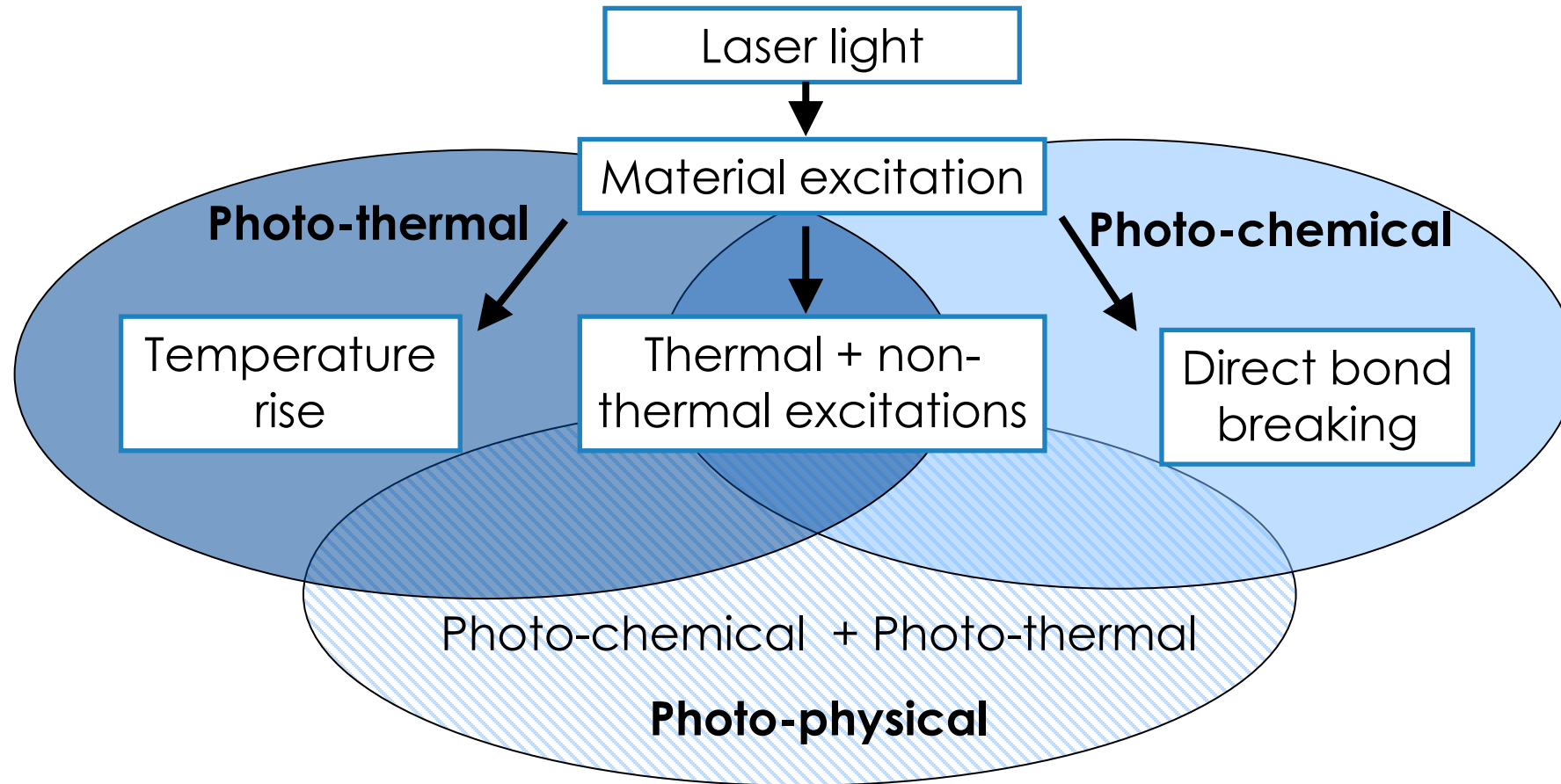


Outlook

- Fundamentals of Laser-Matter Interaction
- Direct Laser Interference Patterning: basics
- DLIP solutions
- DLIP applications

Fundamentals of Laser-Matter Interaction

Thermal, Photophysical and Photochemical Processes



Fundamentals of Laser-Matter Interaction

Thermal, Photophysical and Photochemical Processes

Thermal processes

- Photothermal → Temperature rise
- The most important factor which defines the possibility to heat a material is the “relaxation time” t_T .
- In metals, the time of electron-electron collision $t_e \sim 10^{-14}, 10^{-13} \text{ s}$ → Importance of the pulse duration!
- For a thermal process it is necessary that $t_T \ll t_R$ (time of the initial processing step (pulse duration))

