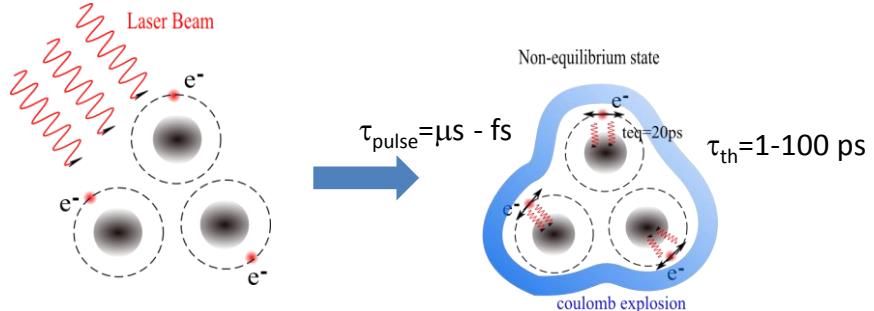




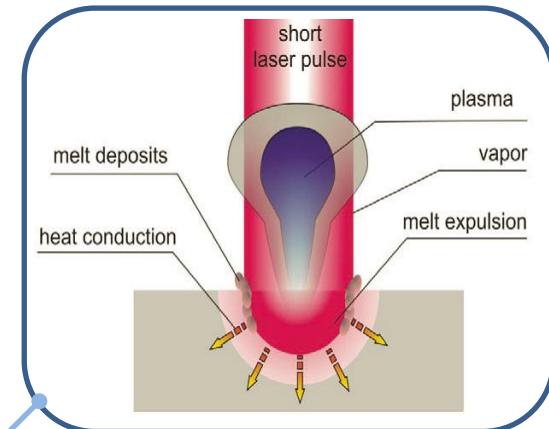
Aplicaciones del micromecanizado láser en el ámbito de la salud: Casos de Éxito

Dr. Iban Quintana

Laser micromachining with ultrashort-pulsed lasers: The concept



Thermalization time in metals



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

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

PHOTOTHERMAL PROCESS

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

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

PHOTOCHEMICAL PROCESS

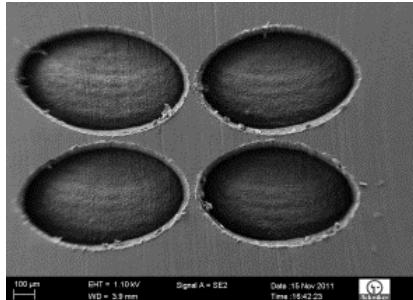
Application with ultrashort pulse laser (e.g., femtosecond)

- Ultrashort laser pulses
- No recast layer
- No debris
- No plasma plume
- No micro cracking
- No melt zone
- No shock waving
- No damaged surface
- No heat transfer to surrounding material
- Hot, dense ion/electron soup (i.e., plasma)

Laser micromachining with ultrashort-pulsed lasers

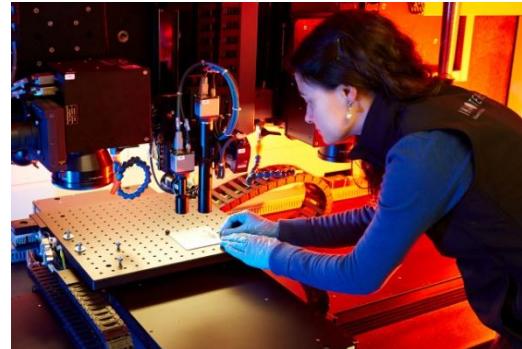
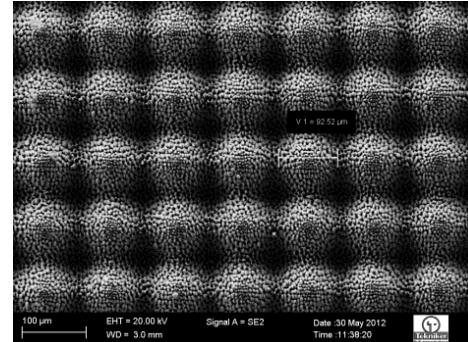
Advantages:

