

Project LiNaBioFluid

Deliverable D3.5: Public summary of laser processing of bug-like surface structures with fast fluid transport

Reporting period	from	01.07.2016	to	30.06.2017
Report completed and released		11.07.2017		

1. Objectives and Detailed Description

The objective of the work delivered by this stage is based on the production of laser-induced structures on steel surfaces so as to mimic the wetting and fluid transport properties of the integument of bark bugs. The goal of D3.5 was to present a public summary of laser processing of bug-like surface structures with fast fluid transport (M24). In milestone MS5 (M24), the status of understanding the laser-based mimicking of bug-like structures on inorganic materials surfaces providing a fast fluid transport will be reported. This includes an up-scaling and large-area manufacturing of the different characteristic surface structures (identified in Tasks 3.1 & 3.2) and performing fluid transport tests (Task 3.3) for identifying the wetting/spreading behaviour of the laser processed surfaces. Delivery D3.5 complements delivery D3.4, presenting first results of bug-like surface morphologies. Once the publication related to D3.6 is accepted for publication in *Applied Physics A* and considering the associated copyrights, which will be transferred to the publisher *Springer*, parts of the content will be made available to the public on the LiNaBioFluid webpage (www.laserbiofluid.eu).

D3.5 is a public summary of the abovementioned findings and was published on the LiNaBioFluid website as the following content:

1. Development of Laser-induced structures with pulsed lasers

To identify the nano-/ microstructures found on bug cuticle, different inorganic materials (different steels, Ti alloy, Si and CrN) were used. In particular, microspike structures realized on the surface of hard inorganic materials, via laser-induced self-organization, exhibit approximately the same size and shape as the natural model (Fig. 1). The realization of these structures is the result of systematic radiation experiments on the inorganic materials tested.

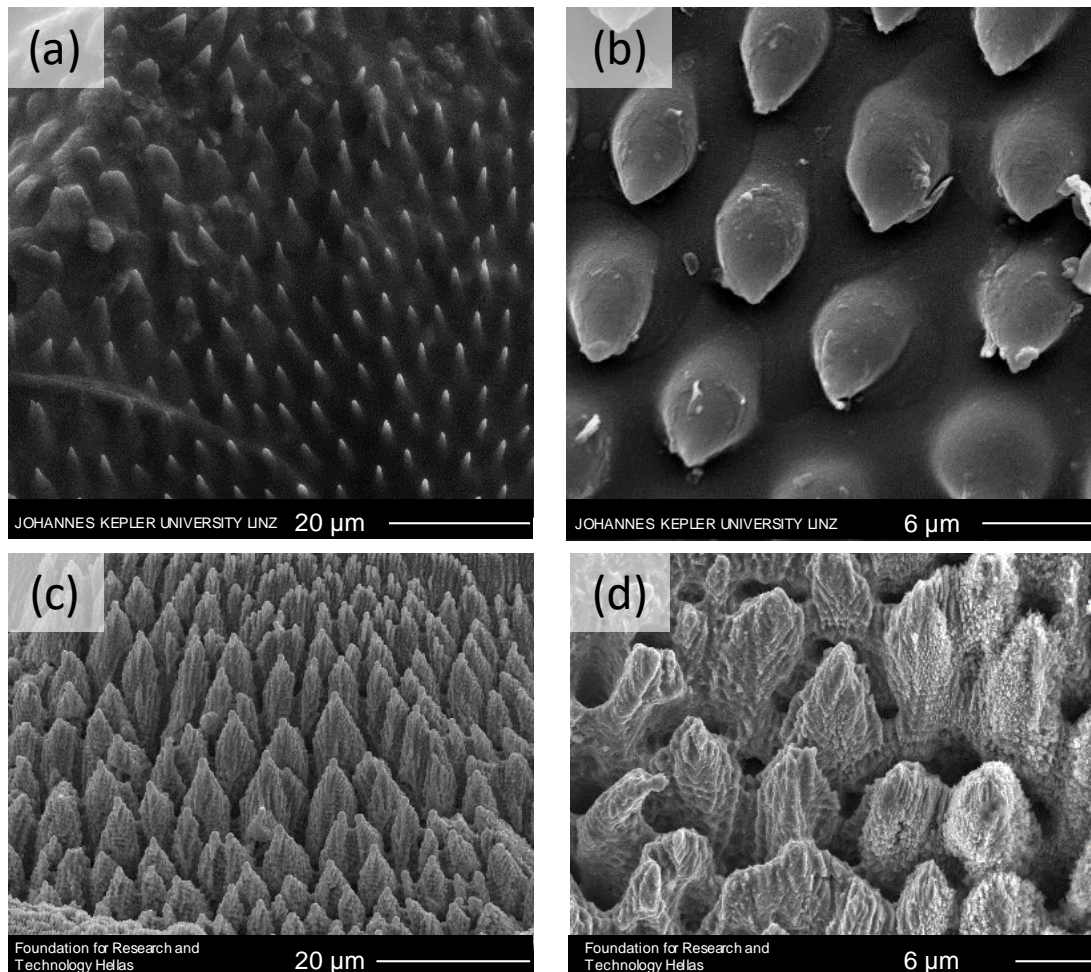


Figure 1: (a), (b) SEM images of different positions at the integument of bark bugs. (c), (d) Laser-induced self-organized nanostructures mimicking the topography of (a), (b) on (c) a titanium alloy and (d) 100Cr₆.