Photochemical processes

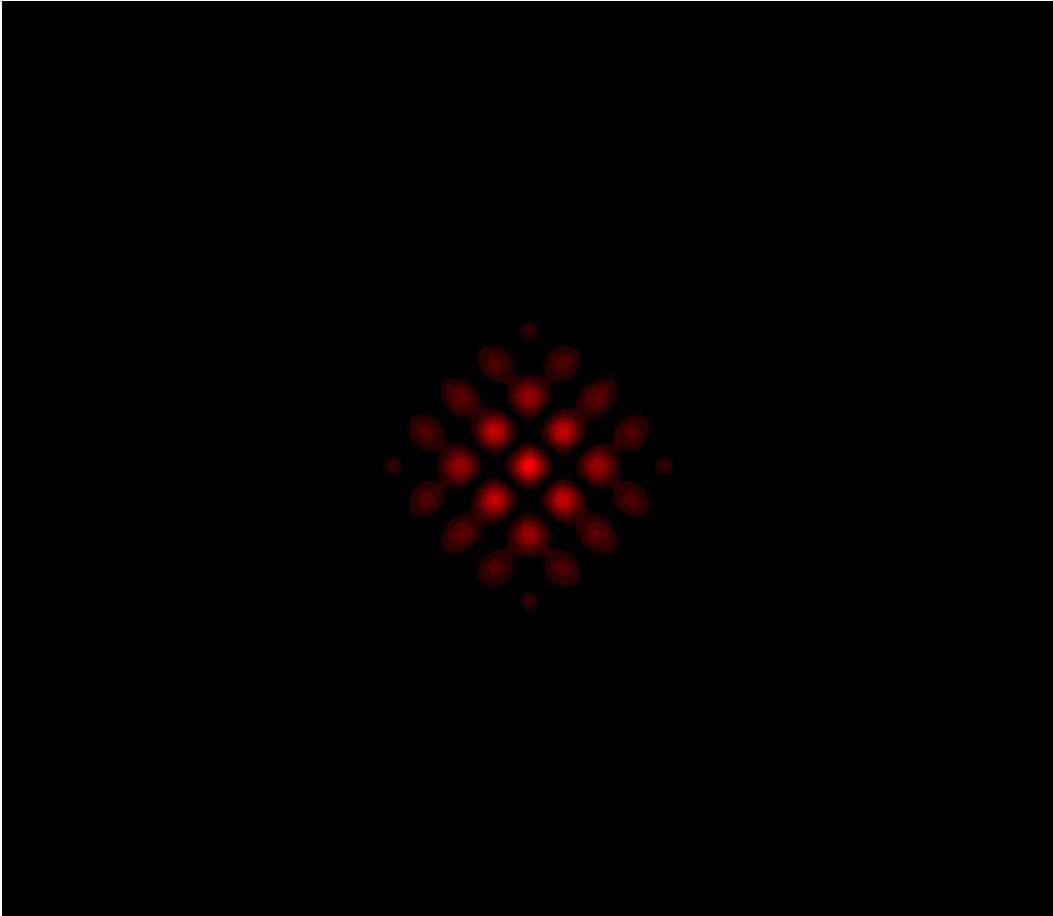
- Photochemical → No temperature rise
- $t_T \gg t_R$
- i.e.: direct bond breaking

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Direct Laser Interference Patterning: basics

The working principle

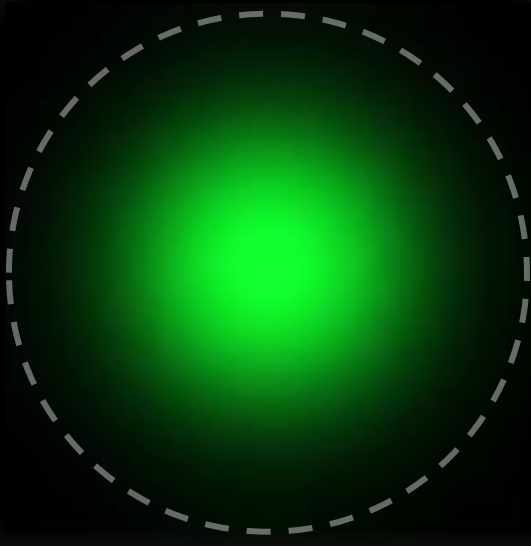


- Controlled splitting and overlapping of coherent sub-beams $N (> 2)$
- Facilitate pulsed laser sources: 1064 nm – 266 nm
- Standing-wave pattern / interference effect
- Typical pattern dimensions: 180 nm – 30 μm
- Different texture geometries possible
- $> 1,000,000$ individual features/ mm^2 ($p=1 \mu\text{m}$) with one laser pulse
- No clean room / vacuum conditions necessary

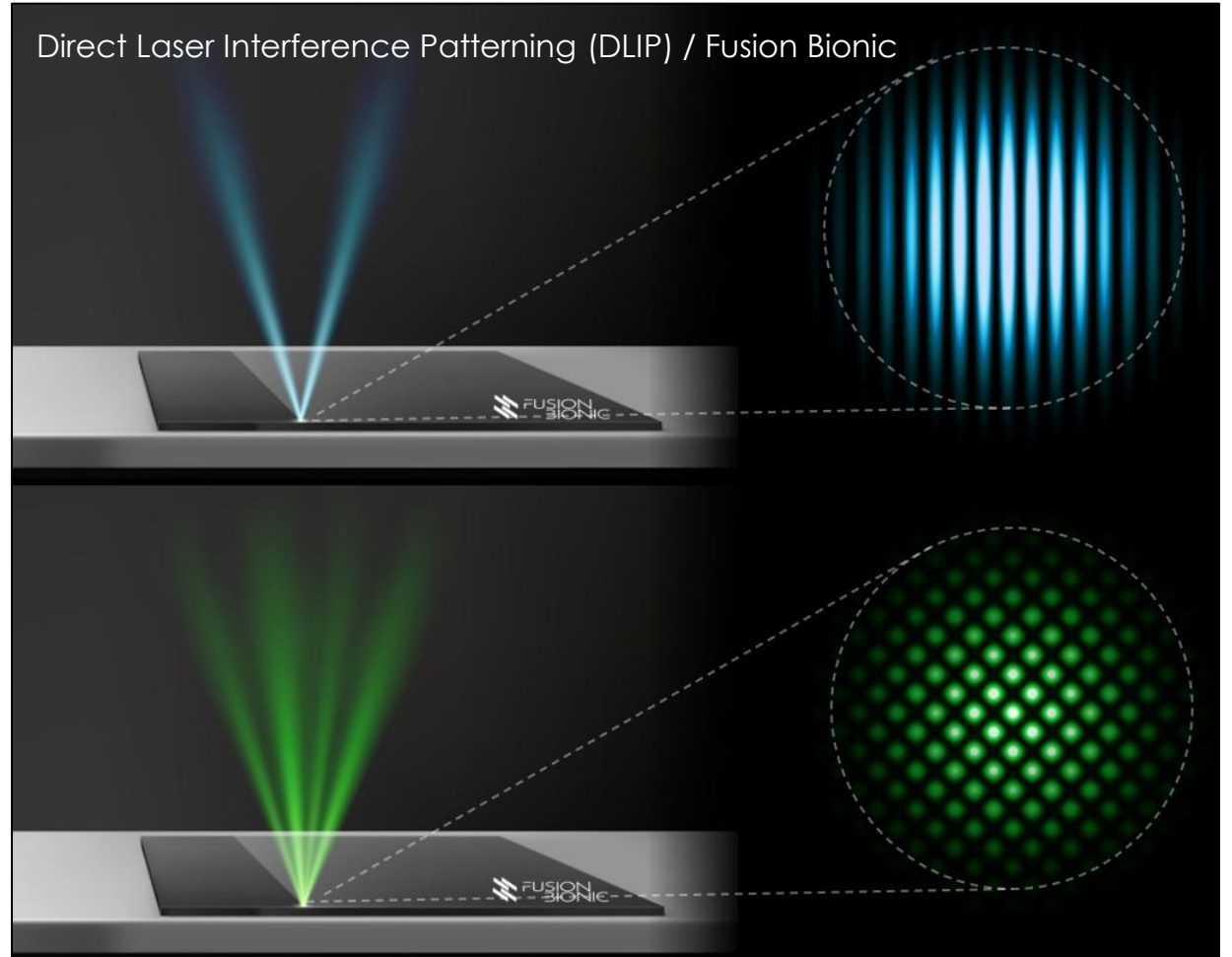
Direct Laser Interference Patterning: basics