- High quality
- Minimal HAZ
- Non-contact process



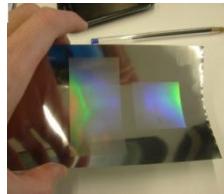
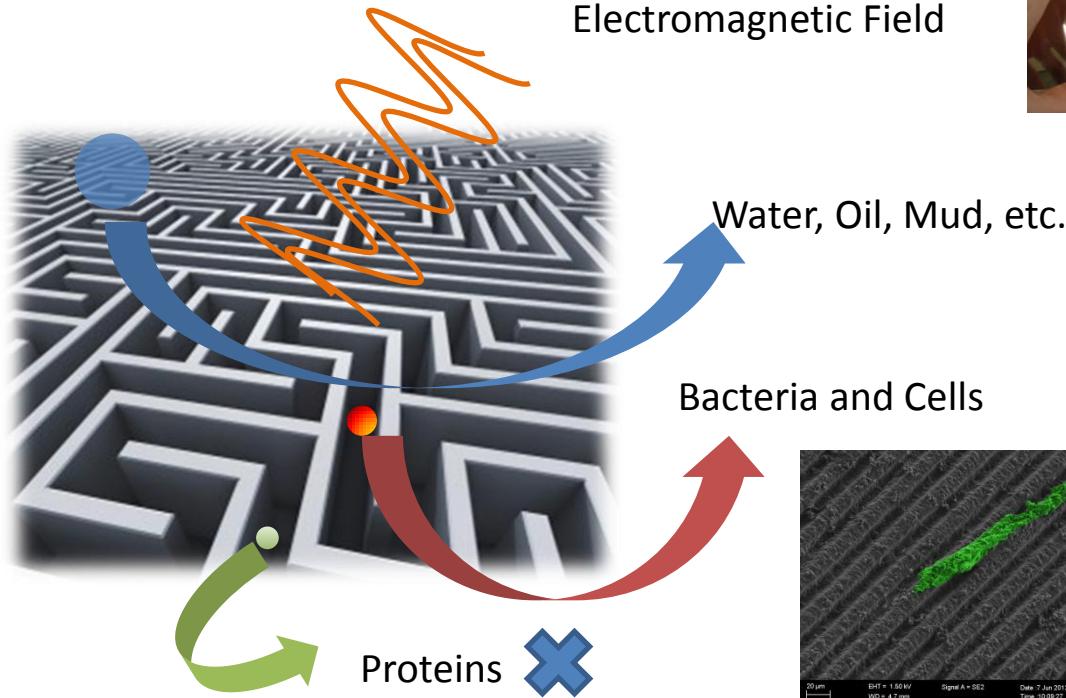
Disadvantages:

