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Editorial: Advances and applications of laser-material interaction

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Editorial on the Research Topic
Advances and applications of laser-material interaction

Lasers, with their excellent directionality, high energy, and monochromatism, enable manipulation of light in ways never previously imagined. Yet more than 60 years after the first demonstration of lasers, our understanding of laser-based light-material interactions is still largely underexplored.

Laser-material interactions entail complex physical processes, which are closely related to the types of laser systems (including beam generators and modulators), the characteristics of laser output, the qualities of interacting materials, and the local environment. In addition to direct light-matter interactions, secondary effects of laser-material interactions include nonlinear ionization, phase change processes, plasma effects, shock wave effects, and radiation effects. Moreover, laser effects have the potential to lead to various types of applications, e.g., cold processing dominated by ultrashort pulses, extreme ultraviolet (EUV) lithography technology, super hard and ultra-brittle material manufacturing, mid infrared laser and biological applications, photodynamic therapy, and laser environmental monitoring and disinfection.

Laser-material interactions can be used to enhance or alter materials directly (ablation, drilling, annealing, matter deposition, texturing, micromachining, etching, cladding, biological diagnostics and therapeutical applications), or to enable sophisticated sensing applications related to material property changes that preserve materials but see deep within them, such as nonlinear optical imaging, laser ultrasonics/photoacoustic imaging, laser spectroscopy and more. Advances on multiple fronts are possible, but the field is so young that it is defined more by the creative range of potential problems it can solve than the fine-tuning of results to overcome problems in previously identified applications.

We hope you enjoy the breadth of creative applications collected in this Research Topic. The articles describe laser-material interactions in many different environments, utilizing a range of wavelengths, and, most importantly, for a wide range of functional applications.

- Ghost imaging is a technique that combines information from two light detectors, a multi-pixel detector that does not view the purported object and a single-pixel object that does. Once thought only the purview of quantum entangled photons, more recently it has been extended to the classical domain and Yang et al. here use it to enhance target detection in underwater environments, indicating other potential uses of the methodology for viewing objects through turbid environments.
- In order to develop a low-cost multi-wavelength mid-IR laser, Deng et al. harness a 1,064 nm BaGa4Se7 pumping laser consisting of optical parametric oscillators that is implemented using fast electro-optic switches to deliver unprecedented energy levels. Such technology has a wide range of biological, security, material processing and communication applications.
- Laser-based inertial confinement fusion devices generating MJs of laser require large areas of substrates coated with highly reflective sol-gel thin films. However, even very low concentrations of volatile organic matter contamination on the surface of optical and mechanical components can lead to optical component damage disasters because the adsorbed contaminants change the refractive index of the antireflective sol-gel films. Miao et al. leverage this understanding to present a new molecular organic contaminant sensor consisting of micronano optical fibers (MNOFs) coated internally with microstructure sol-gel films which use this principle to be able to detect organic contaminations in a vacuum at the ppm level.
- Finally, Xiao et al. demonstrate ablation characteristics of *combined* continuous wave and pulsed lasers. They found that the continuous wave laser led to a pyrolysis-combustion ablation mechanism, while the pulsed laser contributed to changes in the resin matrix including pyrolysis and melting, essentially thermal stress employed at a lower power density. The use of both lasers together increased ablation efficiency by over 50%. Their application is for ablation of glass fiber reinforced plastic composites used for missile shields and unmanned aerial vehicle shells, but the intuitions described could be applied to ablation of many different materials, from biological tissue to large manmade structures, or even to clearing debris in space.

These fascinating papers, we hope, will enable enhancements to existing systems and spur identification and development of even more laser-material applications in the future. The goal of this Research Topic is to collect state-of-the-art Original Research and Review articles on the advances and applications of laser-material interaction to promote the growth of the laser industry.

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