The working principle

Conventional laser machining / Direct Laser Writing

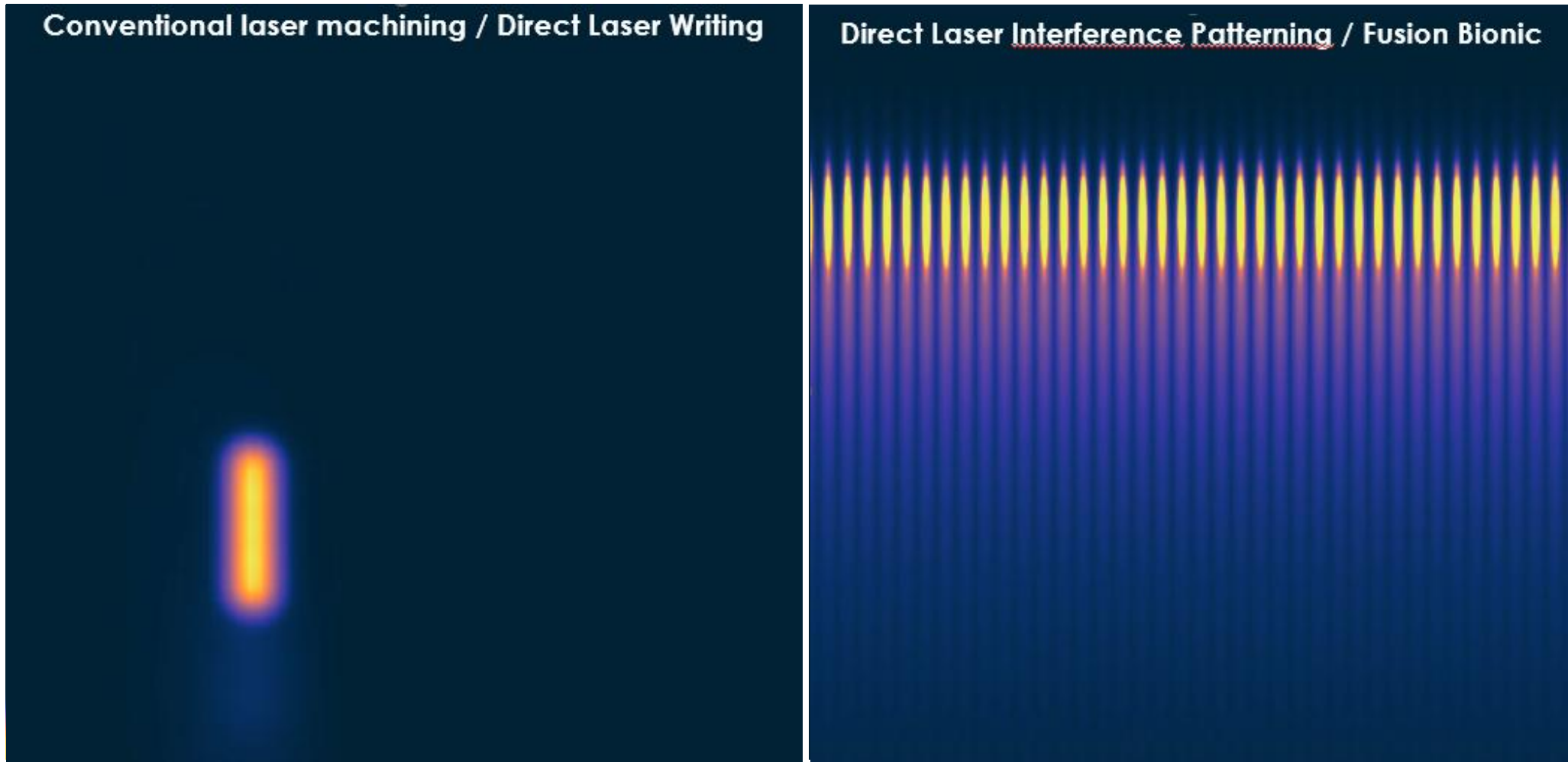


Direct Laser Interference Patterning (DLIP) / Fusion Bionic



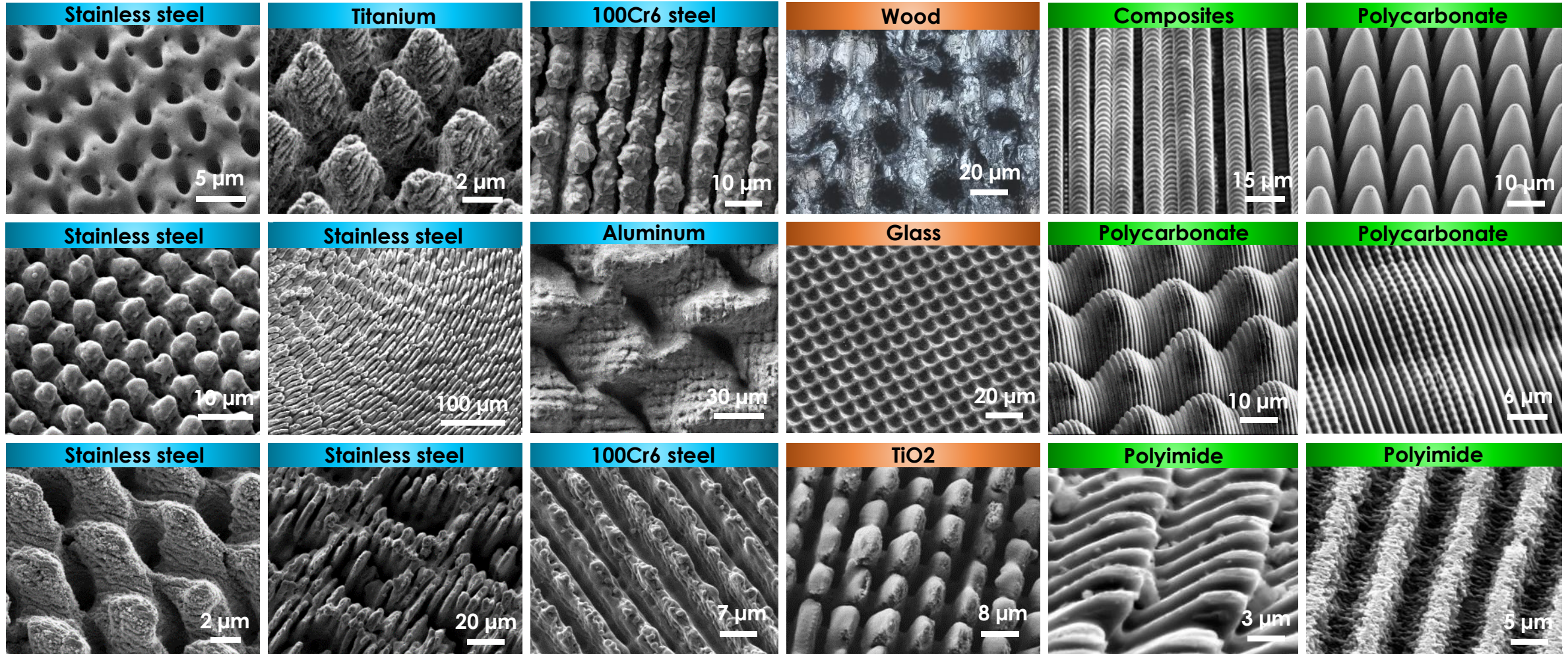
Direct Laser Interference Patterning: basics

