

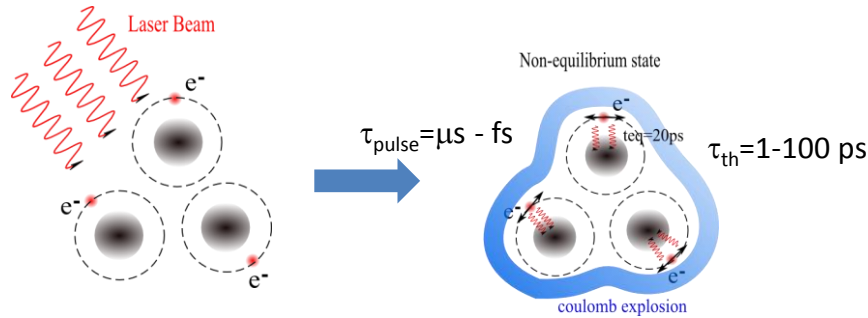


IK4  TEKNIKER
Research Alliance

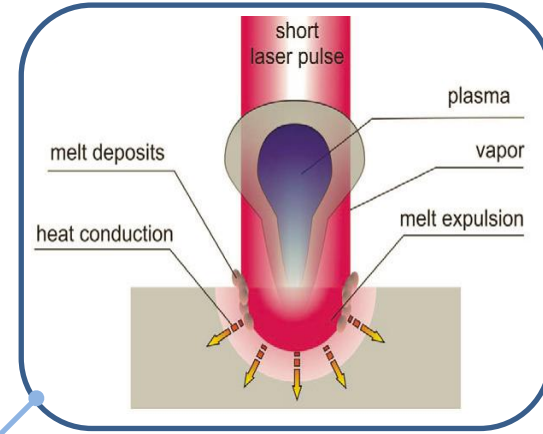
Aplicaciones del micromecanizado láser en el ámbito de la salud: Casos de Éxito

Dr. Iban Quintana

Laser micromachining with ultrashort-pulsed lasers: The concept



Thermalization
time in metals



$\tau_{\text{pulse}} > \tau_{\text{th}}$

The absorbed laser energy as being directly transformed into heat.
Thermal.

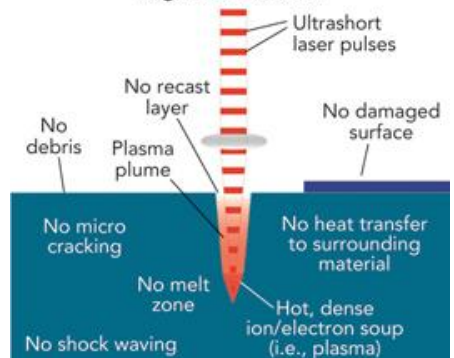
PHOTOTHERMAL
PROCESS

$\tau_{\text{pulse}} < \tau_{\text{th}}$

Non-Equilibrium state: large excitations can build up in the intermediary states: Direct Bond Breaking without thermalization.

PHOTOCHEMICAL
PROCESS

Application with ultrashort pulse laser
(e.g., femtosecond)



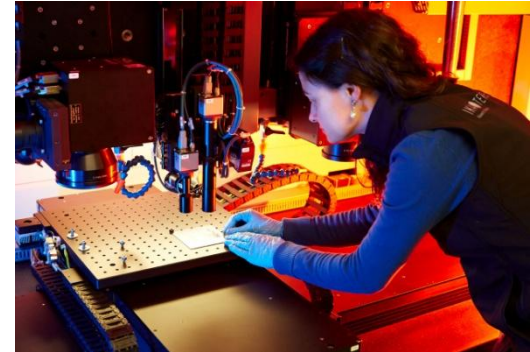
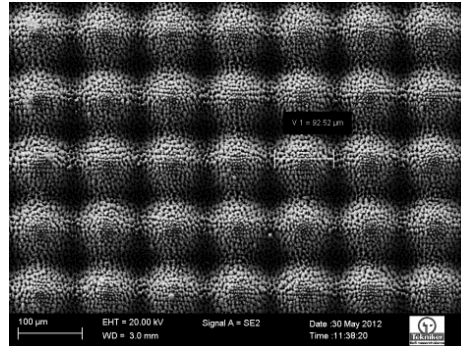
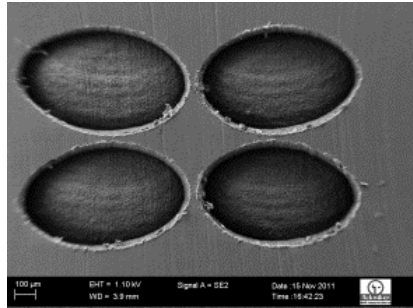
Laser micromachining with ultrashort-pulsed lasers