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

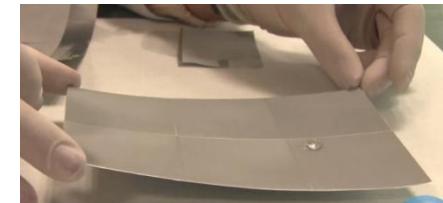


Laser micromachining with ultrashort-pulsed lasers: Applications

Micro-scale: the role on surface modification

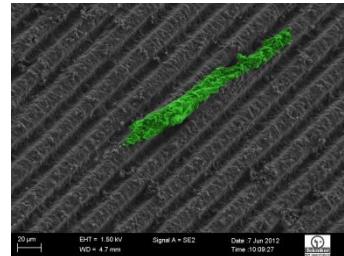


Laser Micro- and Nano-
Structuring



Sol – Gel Coating

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



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

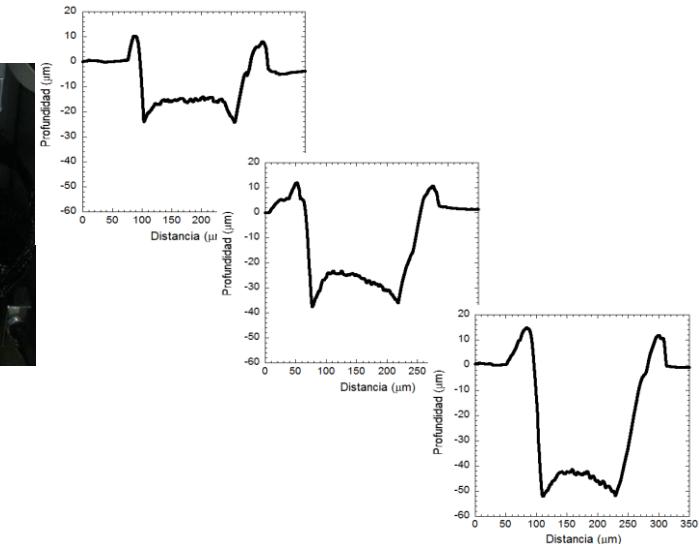
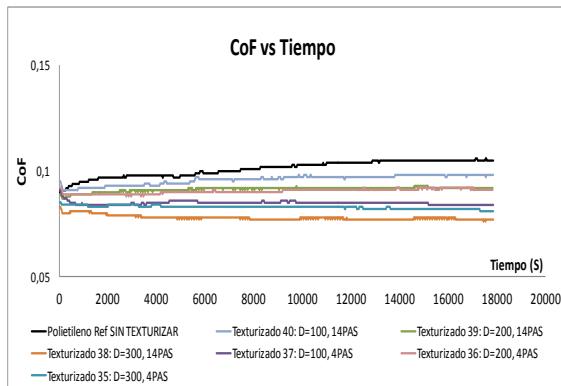
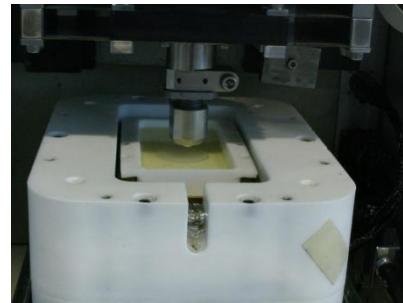
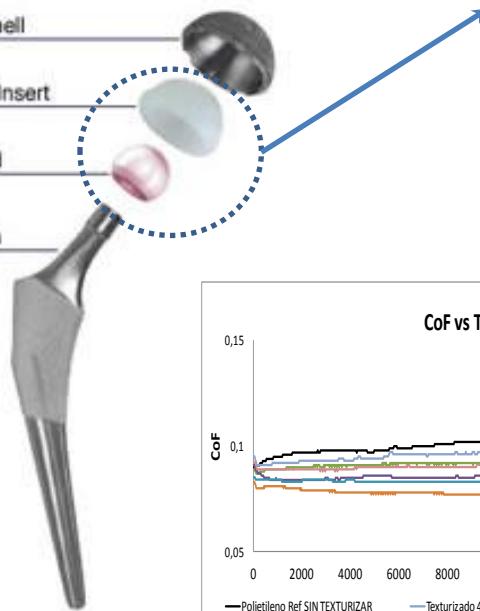
Tribology on hip implant: Friction and wear

Acetabular Shell

Polyethylene Insert

Femoral Head

Femoral Stem

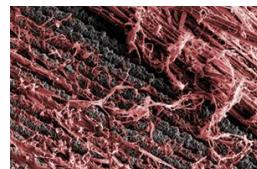
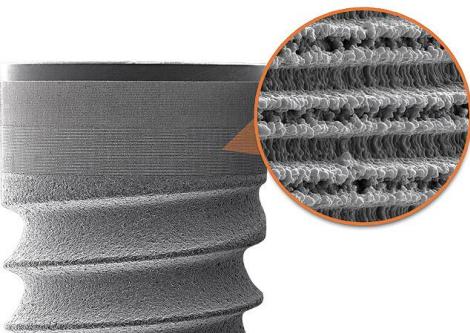


Reduction on Friction coefficient: $\approx 40\%$

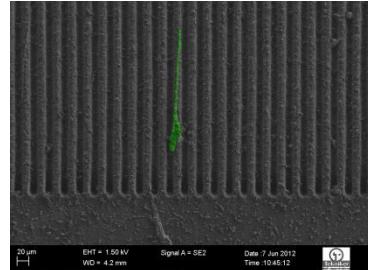
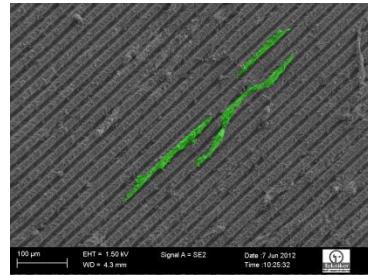
Reduction on Wear: $\approx 20\%$

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

Regeneration and cell activity: Customization

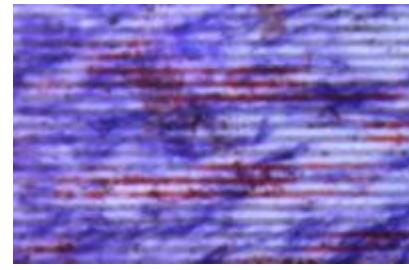
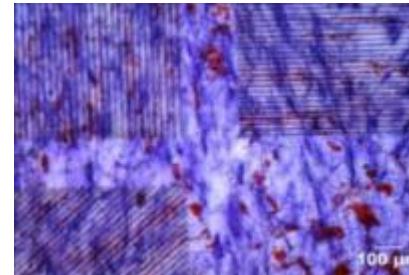