The working principle



Direct Laser Interference Patterning: basics

Laser textures on different materials



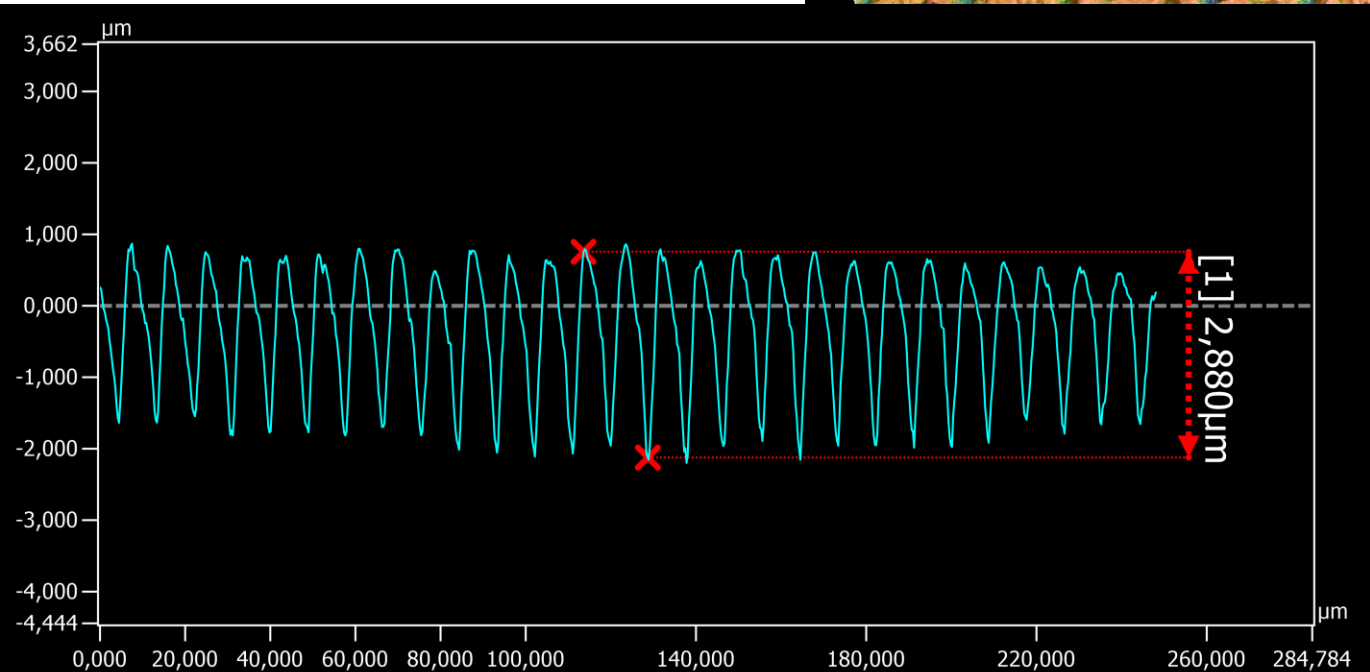
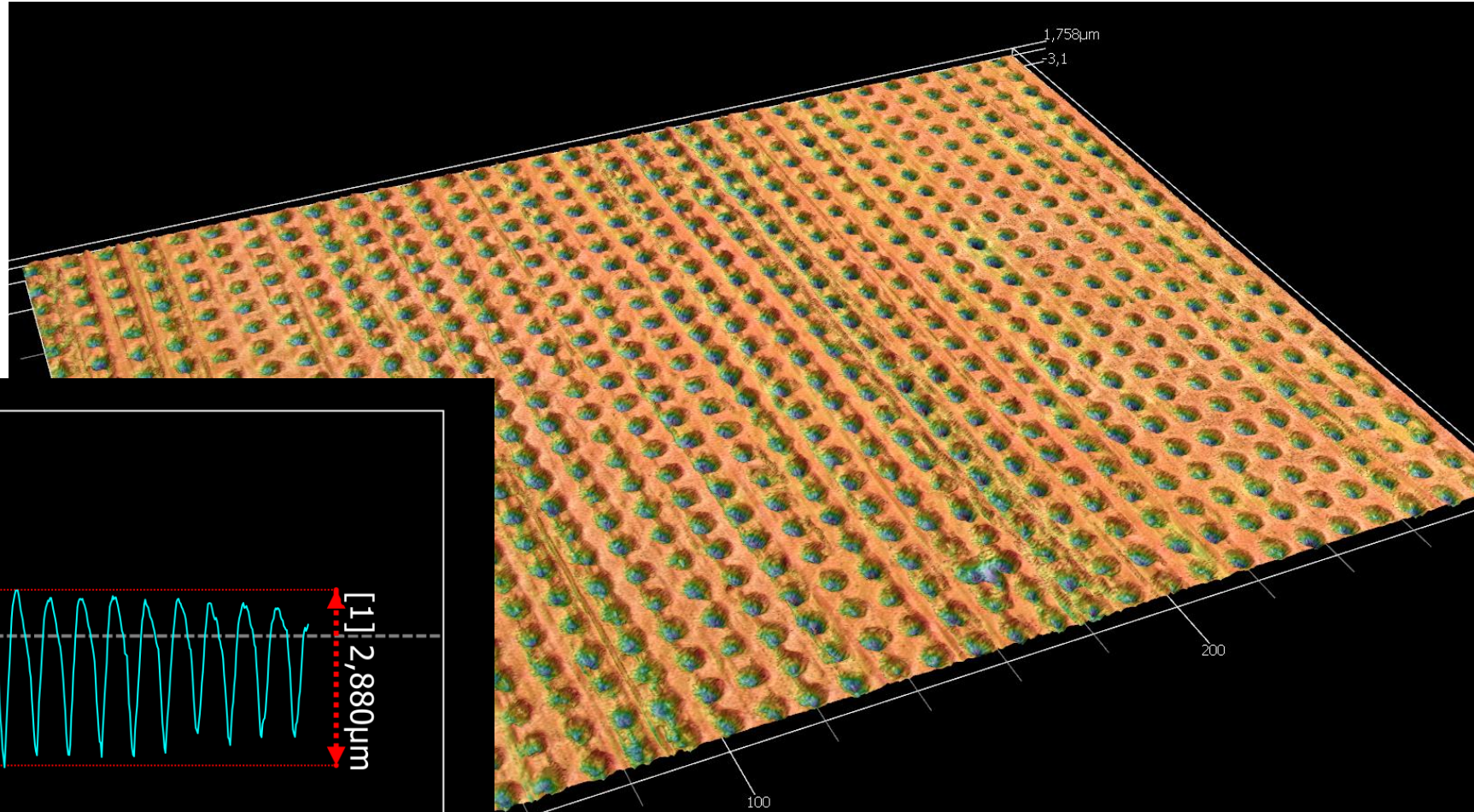
Direct Laser Interference Patterning: basics

The role of pulse duration: sub-ps DLIP

Pulse duration: **500 fs**

