Laser microbeam meets nonlinear and superresolution microscopy

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Abstract

Nonlinear absorption with plasma formation enables highly localized energy deposition in nominally transparent tissues and cells. This opens many avenues for laser cell surgery and for free-electron-mediated modifications of biomolecules and tissue properties. Combining a laser microbeam with confocal, nonlinear, and superresolution fluorescence microscopy enables the create microscopic effects on cells or biomolecules and to study the subsequent response in vivo. This will be illustrated on two examples:

1. Probing the immune and healing response of murine intestinal mucosa by time-lapse 2-photon microscopy of laser-induced lesions,

2. Induction of specific types of DNA damage in living cells that are of interest for studying DNA repair and the mechanisms of radiotherapy. Nonlinear absorption of femtosecond laser pulses at different wavelengths can be used to change from photochemical damage through 2-photon absorption at 515 nm to free-electron-mediated single- and double strand breaks at IR wavelengths (620 nm, 775 nm, 1030 nm). Effects and cellular repair reactions are monitored by confocal microscopy of immune-histochemical assays. They are analyzed with the help of numerical simulations of density and kinetic energy spectra of the laser-generated free-electrons in conjunction with known yield functions for electron-DNA interactions from radiation physics.

Full-field structured illumination microscopy pushes both image resolution and imaging speed, which may open new avenues for cellular reaction and repair studies if it can be combined with a laser microbeam. The last part of the talk explores a potential pathway for such venture.

Short Biography

Prof. Alfred Vogel is Senior Professor and Director Emeritus of the Institute of Biomedical Optics at the University of Lübeck, Germany. He is fellow of SPIE and Optica, served on the editorial board of *JBO* and *Optics Express*, and is advisory editor of *Biomedical Optics Express*. He authored 163 publications (17200 citations, h = 55), reviewed for 64 international journals and holds 15 patents. Dr. Vogel made pioneering experimental and theoretical contributions to the fields of laser-induced plasma formation and cavitation and to pulsed laser interactions with cells and biological tissues, with applications in intraocular eye surgery, refractive surgery and cell surgery. In recent years, he explored the mechanisms of free-electron-mediated modifications of biomolecules. Results were applied for studying DNA damage and repair, and for understanding and mitigating photodamage in nonlinear microscopy.