Cell Guidance Effect



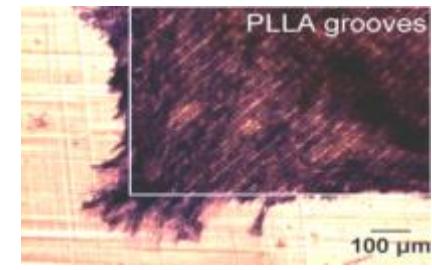
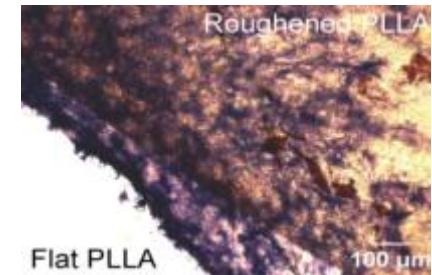
Fat globules align along the grooves (confinement effect)

Cell Fate



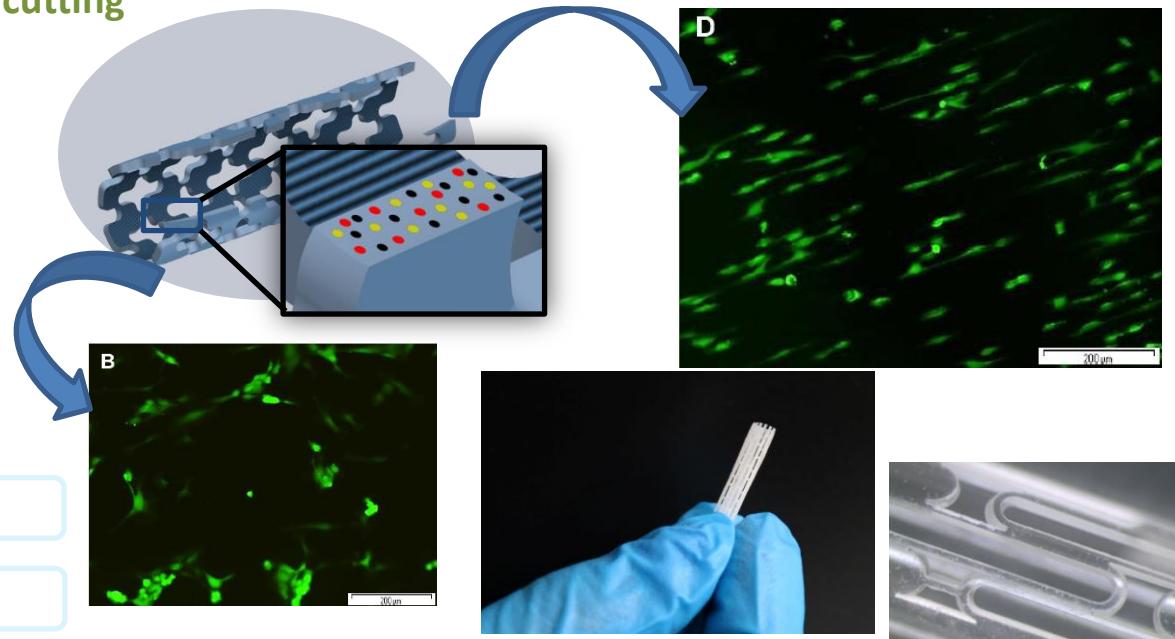
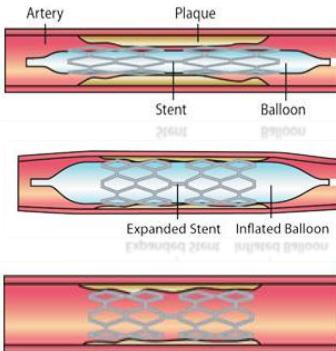
Laser treatment enhanced differentiated cells attachment to the substrate

Cell Attachment



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

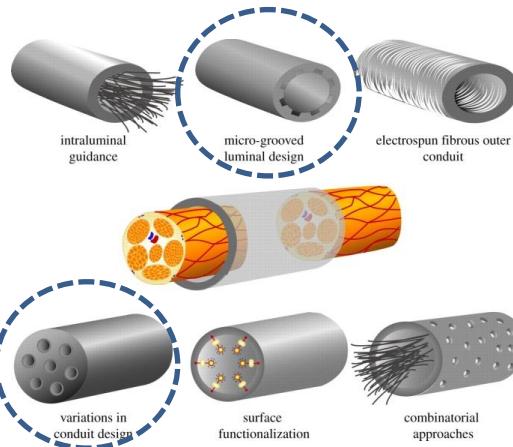
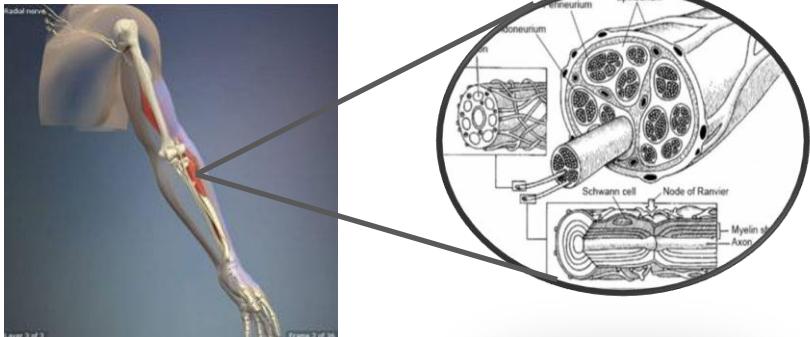
Stents: Surface Functionality and cutting