Interference Period: $9.0\text{ }\mu\text{m}$

LIPSS: present all over the area

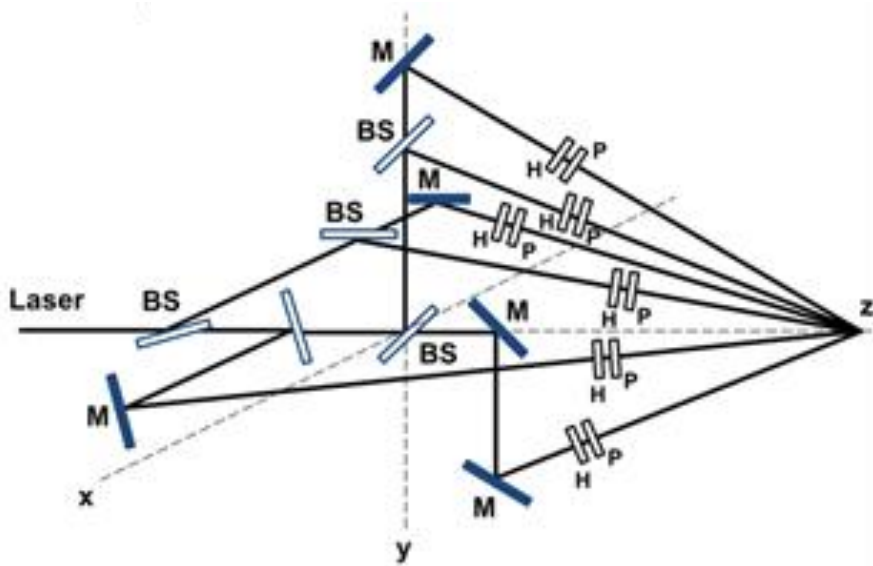


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- DLIP applications

DLIP solutions

Industrial solutions



Xu, J., et al., J. Appl. Phys. 115, 203101 (2014)

