UNIVERSITY OF BIRMINGHAM

The Laser Micro Processing Group is part of the Advanced Manufacturing Centre, a recent strategic investment of the University of Birmingham. Based in the Department of Mechanical Engineering, our facilities include two short- and one ultra-short pulsed laser systems, all of which operate in the near infrared.

The group conducts research in milling, drilling, structuring, texturing and polishing of large planar and 3D surfaces. Our reconfigurable laser micro processing platform integrates inspection and process monitoring sub-systems and allows various laser processing configurations to be designed and validated. Laser-material interactions are studied on metallic, ceramic and glassy substrates. There is a particular emphasis on developing and validating solutions for functionalising surfaces and also for producing miniaturised components.

The following work was performed within the H2020 ITN programme on Short Pulsed Laser Micro/ Nanostructuring of Surfaces for Improved Functional Applications (No. 675063, www.laser4fun.eu).

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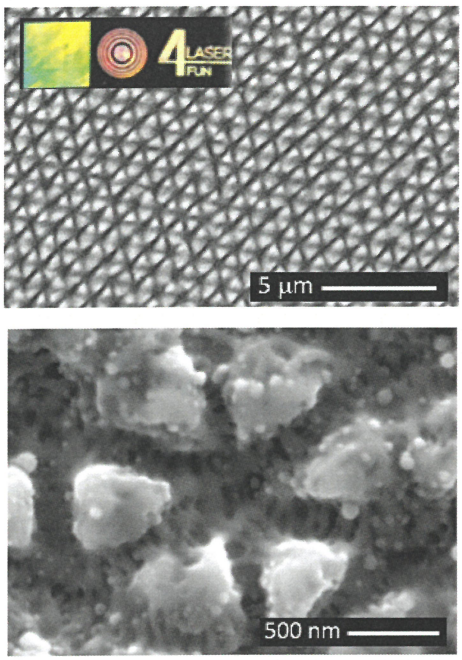
UNIFORM SUBMICRON LASER TEXTURING

Laser Induced Periodic Surface Structures (LIPSS) is a promising route for fabricating sub-micron topographies. LIPSS are self-organised periodic structures that appear on processed surfaces after irradiating them with multiple pulses that are insufficient to melt or vaporise the material. The drawback is that such self-organised topographies usually present very wavy, irregular ripples. One of the main challenges is to produce uniform, regular topographies over large areas.

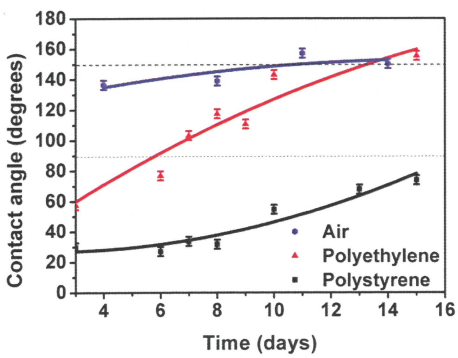
We recently performed a comprehensive study on LIPSS that provided new insights into the generation of complex LIPSS morphologies. In particular, highly uniform triangular-shaped LIPSS were generated in a single-scanning process with high repetition rates and high scanning speed.



Large area uniformity of LIPSS on stainless steel for light-scattered holograms (above). Close up on triangular-shaped LIPSS fabricated in a single pass (below).

EFFECT OF STORAGE ON FUNCTIONAL SURFACES

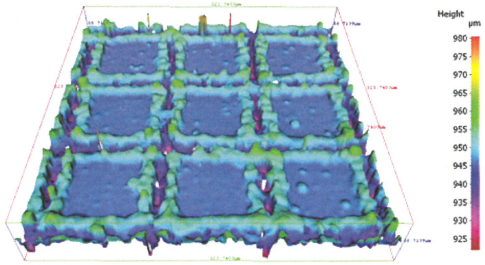
While laser-textured metallic and polymeric surfaces have been widely investigated in the past decades, the ageing behaviour of such engineered surfaces remains an active research field. Surface topographies play a relevant role, but surface chemistry is another important factor. Through collaborative research with the Polytechnic University of Madrid and the University of Warwick, the ageing process of laser-textured metallic surfaces was investigated. Conditioning the laser-textured surfaces, i.e. storing them in plastic bags, has shown to be a viable way to achieve super hydrophobic properties while protecting the surface topography and chemistry until their functional use.



Evolution of the wetting properties of laser-textured aluminium depending on storage conditions.

DURABILITY OF FUNCTIONAL SURFACES

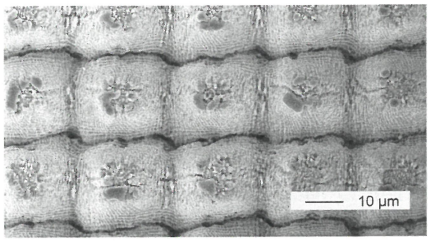
Traditionally achieved through coatings, functionalised surfaces may be severely degraded over time due to scratches, wear or the operational environment, consequently limiting a product's lifespan or requiring new treatments to recover its properties. Similarly, when surfaces are functionalised by modifying topographies, their durability remains in question and the use of hard and wear-resistant materials can increase their lifespan. A cost-effective hybrid process was investigated that combines low temperature plasma surface alloying of stainless steel with nanosecond DLW to achieve synergistic surface engineering effects.



SP laser texturing of carburised stainless steel showing good wear resistance (above). Dynamic bouncing effect of water drops (below, time scale: 6µs).

ANTI-ICING SURFACES

Ice formation is a topic of major interest in the aviation industry, since its effects impact the safety and performance of aircrafts and rotorcrafts. Among the several approaches, superhydrophobic surfaces represent a promising solution to tackle the icing phenomenon, inhibiting ice formation by water repellence. Laser texturing is performed to reproduce lotus-leaf inspired structures on different metals to achieve superhydrophobic behaviour. Ice accretion and ice delamination tests were performed in collaboration with Airbus Defence and Space GmbH and they show a slower apparition of ice on textured wing profiles.



USP laser-fabricated lotus-leaf inspired topography on titanium alloys that exhibited interesting wetting and anti-icing properties.