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Editorial: Ultrafast laser direct writing self-organized microstructures

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Editorial on the Research Topic
Ultrafast laser direct writing self-organized microstructures

Based on the ablation and the melting of the targeted materials, some self-organized structures like laser-induced periodic surface structures (LIPSS) on the surface or volume nanogratings in the bulk are readily formed in the focused region depending on the characteristics of the incident beam, material properties and even experimental environment. Indeed, since the first experimental observation of LIPSS on semiconductor surfaces by Birnbaum (1965) as well as a large amount of eminent theoretical and experimental work conducted with laser duration of a few nanosecond, many investigations have been done in this field. In 1982 Van Driel et al. reported LIPSS which is related to the wavelength (λ) and the polarization direction of the light. LIPSS can be formed in the range of pulse duration (τ) from continuous wave irradiation (Nemanich et al. 1983) to a few femtosecond (Bonse et al., 2002), and more review articles recently consider even shorter laser pulse durations in the ultrafast region (Her, 2011; Bonse et al., 2012; Epperlein et al., 2017; Vorobyev and Guo, 2013). LIPSS can be used for numerous applications in the fields of optics (structural color, emission/absorption enhancement), chemistry (catalytic activity), fluidics (contact angle control and liquid transportation), medicine (antibacterial and cell growth), tribology (reduction of friction and wear) and etc. High-speed scanning of surface by easily available high repetition rate laser have provided area processing speed as high as cm^2/min, which will greatly push this LIPSS-based surface optimization technology into practical application. On the other side, volume nanogratings inside silica glass was first observed by Shimotsuma et al. through backscattering electron image and the mechanism (plasma interference, material memory effects and interference of ultralong-living exciton-polaritons) of nanograting formation is still under debate to date. However, even if the mechanism is complex the applications attract strong attention due to nanogratings' predominant thermal stability, chemical selective etching, birefringent feature and optical memory etc.

In this Research Topic,Lin et al., as in, have reported the effect of different combinations of laser fluences and pulse number on the formation of femtosecond laser induced LIPSS on Titanium. They revealed a new phenomenon: LIPSS appeared blurred and disappeared in the middle of the laser fluence region which can be attributed to the two ablation region under different laser fluence (ultrafast non-thermal and thermal ablation processes). Their results provided a powerful guide for preparation of highly controllable and high-quality LIPSS by avoiding the risk of the LIPSS period disappearing. In addition, Jia et al., presented the birefringence effect of ultrafast laser induced periodic nanostructures on F-doped tin oxide (FTO) film with refractive index difference Δn = ne-no reaching a maximum of 0.21 and the maximum phase retardance of 135 nm obtained by 515 nm laser direct writing. Also, a large-area periodic nanostructures on FTO film was efficiently fabricated by 515 nm laser direct writing *via* a cylindrical lens demonstrating its potential application as a quarter-wave plate of 515 nm light. On the other hand, in Werr et al., ultra-short-pulse laser filamentation was presented as an appealing technology for float glass cutting due to the advantages of a small heat-affected zone, a quasi-non-gap cut and the possibility to free form cut. A micro-crack-formation and -propagation model along a filament line was proposed. Based on this model, Schematic parameter dependent crack development could be predicted, which is very meaningful for cleaving guidance. Moreover, a Ge-doped ternary chalcogenide glass Ge23Sb7S70 was systematically investigated for ultrafast laser induced self-organized modifications both at the surface and in the volume, as in Torun et al.. These self-organized nanostructures were found to be correlated to photo-oxidation, photo-darkening, and restructuring of the glass network. Tailoring of self-organized structures with laser inscription parameters may enable the direct-write of functional 2.5 dimensional or 3D structures inside these infrared materials.

We hope that these findings in theoretical models and practical applications will promote further research and development of self-organized structures in laser cutting, microoptics and all-optical switching devices.

Author contributions

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Conflict of interest

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