Optical setup made of mirrors



Fusion Bionic (2021)

CORErapid: scanning DLIP module

DLIP solutions

R&D and production solutions using Fusion Bionic Technology



Optical solutions
COREmini, CORE, CORErapid



FUSIONone-K
Productivity example:
up to 1.500.000 parts p.a.



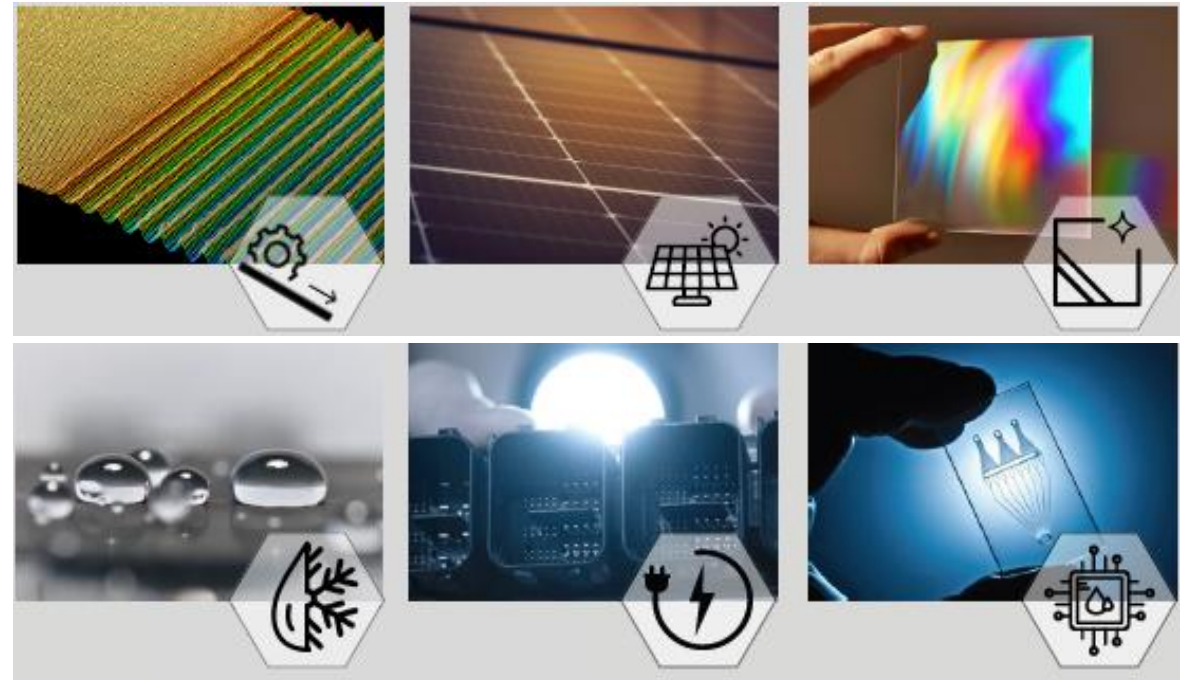
FUSIONone-R
Productivity example:
up to 40.000 wafer p.a.

DLIP solutions

COREmini: Ultra-compact DLIP module



Parameter	COREmini
Wavelength	NIR, VIS, UV
Pattern Type	Lines
Pitch	2 μm , 10 μm , 20 μm
Working Distance	46.6 mm, 196.2 mm, 196.2 mm
Laser Pulse Duration	> 1 ps
Pulse Energy (recommended)	> 150 μJ
Transmittance	~70 %
Maximum Optical Power	100 W