To achieve passive fluid transport properties, large areas were fabricated with morphological gradients (Fig.2). The surface morphological gradient causes liquid transport due to escalating wetting behavior differences induced by the gradient surface morphologies. Thus, by adjusting the fabrication parameters, it is possible to control the flow directionality of the liquid on the treated surface.

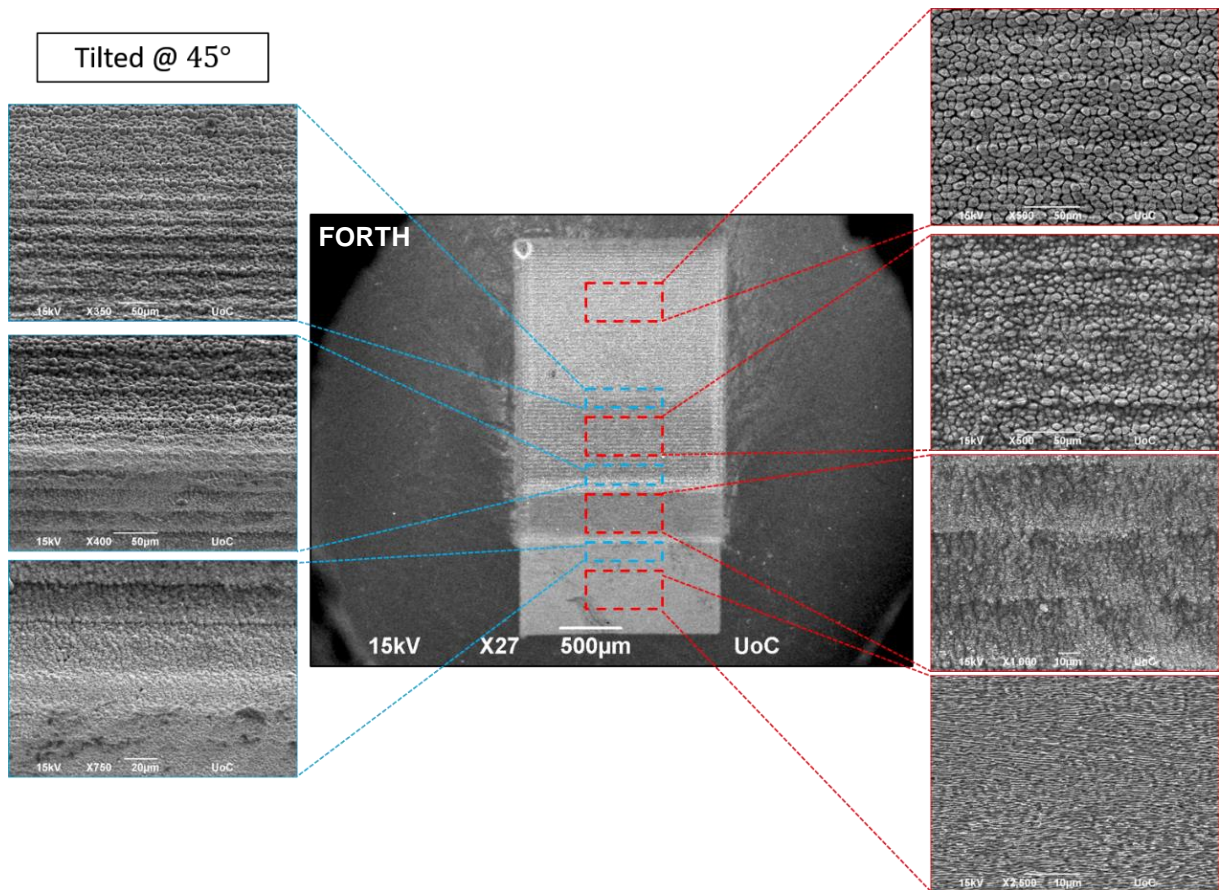


Figure 2: Gradient surface morphologies featuring different kinds of laser induced structures. Spikes can be seen on the upper part of the structure. The gradual transition to grooves and finally to ripples can be observed.

The water transport properties of the treated surfaces were tested for both water and engine oil droplets. By applying a water droplet on the center of the structure just after irradiation, very swift and preferential passive water transport motion can be observed (Fig. 3).

