INDUSTRIALIZATION CONSIDERATIONS OF ULTRASHORT LIPSS TEXTURING FOR BIOLOGICAL APPLICATIONS

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ABSTRACT

In the context of the European H2020 Horizon project LaserImplant, we try to put in evidence that femtosecond laser texturing can play a key role by providing dedicated surface functionalization for biomedical implants [1]. Both osteoblast cell repellent surfaces [2] as well as surfaces promoting osteogenesis [3] are studied for two opposite applications: temporary bone screws and permanent dental screws. Two main texturing including LIPSS formation are proposed. This presentation will concentrate on industrial considerations as the end of the project aims at proposing a demonstrator to anticipate the commercialization of such processes. A versatile machine with limited processing times is expected and implies parameter upscaling that should avoid thermal effects and keep the surface properties developed by researchers at lower repetition rates. Dedicated beam delivery strategies are also studied and should adapt to different laser configurations depending on the textured products and their application.

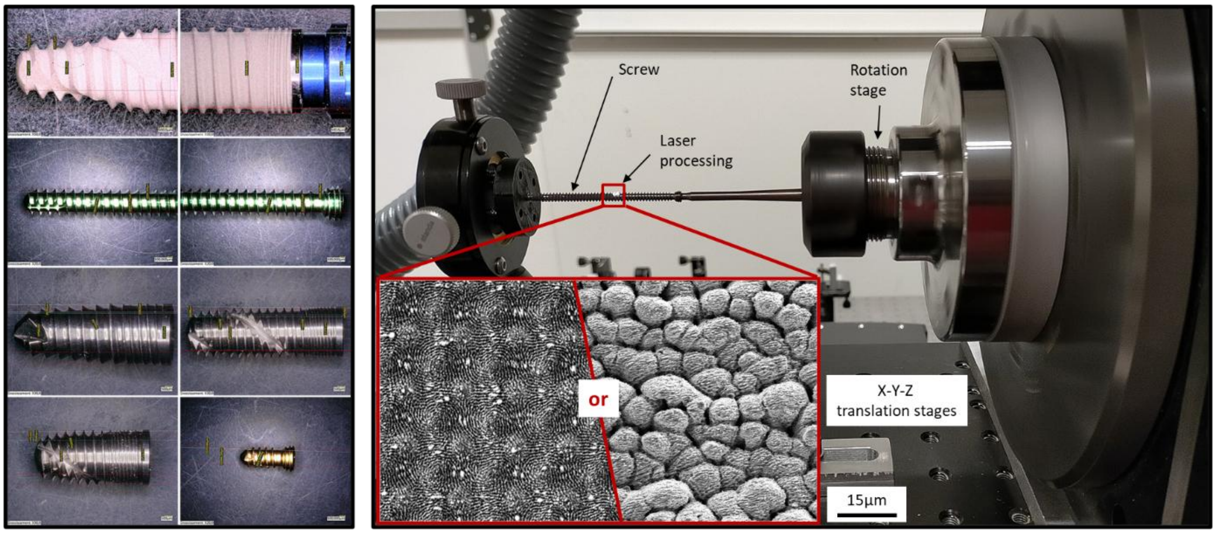

Fig. 1 : Left : Panel of considered screws to be textured during the LaserImplant project. Right : Example of a screw textured by laser with one of the two selected LIPSS pattern.

Titanium alloys (Ti6Al4V) are textured using several protocols and pattern designs with 1030nm ultrashort lasers. Different kind of polarizations associated with pre- or post-treatments reveal new surface functionalizations such as bone repellence or adhesion which are well suited for biomedical applications. The two promising textures selected by researchers are either composed of uniform spikes covered by LIPSS or tangential radial LIPSS. The choice of which texture to select mainly depends on the targeted product: permanent dental implant or temporary bone implant.

Industrial considerations concentrate on a unique laser solution that could easily provide both textures with acceptable processing times and quality robustness on screw type products with multiple dimensions. However each texture present specificities that are not necessarily compatible for a simple industrial workstation :

- Spikes covered by LIPSS require high recovering rates and are sensitive to thermal effects. Higher repetition rates as well as faster translation and rotation speeds are consequently limited, affecting the upscaling capacities. Playing with bigger beam diameters as well as a deeper look into parameter variations help improving such limitations.
- On the contrary, radial LIPSS are not drastically affected by repetition rates of several hundreds of kHz and marking speeds can be even faster due to a very low recovering rate. However, increasing the beam diameter to fit with spikes constraints may modify how bone cells interact with this surface.

These differences force to think about different beam delivery strategies but still compatible on a unique laser system. These strategies still have to be adapted to cylindrical parts with different lengths and diameters. Several mechanical constraints have to be also considered here such as limited rotation speed, translation speed, or time losses due to acceleration/deceleration of the moving parts. Previous to experimental tests thanks to a dedicated software, time simulators were developed to anticipate the pertinent configurations while showing their advantages and drawbacks.

Finally, post or pre-treatments are used to stabilize the surface functionalization provided by laser texturing. While spikes covered by LIPSS are coupled with post or pre-anodization as usually done for colored bone screws, dental screws do not present such treatments since most of the time sandblasted. For this last case, wettability tests on radial LIPSS are conducted since representative of the surface evolution in time. Different sterilization processes as well as storage environments are compared with unstructured surfaces to see the viability of such a technic for the industry.

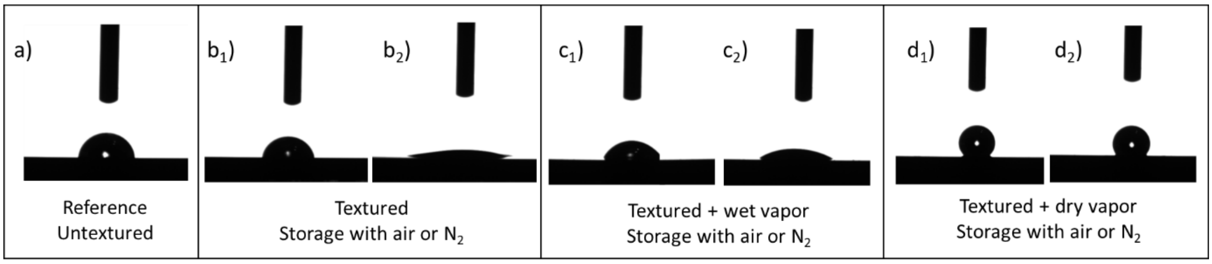

Fig. 2 : Differences of Titanium alloy wettability 11 days after laser texturing. Samples were not sterilized or sterilized by wet vapor (autoclave) or dry vapor (oven). Samples were stored in ambient air or in N_2.

REFERENCES

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