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Applications

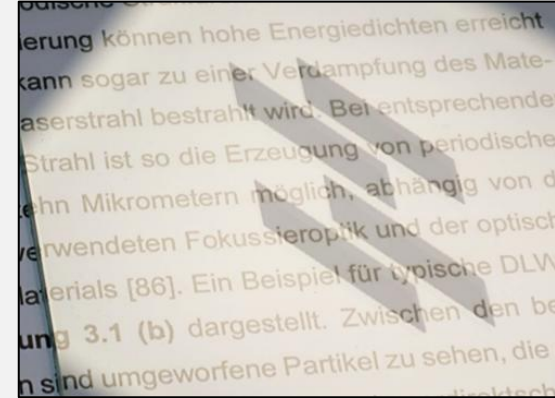
Anti Soiling



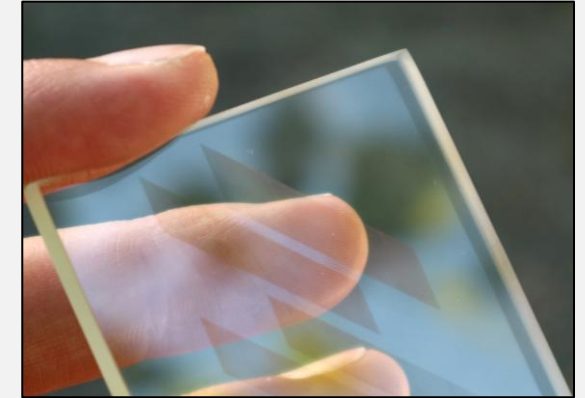
Anti Fog



Anti Glare



Anti Reflex



Matting/Whitening



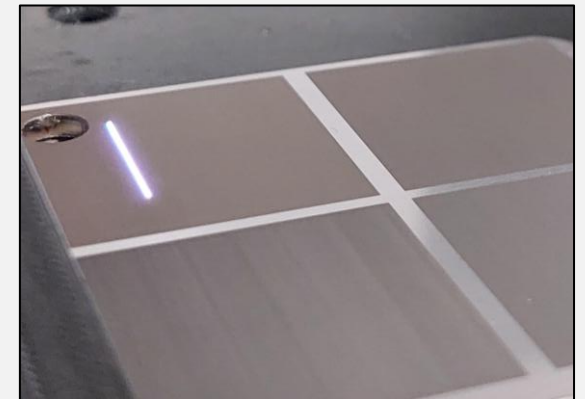
Anti Slip



Decorative



Adhesion



Applications

Scanning DLIP for laser blasting*

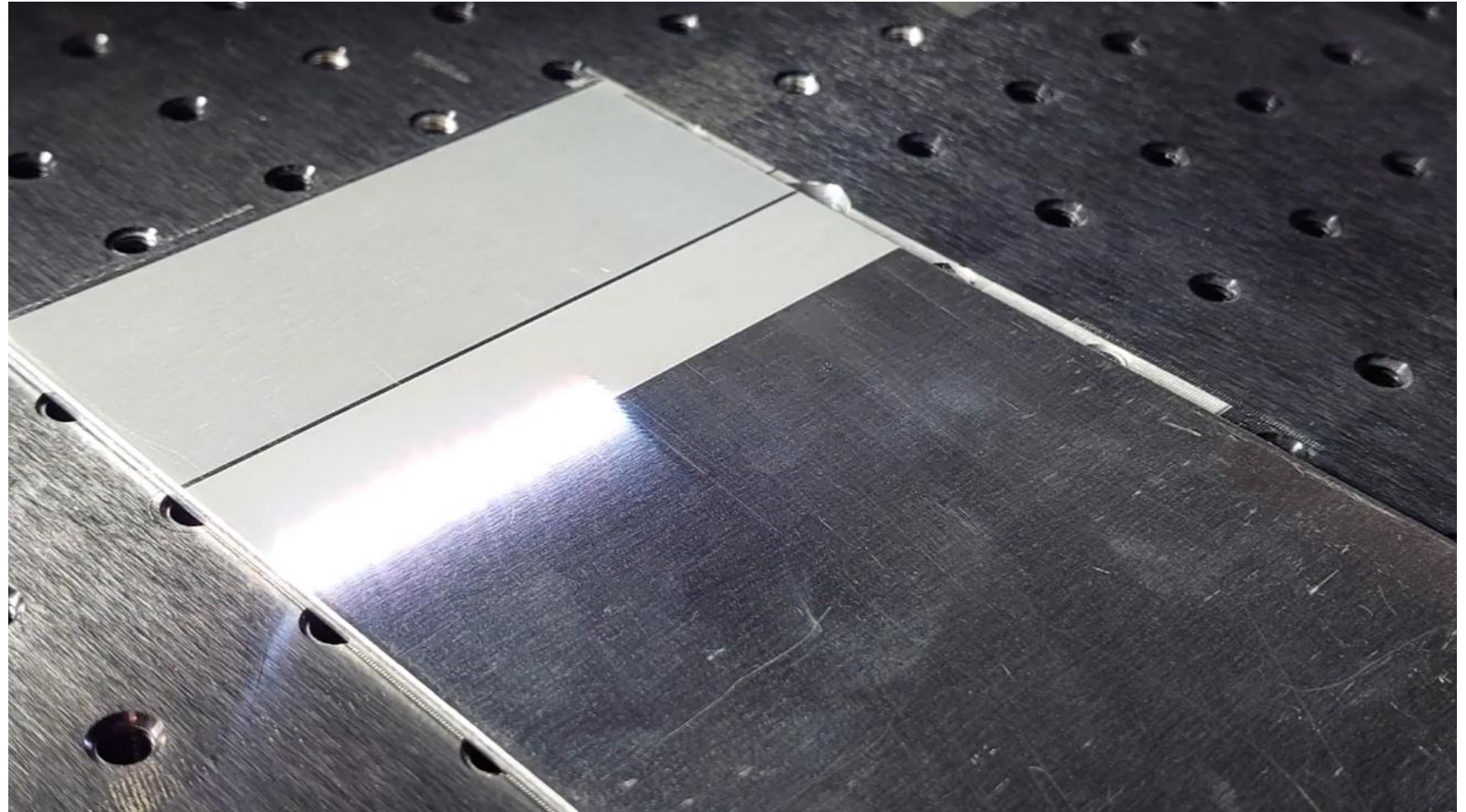


Aluminum

Speed: 0.11 m²/min (@50W)

Roughness: 6 - 9 μm (Sz)

