基于高重频飞秒激光时空聚焦技术的三维各向同性加工

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高重频飞秒激光光源带宽通常较窄，空间色散量引入大量的负时间啁啾，激光器本身无法提供足够的时间补偿，导致焦点处脉宽无法恢复到飞秒量级，从而限制了时空聚焦技术在高重频激光加工中的应用。因此，基于高重频飞秒激光时空聚焦技术的三维各向同性加工需要提供额外的时间补偿。

山东师范大学蔡阳健教授团队与华东师范大学程亚教授团队合作提出了一种高重频激光器腔外时间补偿的方案，实现了基于高重频飞秒激光光源时空聚焦技术的高效率、三维各向同性加工。在这一工作中，激光器外搭建的 Martinez 脉冲展宽器被用来引入大量的时间正啁啾，将脉冲宽度展宽到皮秒量级，再通过单通光栅压缩器（光栅对）的空间色散和物镜的聚焦，确保焦点处不同频谱成分重新组合，脉宽在飞秒量级。为了更直观地展示该时空聚焦装置的三维制造能力，研究团队结合时空聚焦技术和后期化学腐蚀方法，在光敏玻璃内部制造了多种三维各向同性的微流体结构。与传统的激光加工相比，该装置同时具备高效、连续可调的三维各向同性加工分辨率、对加工深度不敏感等优点，该研究结果有望应用于三维微流控芯片、光子芯片的制造以及激光三维打印等领域。

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Three-dimensional isotropic microfabrication in glass using spatiotemporal focusing of high-repetition-rate femtosecond laser pulses

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In recent years, several beam shaping techniques have been proposed to balance the difference between lateral and axial resolution in FLDW, such as slit shaping technology, astigmatism shaping technology, and cross-beam irradiation technology. However, these techniques cannot achieve three-dimensional isotropic processing based on a single objective lens.

The research group of Professor Yangjian Cai from Shandong Normal University and Professor Ya Cheng from East China Normal University propose a pulse compensation scheme by building a pulse stretcher outside a high-repetition-rate fs laser source for the generation of the SSTF fs laser pulses, which realize truly 3D isotropic microfabrication with a tunable resolution ranging from 8 μm to 22 μm in glass. In this work, a Martinez-type pulse stretcher was adopted to introduce a large number of positive temporal chirps, the output pulse width was stretched to the picosecond level, and then different frequency components of laser pulses were spatially dispersed by grating pair and then recombined by an objective lens, pulse width at the focus of objective lens was restored to fs leve. Compared with conventional laser processing, SSTF high-repetition-rate fs laser pulse has the advantages of high efficiency, 3D adjustable isotropic fabrication resolution. The research results are expected to be applied to the fabrication of 3D microfluidic chip, photonic chip and laser 3D printing.

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