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～若手研究者のための光・電子・情報科学に関する情報交換～

Controlled micro-explosions: a new tool of material structuring and synthesis

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Tightly focused femtosecond (fs) laser pulses are widely used for surface and in-bulk structuring of materials. Due to localization of light into a spot size with cross sections comparable with the light wavelength, and due to a short pulse duration ~100 fs, a comparatively small pulse energy of ~100 nJ creates intensity/irradiance far exceeding the dielectric breakdown of crystals and glasses. Physical and chemical pathways of material modifications at the conditions close to and exceeding the breakdown plasma formation provide unexplored new avenues to the surface and three-dimensional (3D) volume structuring; e.g., a cross linking of photo-polymers at the close-to-breakdown excitations by a controlled avalanche ionization provides a photo-initiation step even in a non-photo-sensitized monomer and oligomer-only resists [1]. Void-formation in crystals and glasses by a single focused fs-laser pulse [2] is another example where 3D enclosure of dielectric breakdown and plasma formation provide a new method of synthesis for high pressure/temperature (high-p/T) phases of nano-materials [3]. Formation of fine-ripples on surfaces of dielectrics and transparent semiconductors opens way to modify macroscopically large areas by self-replication mechanism of nanostructures [4]. We overview the recent state-of-the-art in fs-laser fabrication.

[1] M. Malinauskas et al., Opt. Express 18, 10209 (2010).
[2] S. Juodkazis et al., Phys. Rev. Lett. 96, 166101 (2006).
[3] A. Vailionis et al., Nature Communications (2011) in press
[4] R. Buividas et al., Nanotechnology 22, 055304 (2011).

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