Advantages:

- ➔ High quality
- ➔ Minimal HAZ
- ➔ Non-contact process

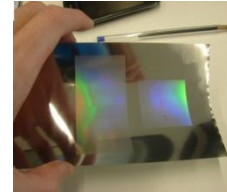
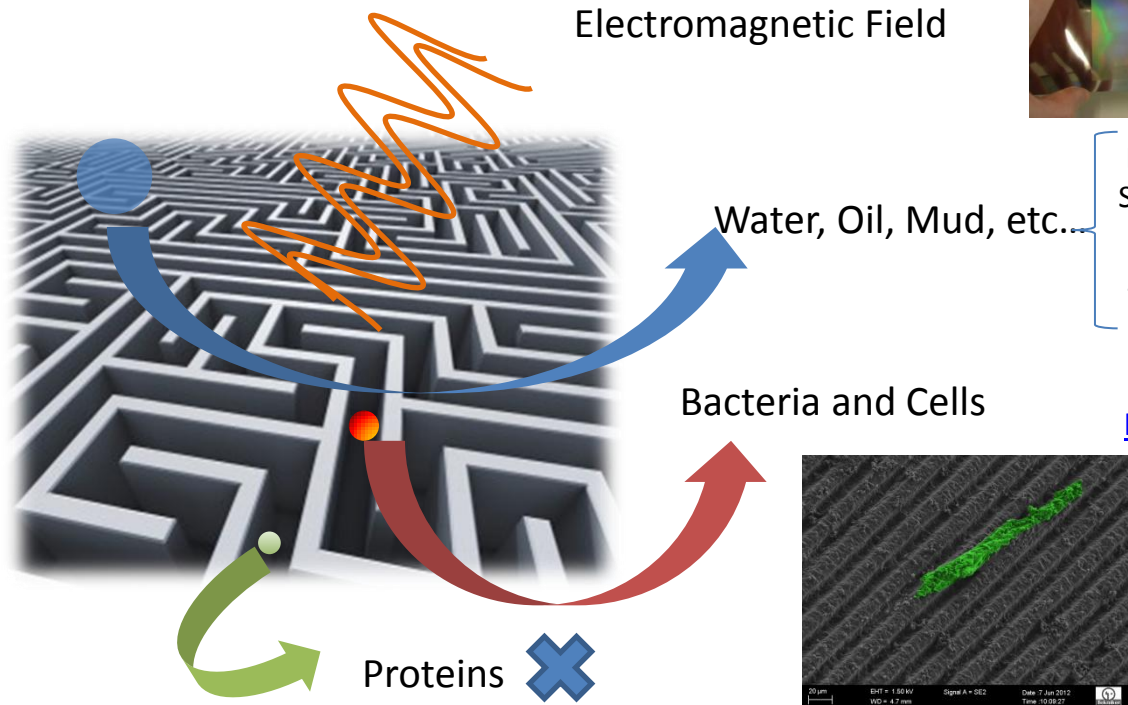
Disadvantages

- ➔ Low material removal rate (even using high power)
- ➔ Robustness
- ➔ Scalability at industrial scale
- ➔ Cost



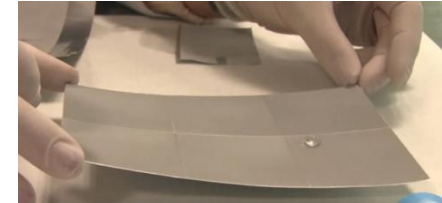
Laser micromachining with ultrashort-pulsed lasers: Applications