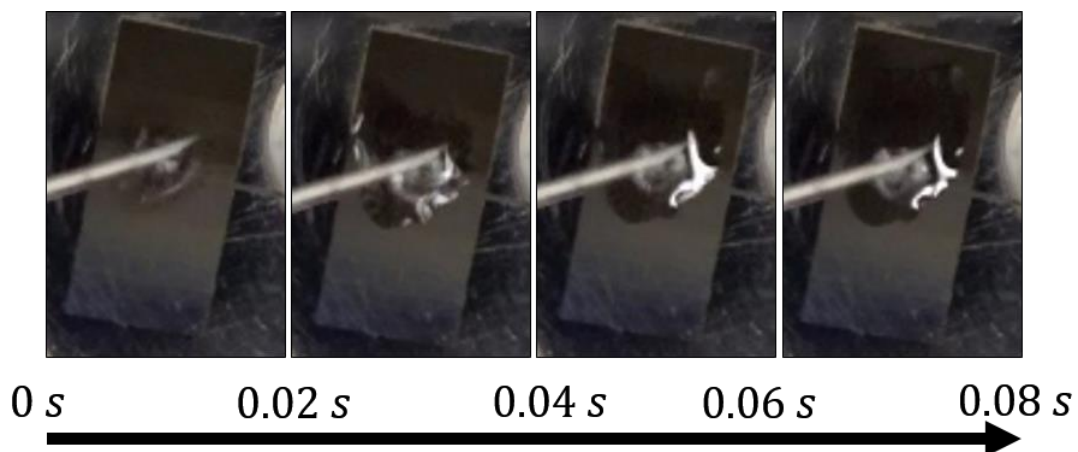


Figure 3: Video frames depicting water transport properties of gradient structures demonstrating swift passive water transport.

Directional fluid motion is also demonstrated by applying an engine oil droplet on the center of the gradient structure (Fig. 4). There is a tendency of the oil to move from the lower (ripples) to the higher (spikes) roughness areas.

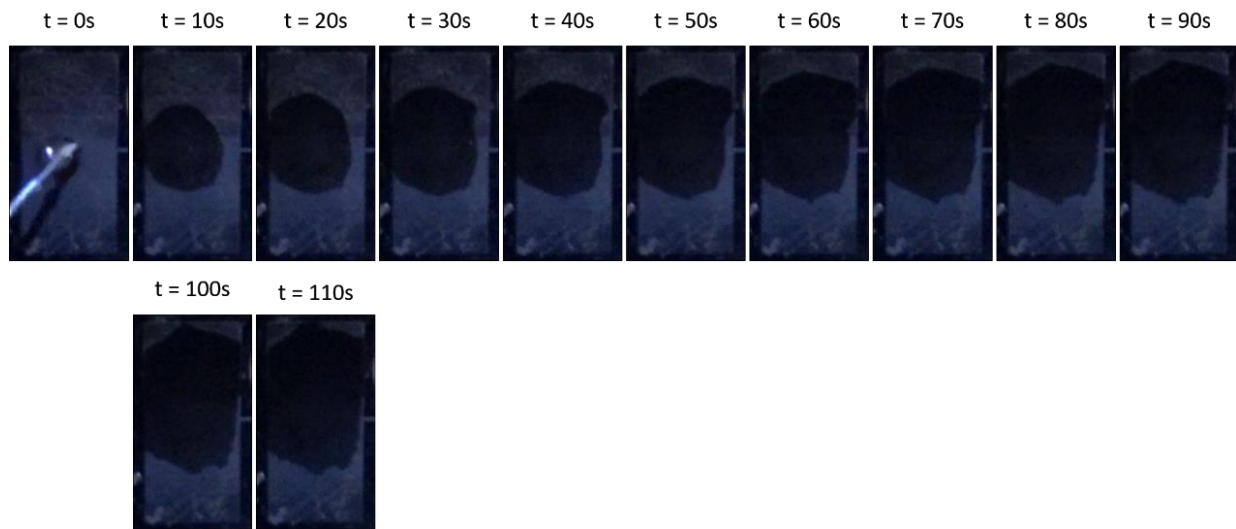


Figure 4: Video frames illustrating oil transport motion on gradient surfaces.

2. Evaluation of Goals and Resulting Actions

The above description summarizes the research activities towards introducing the laser-based fabrication of biomimetic structures as well as the wetting properties of such structures. It turns out that the laser-induced morphologies bear wetting properties very similar to those occurring in nature. Therefore the above results emphasize the significance of the technique as a novel methodology towards efficient laser processing of various types of materials assuming the large variety of potential applications.

Having published the summary of biological fluid transport mechanisms on the project website, the consortium accomplished D3.5. Further information can be obtained from the following publications:

1. S. V. Kirner, U. Hermens, A. Mimidis, E. Skoulas, C. Florian, F. Hischen, C. Plamadeala, W. Baumgartner, K. Winands, H. Mescheder, J. Krüger, J. Solis, J. Siegel, E. Stratakis, J. Bonse, submitted to Applied Physics A.
2. C. Plamadeala, F. Hischen, R. Friesenecker, R. Wollhofen, J. Jacak, G. Buchberger, E. Heiss, T. A. Klar, W. Baumgartner, J. Heitz, Roy. Soc. Open. Sci. 4, 160849 (2017).
3. U. Hermens, S.V. Kirner, C. Emonts, P. Comanns, E. Skoulas, A. Mimidis, H. Mescheder, K. Winands, J. Krüger, E. Stratakis, J. Bonse : “*Mimicking lizard-like surface structures upon ultrashort laser pulse irradiation of inorganic materials*”, E-MRS 2016 symposiums C proceedings (special issue in [Applied Surface Science](#), 418, 1, 499-507 (2017)).