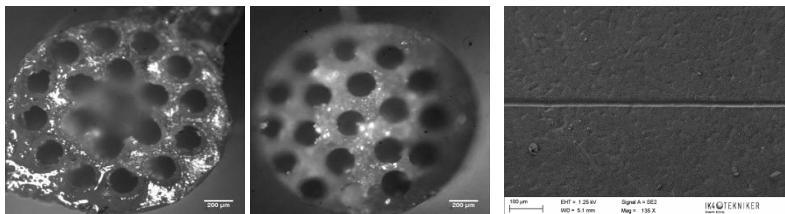
- Laser cutting: 50 – 500 microns
- Surface Structuring

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

Peripheral nerve implants

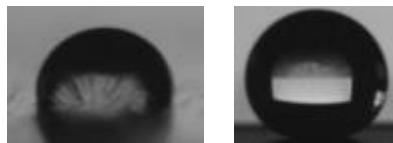
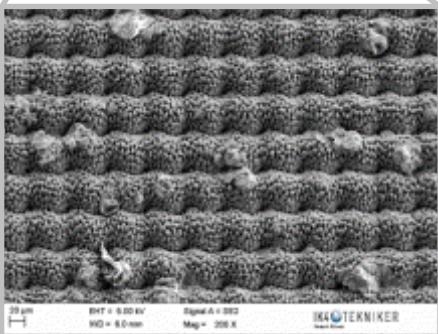
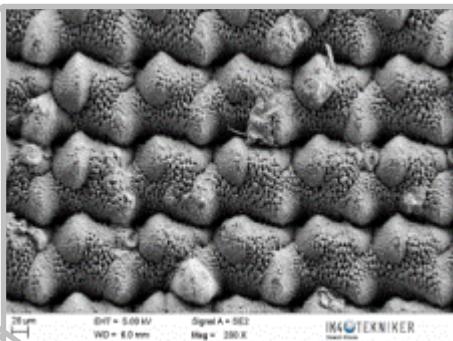
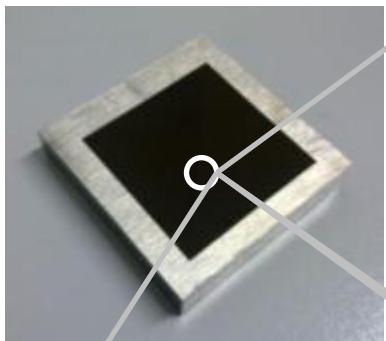


- Challenges to face: Materials (biodegradable, porosity, mechanical properties) and high throughput micromanufacturing technologies

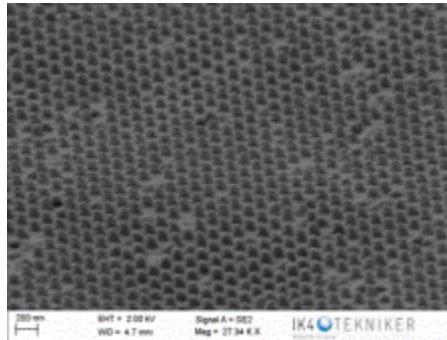


Laser micromachining with ultrashort-pulsed lasers: Applications in the health sector

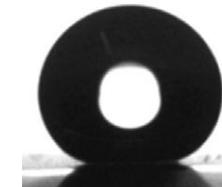
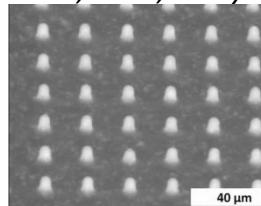
Antibacterial Surfaces



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**

The background features a graphic design consisting of several overlapping circles. There are four main circles: a large white circle at the top left, a medium light blue circle partially overlapping it, a large teal circle below and to the right of the white one, and a smaller teal circle partially overlapping the light blue one. The circles overlap in a way that creates a sense of depth and movement.

Thank you