Micro-scale: the role on surface modification

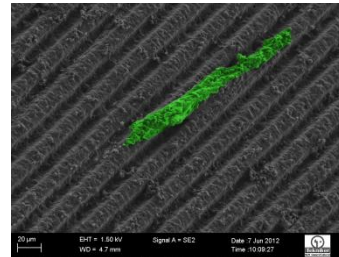


Laser Micro- and Nano-Structuring

Sol – Gel Coating

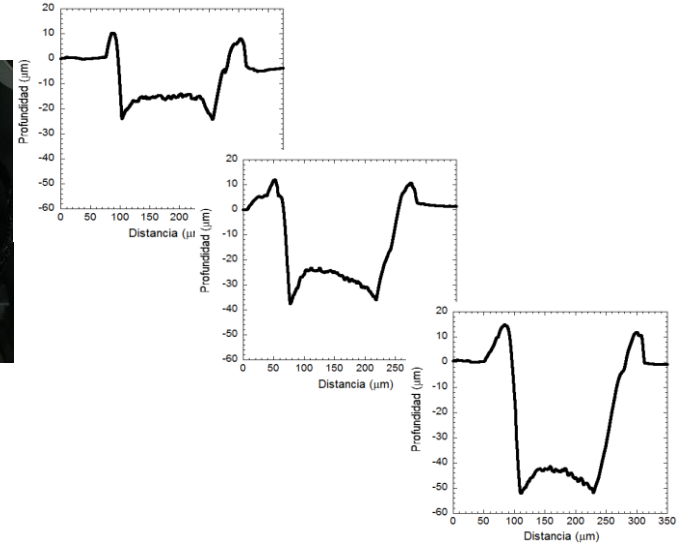
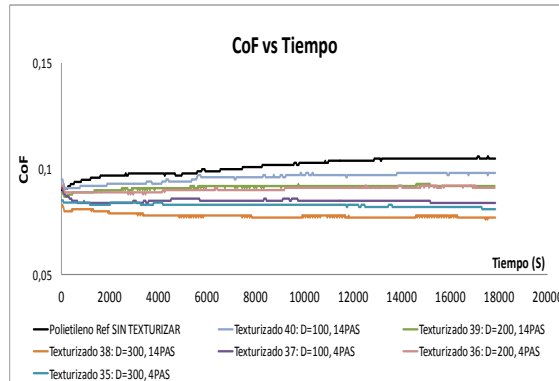
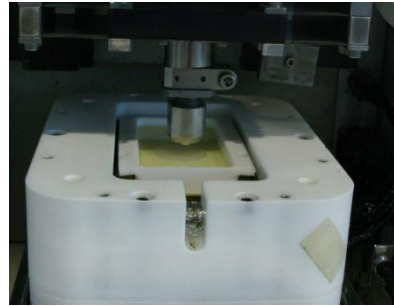
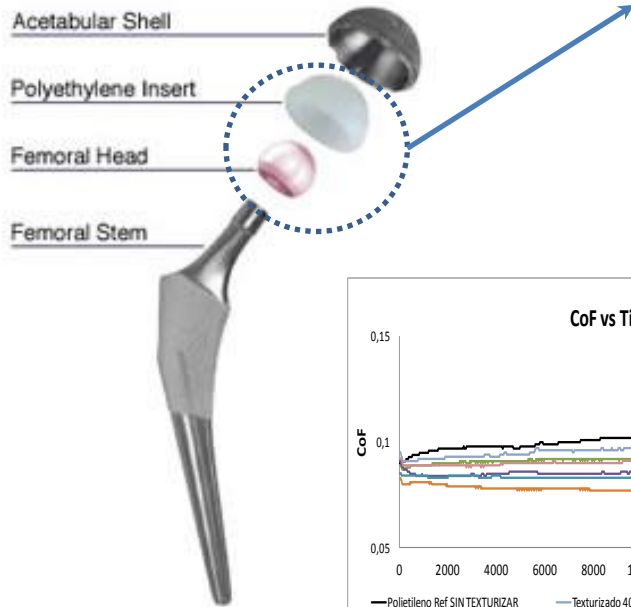


<https://www.youtube.com/watch?v=-PIEtReTa8U>



Laser micromachining with ultrashort-pulsed lasers: Applications in the health sector

