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SUPERLASERS FOR THE REAL WORLD

Supervisor's report on PhD thesis

"Large surface functionalization by laser-induced micro and nanostructures"

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Supervisor:	Ing. Tomáš Mocek, Ph.D., HiLASE Centre, FZÚ AVČR
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This dissertation was prepared in a full-time form of doctoral studies at the Department of Physical Electronics of the Faculty of Nuclear and Physical Engineering of the Czech Technical University in Prague. The research activities were carried out by the candidate at the HiLASE Centre, Institute of Physics of the Czech Academy of Sciences in Dolní Břežany, within the research program of Industrial Laser Applications. The main objective was investigation and development of processes for rapid, large-scale fabrication of functional micro and nanostructures using high-power lasers. The thesis is divided in 6 chapters, covers about 90 pages, and key results are presented in a form of scientific papers published in international peer reviewed journals.

The thesis can be divided into several logical parts. First, a review of suitable microstructure geometries for superhydrophobic, anti-icing and anti-bacteria surfaces is given. Then, appropriate fabrication methods are presented with the special emphasis on laser micro/nanotexturing with optimal parameters and state-of-the-art fabrication techniques for rapid, large-scale laser microstructuring by means of polygonal scanning systems, direct laser interference patterning, and multi-beam scanning approaches using diffractive optical elements or spatial light modulators. Finally, new experimental results and findings are presented, analyzed and explained: (1) Two different laser sources (PERLA thin-disk DPSSL: 1030 nm, 1.8 ps, 100 kHz; commercial fiber laser: 1062 nm, 3 ns, 10-1000 kHz) have been successfully used for dual-scale (micro and nano) hierarchical structure fabrication of aircraft aluminum alloy 7075, showing great potential for superhydrophobicity. (2) Functional superhydrophobic microstructures were fabricated on Carbon Fiber Reinforced Plastics by infrared and ultraviolet Direct Laser Interference Patterning technique. (3) Laser Induced Periodic Surface Structures have been simultaneously generated on surface of AISI 316L steel in more than thousands of spots at once using four beam DLIP with optimized parameters of the PERLA laser. (4) Novel, cost-effective technology for micromachining of invar with 784 beams using 1.3 ps laser PERLA at 515 nm has been demonstrated. All these exciting results show great potential for hi-tech industrial laser processing.

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In summary, the research outcomes presented in this thesis not only fulfilled all planned objectives but in fact greatly exceeded the expectations, both in terms of quality and speed. The work is undoubtedly at the cutting edge in the field of high-power laser material processing. The original results were published in 7 articles in high-impact journals (the candidate is the first author in 6 of them which is absolutely exceptional) and presented at several international conferences. The thesis is written to a standard acceptable for academic and professional communication. The candidate clearly demonstrated deep knowledge of the topics and capability for conducting independent & meaningful research.

The submitted thesis fully satisfies the requirements for the award of PhD degree. Therefore, I strongly and wholeheartedly recommend the candidate for the PhD award subject to the successful oral defense.

In Dolní Břežany on October 21, 2020.

Ing. Tomáš Mocek, Ph.D.

Digitally signed by Ing. Tomáš Mocek, Ph.D.
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