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Targeting mass production of nano/micro textured surfaces by USP laser: the New Skin project

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Abstract

Ultra-Short Pulse laser texturing (USP-LT) is a key technology for functionalisation of materials surface. Although the texturing of ≈1m2 surfaces have been successfully shown, extend USP-LT over several m^2 surfaces represents an issue due to the need of high P, and a difficult process control. The "New Skin" project could represent a turning point pushing the readiness of USP-LT with a significant up-scale of the production volume. Here we show the preliminary results obtained with the implementation of a demonstrative pilot line based on a 350 W, fs laser and a polygon scanner. We report the optimisation of the structures morphology on steel when P exceeds few hundreds of watts as well as the impact of the repetition rate (up to 10 MHz) and the hatch. A roll-to-roll approach is proposed jointly with an in-line monitoring system based on scatterometry. Finally, possible applications and values propositions are introduced and discussed.
Keywords: surface texturing, roll-to-roll processing, large surface texturing, ultrashort pulse lasers, New Skin project;

1. Introduction

The recent availability on the market of rugged and industrial Ultra-Short Pulse (USP) Laser delivering average power of some hundreds of Watts has open the possibility to address the demand for high throughput UPL machining. It has been reported that by using a 350 W, 10 MHz, 500 fs laser jointly with a polygon scanner delivering the beam at 200 MHz it is possible to make the nanotexturing (regular ripples with period of roughly 800 - 900 nm) of a nearly $1m^2$ stainless steel surface showing antibacterial properties. Importantly a throughput of 20 cm^2/s has been measured which represent a significant improvement of the process technological readiness [1]. Nevertheless, for a continuous, automatic, mass production of (USP) Laser nanotextured metallic surfaces a different technological approach is required. We mention for instance roll-to-roll. The H2020 project New Skin aims the creation of an Open Innovation Test Bed for diffusion of

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nanotechnologies in the ecosystem of those company and industries open to the innovation [2]. The ambition is to promote the production of new, nanotechnology enabled products. In this frame, USP-LT by nano-and micro structures can play an important role.

In the frame of the NewSkin project a Roll-to-Roll pilot production line (R2R_PL) has been developed by Alphanov (see Fig.1).

2. A Roll-to-Roll pilot line

The R2R_PL has been engineered for nano and micro texturing of metallic coils (Stainless steel, Aluminum, Copper) having a thickness of few hundreds of microns. It includes a polygon Scanner (UHHS delivered by Raylase) with a scanning field of 32 cm and a 500 fs, IR laser (Tangor 300 W delivered by Amplitude)

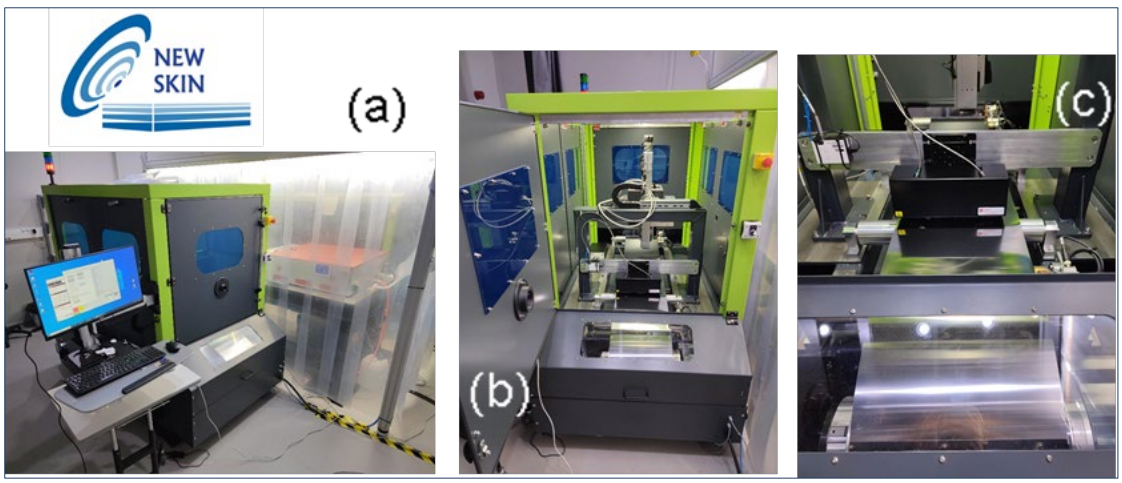

Fig. 1. The picture shows the R2R_PL developed in the frame of the project NewSkin. With the laser beside (a) and the internal part (b). The optical part of the in-line monitoring system is the black box in (c*)*

