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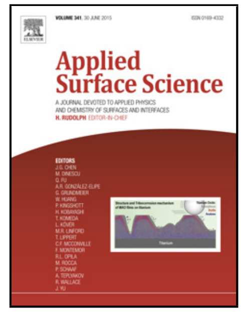

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Probing spatial properties of electronic excitation in water after interaction with temporally shaped femtosecond laser pulses: experiments and simulations

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Abstract

In this work, laser excitation of water under ambient conditions is investigated by radially-resolved common-path spectral interferometry. Water, as a sample system for dielectric materials, is excited by ultrashort bandwidth-limited and temporally asymmetric shaped femtosecond laser pulses, where the latter start with an intense main pulse followed by a decaying pulse sequence, i.e. a temporal Airy pulse. Spectral interference in an imaging geometry allows measurements of the transient optical properties integrated along the propagation through the sample but radially-resolved with respect to the transverse beam profile. Since the optical properties reflect the dynamics of the free-electron plasma, such measurements reveal the spatial characteristics of the laser excitation. We conclude that temporally asymmetric shaped laser pulses are a promising tool for high-precision laser material processing, as they reduce the transverse area of excitation, but increase the excitation inside the material along the beam propagation.

Keywords

Laser-induced breakdown; Spectral interference, Femtosecond spectroscopy; Ultrashort laser ablation; Dielectrics; Temporal pulse shaping; Water

1. Introduction

Laser-based material processing with ultrashort laser pulses is a promising field that has emerged over the last decades [1] and is one of the key technologies for a variety of applications ranging from micro- and nanoprocessing of dielectric materials for photonic applications to medical and biological research. The main advantage is the increased precision of laser ablation due to a strongly reduced heat-affected zone. Moreover, it is possible to push the limits of the processing precision by using, for example, temporal [2] [3] or spatial pulse-shaping techniques [4] [5]. By employing temporally asymmetric shaped laser pulses, the lateral size of ablation structures in fused silica has been reduced by an order of magnitude below the diffraction limit [6] [7]. Similar results have been found in a recent investigation, where these pulse shapes were used to process sapphire [8]. These structures may find applications in optoelectronic devices [9]. Even on soft matter, like polymers, these temporal pulse shapes have been used for downsizing purposes [10]. In addition to solid transparent dielectrics,