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PhD Defence

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Laser induced periodic micro- and nanostructures for biomimetic applications

The interdisciplinary field of biomimetics has been very successful in solving engineering problems by searching for solutions in nature. The outstanding advantage of applying a biomimetic approach in solving a given problem is that nature developed and tested numerous solutions for problems regarding surface structure and chemistry, and subsequently function, for millions of years of evolution and natural selection. Therefore, mimicking nature is the most convenient way of implementing a certain biological process in solving current technological problems.

In the past decades, laser material processing has become a powerful and flexible tool used extensively to change a given material's topography, surface chemistry and other physical parameters. Some characteristic surface morphologies that can be induced during laser processing are direct: self-organized structures, such as laser-induced periodic surface structures (LIPSS), grooves, spikes/cones, and directly written structures, that can be arbitrary user-defined shapes, performed by either additive or subtractive laser processing techniques. These methods can be used for processing metals, plastics, ceramics, glass, and have found applications in a large range of fields: bio-medical, microfluidics, solar cells, electronics, tribology etc.

This thesis presents several direct laser-processing techniques for periodic micro- and nanostructures, and their use in the field of biomimetics, that is, replicating micro- and/or nanostructures found on the bodies of several bugs and spiders. Two-photon lithography (TPL) was employed for direct writing of polymer channels and microneedles embedded with bug-inspired microstructures; femtosecond and nanosecond ultraviolet (UV) laser processing was employed to create self-organized bug-inspired microstructures in steel alloys and in polymer foils, respectively. These polymer and metal surfaces are efficient in directional transportation of oil- and water-based solutions, and show promising potential in microfluidics, wetting and tribological applications. Lastly, a combination of UV lithography and nanosecond UV laser processing of polymer surfaces have been employed to reproduce the micro- and nanotopography on cribellate spider legs. These hierarchical structures are efficient in reducing the adhesion of artificial nanofibers, and shows promising application potential in the design and production of nanofibers handling tools.

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