Scalable to 0.4 m²/min



Applications

Self-cleaning on metals & anti-fogging on glass



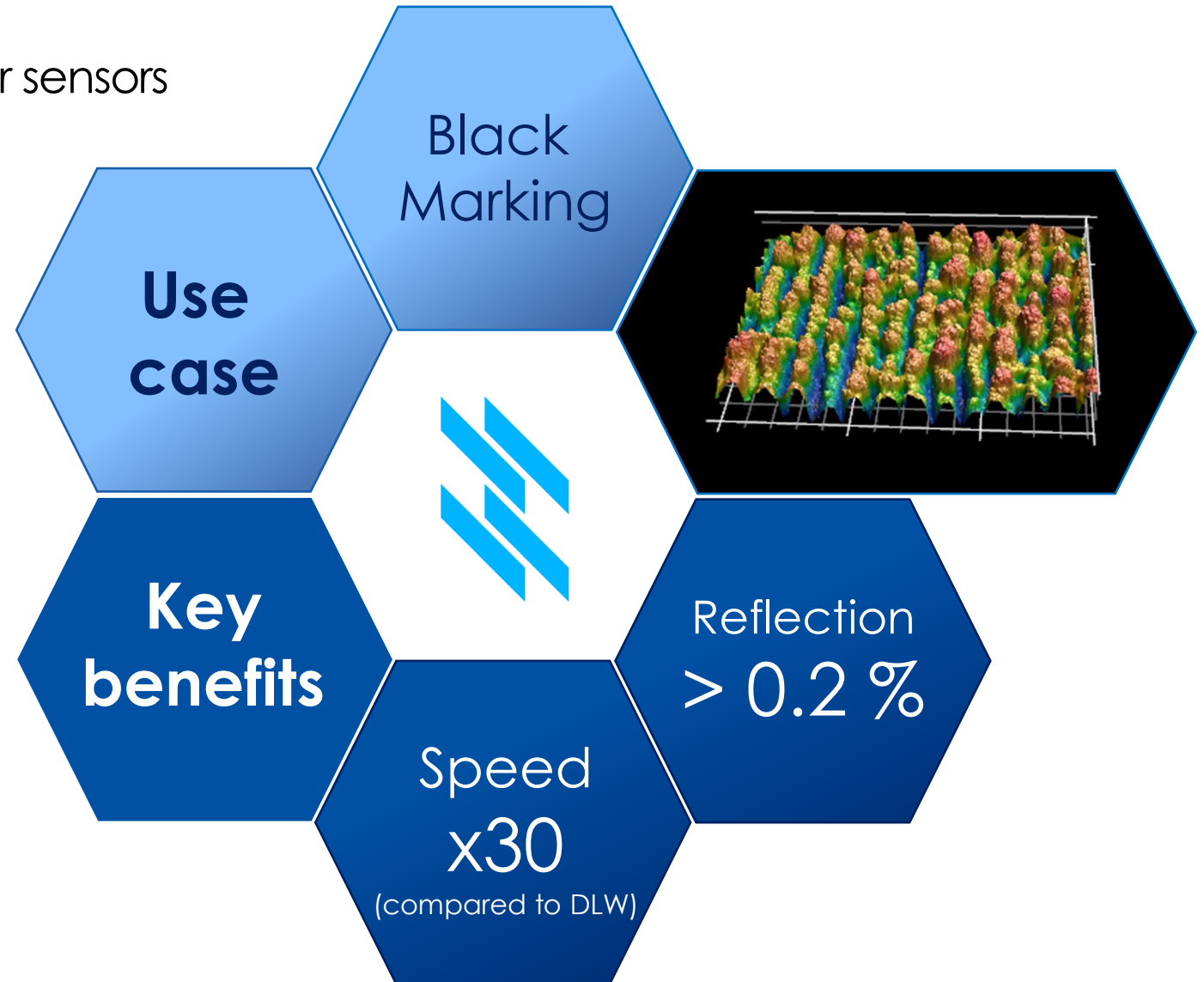
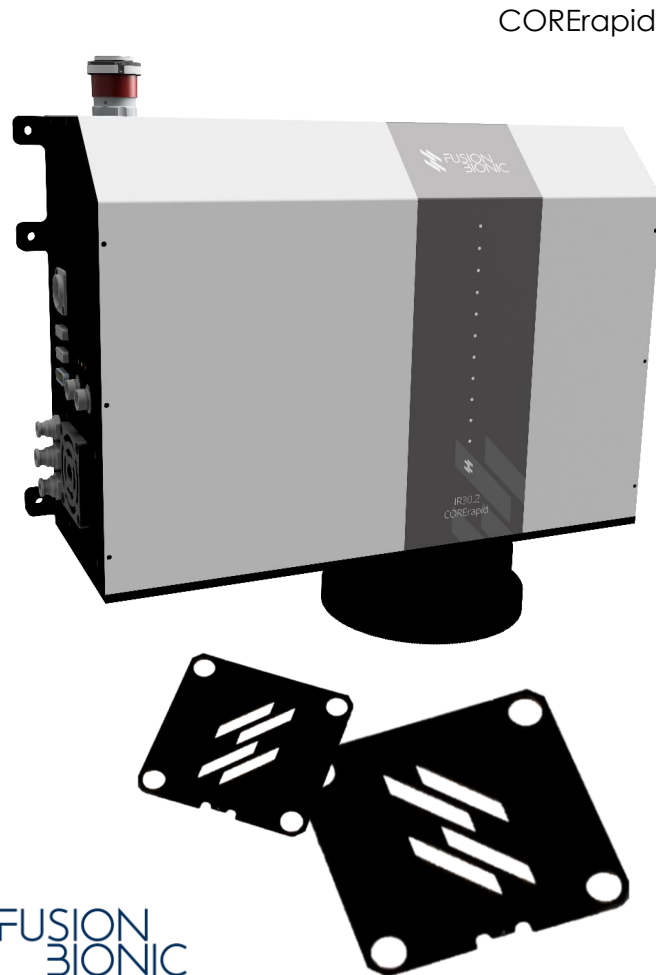
Artificial **self-cleaning** structure on stainless steel



Anti-fogging
on glass

DLIP applications

Blackening and stray light reduction for sensors



DLIP applications

Anti-soiling:
Efficiency-enhancing
PV surfaces

[Link: Demonstration-Video](#)

DLIP applications

Efficiency-enhancing PV surfaces



[Link: Demonstration-Video](#)



Get ahead
of the curve.



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