**HiLASE Centre**
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# Toward controlling the regularity of laser induced periodic surface structures on metal/metalized surfaces

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Short and ultrashort laser irradiation can lead to formation of nano- and micro-sized periodic structures on the surfaces of various material (metals, dielectrics, semiconductors, polymers) [1]. A key feature for applications of such structures in science and industries is their regularity [2,3]. Achieving high-speed fabrication of highly regular laser-induced periodic surface structures (HR-LIPSS) over large areas could foster the development of nanostructure-demanding applications such as manufacturing diffraction gratings for chirped pulse amplification technique, designing ultra-compact particle accelerators, and construction of opto-electronic circuits [4-6]. Powerful impetus would also be given to daily-life applications, including laser coloring and marking of metals, tuning surface wettability [7]. Recently, an efficient control of the LIPSS regularity was demonstrated on large laser-processed areas on Mo, Ti, and steel at industrially competitive speeds [4,8]. At the same time, the high regularity was not achieved on surfaces of Au, Cu, and Al.

In this seminar, the progress in theoretical understanding and experimental realizations of LIPSS formation will be reported. It is widely believed that laser excitation of surface plasmon polaritons (SPP) [9] is followed by laser-enhanced oxidation [2], molten material reorganization [10] or spatially modulated material ablation [9]. To gain insights to the different stages of the LIPSS formation, several numerical codes have been developed at the HiLASE RP4. For description of the early stage, a code for describing the SPP properties on cold surfaces [12] was applied to a large number of materials. The obtained results revealed a strong

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correlation between SPP propagation distance with the quality of obtained periodic structures [4,8,13]. This has allowed, according to the SPP decay length, to classify plasmonically active metals into groups enabling and hindering HR-LIPSS formation. Furthermore, it has been predicted that the LIPSS regularity for a specific metal strongly depends of laser wavelength. To investigate impact of non-equilibrium heating of free electrons upon ultrashort laser irradiation on the evolution of the SPP decay length, a code based on the two-temperature model was developed, which takes into account the transient changes of metal optical properties.

Simulations performed for Ti and Mo revealed that the SPP decay length does not increase but on the contrary decreases upon laser-induced excitation of these metals, thus improving the condition of HR-LIPSS writing. The theoretical findings will be supported by recent experiments which were performed by the RP4 members in the HiLASE facilities and in collaboration with the Center for Physical Sciences and Technology, Vilnius, Lithuania.

When: Wednesday, **9/05/2018 at 15:00**

Where: Seminar room, HiLASE Centre