Ultrashort-pulse processing with tailored laser vector fields

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Micro-texturing processes using ultrashort-pulse lasers present significant advantages compared with traditional laser manufacturing methods. The laser-material interactions occur within a time span that is shorter than characteristic thermal diffusion, and this leads to high accuracy processing without Heat Affected Zones and promotes non-linear interactions such as multi-photon absorption [1-3]. Thanks to the availability of robust, affordable ultrashort-pulse laser systems delivering repetition rates and average power values compatible with commercial applications, these processes are gradually becoming mainstream in several high-precision industries and allowing to develop new applications. As a result, there has been a growing urgency to develop new methods for optimizing the optical characteristics of ultrashort-pule laser beams e.g. intensity or polarization profiles to tailor laser material interactions for specific processes. Various optical control methods have been developed, referred to as adaptive optics, structuring of light or vector beam shaping. For example the technique of adaptive optics has been used to inscribe micro-structures such as waveguides or electrodes in transparent bulk material [4]. The research presented here will provide an overview of these methods, and will present specific applications. Example surface micro texturing using various cylindrical vector beams, laser internal direct writing of diamond with distinct optical polarization and wavefront fields will be presented. We will illustrate how these techniques can be used to improve the flexibility, speed and reliability of these laser processes.

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