The line speed can be adjusted between v = 1 mm/s and v = 20 mm/s. The last case corresponds to a maximum throughput of 60 cm^2/s. With the present set-up, an optimum in terms of texturing homogeneity is obtained for v ≈ 10 mm/s corresponding to a continuous throughput of nearly 40 cm^2/s.

The set-up includes an in-line monitoring system (Sindri 490 by DFM) which can measure at 1 Hz the periodicity *P* and the height *h* of the ripples. The light emitted by a large spectrum diode is sent through a fiber on the textured surface. A spectrophotometer acquires the percentage of scattered light *S (λ)* in the UV and visible range. *P* and *h* are retrieved by comparing *S (λ)* with a library of a sufficiently large number of spectra (minimum χ^2) [3].

3. Values Propositions and Applications

The R2R_PL will be utilized in a first time for texturing of stainless steel having antibacterial properties [4] (see Fig. 2(a) although further possible applications have been identified.

We mention for instance:

- texturing of surfaces having an anti-ice behavior (see fig. 2(b)] for application in key sectors like aeronautic, viability, storage and transport of energy, etc.
- texturing of surfaces showing antifouling or self-cleaning/water repellent functionalization for industrial sectors like food, electro-appliance, pumps and boats manufacturing, etc. (see fig. 2 (c)).
- Improving of performances of various technologies like heat exchangers, batteries, (see fig. 2 (d))

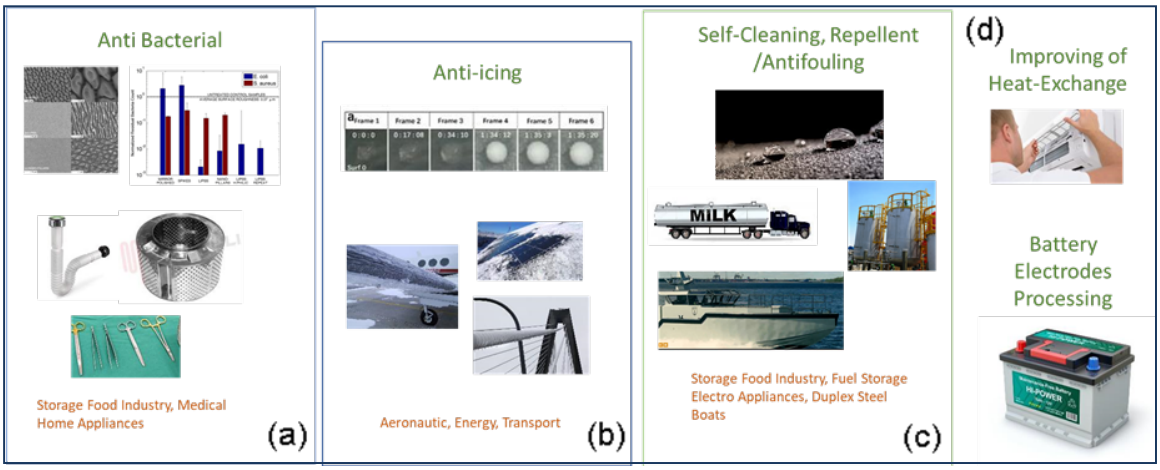

Fig. 2. Overview of different functionalisation which could be enabled by the R2R_PL with their applications: (a) antibacterial, (b) anti-icing, (c) anti-fouling, self-cleaning/water repellent. Surface texturing could as well boost the performances of various devices like batteries or heat exchangers (d).

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