Tribology on hip implant: Friction and wear

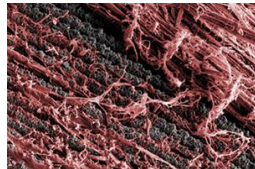
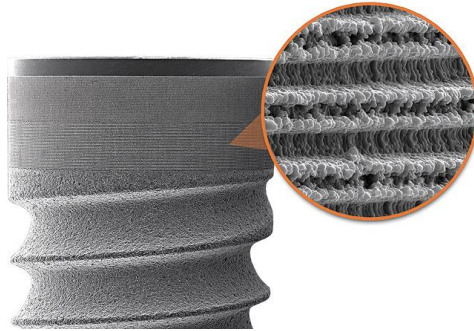


Reduction on Friction coefficient: $\approx 40\%$

Reduction on Wear: $\approx 20\%$

Laser micromachining with ultrashort-pulsed lasers: Applications in the health sector

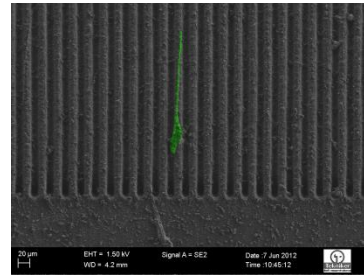
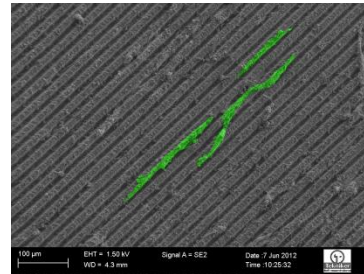
Regeneration and cell activity: Customization



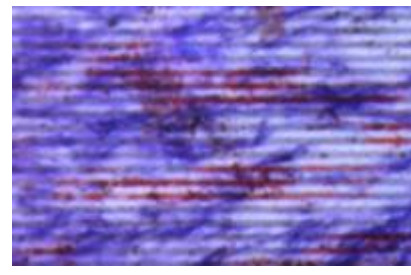
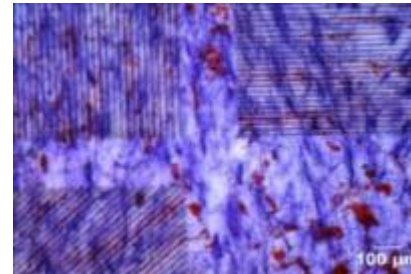
Fat globules align along the grooves (confinement effect)

Laser treatment enhanced differentiated cells attachment to the substrate

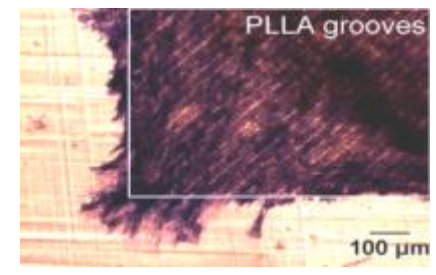
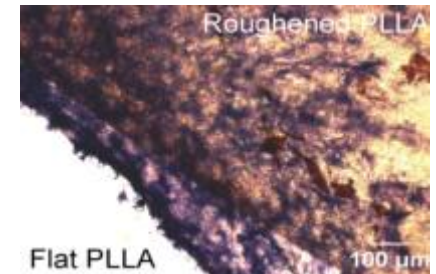
Cell Guidance Effect



Cell Fate

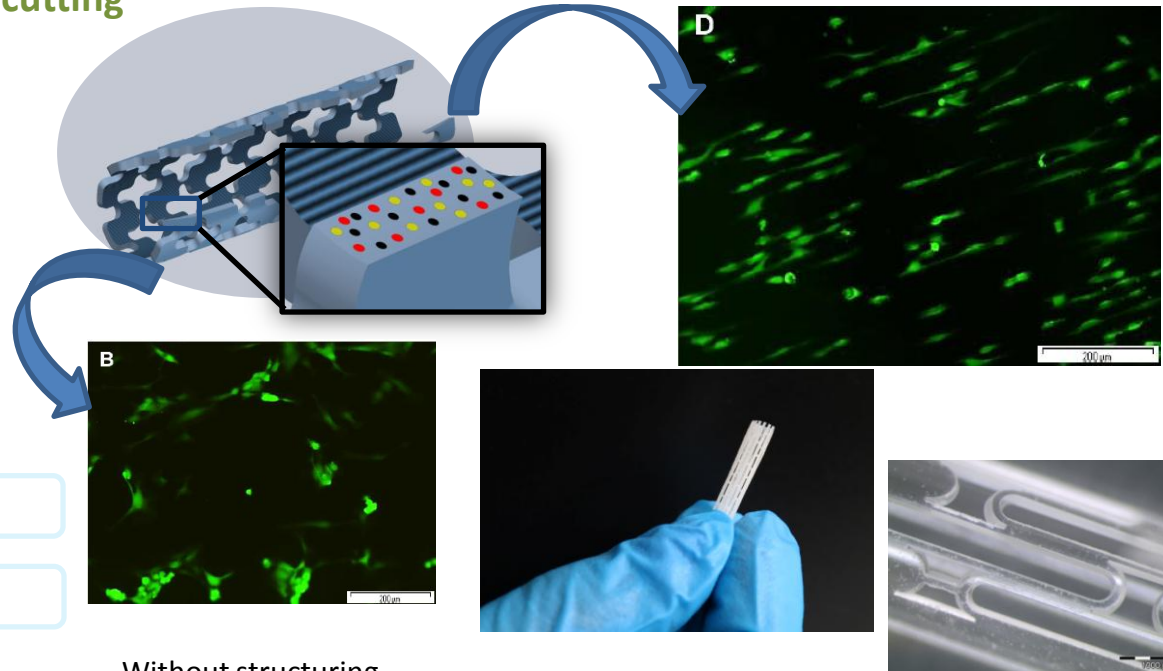
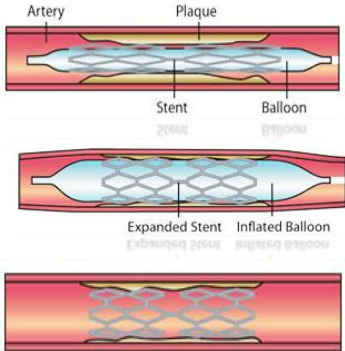


Cell Attachment



Laser micromachining with ultrashort-pulsed lasers: Applications in the health sector

Stents: Surface Functionality and cutting



- Laser cutting: 50 – 500 microns

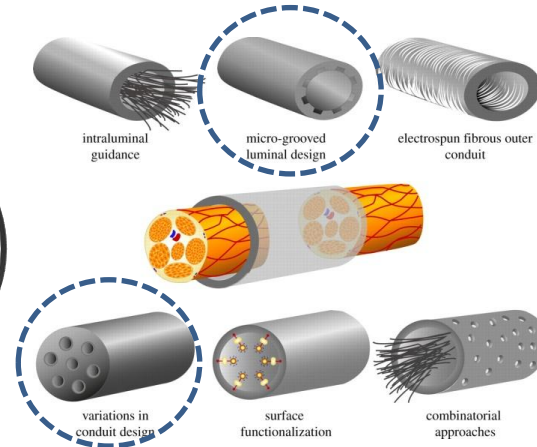
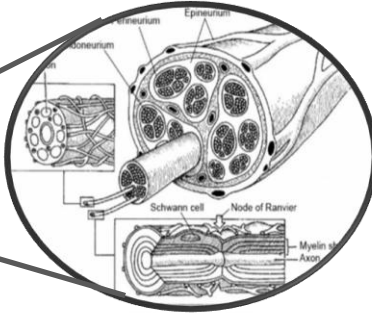
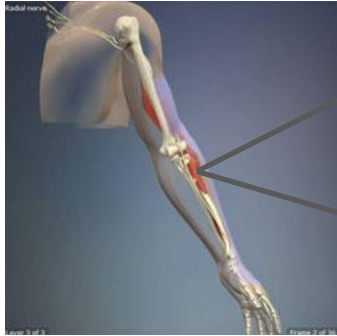
- Surface Structuring

Without structuring

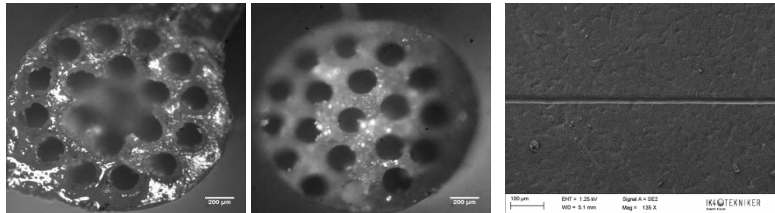
Laser Cutting

Laser micromachining with ultrashort-pulsed lasers: Applications in the health sector

Peripheral nerve implants

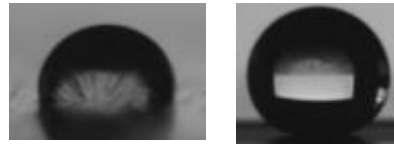
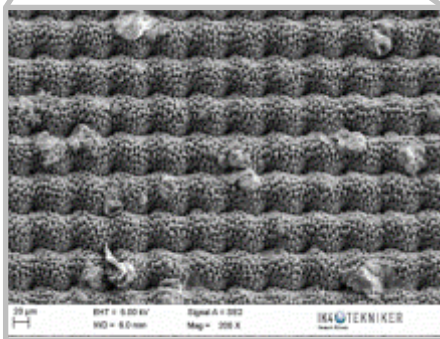
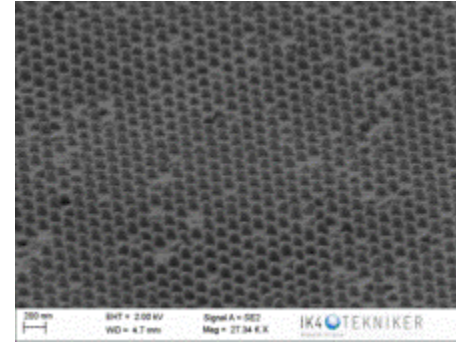
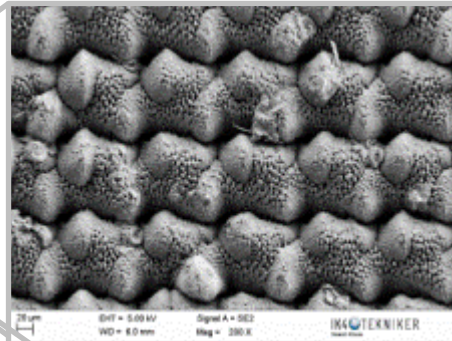
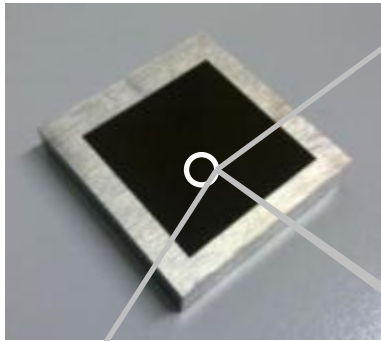


- Challenges to face: Materials (biodegradable, porosity, mechanical properties) and high throughput micromanufacturing technologies



Laser micromachining with ultrashort-pulsed lasers: Applications in the health sector

Antibacterial Surfaces

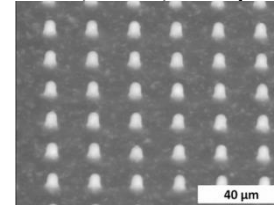


Reduction of *S. Aureus* adhesion > 90%

Reduction of *S. Epidermidis* adhesion: 70<R<80%.

Durable surface solution

A. Pruna, et al., J. Phys. Chem. Solids (2013)



Laser micromachining with ultrashort-pulsed lasers: Applications in the health sector

Conclusions

- ⇒ Laser micromachining (LM) with ultrashort pulses can be applied to directly manufacture complex microstructures on a biomaterial surface that control cell behaviour in terms of cell guiding and shaping, adipocyte morphology and long term adhesion of MSCs. Importance in regenerative medicine.
- ⇒ LM offers a viable alternative to enhance tribological behaviour of implants
- ⇒ Antibacterial surface solution can be obtained via LM, covering large areas and being a long term solution



Thank you