Applications of ultrafast lasers in optoelectronic technologies

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Development of the high power, ultrashort-pulse lasers enabled a range of new applications in research and technology, particularly for the purposes of material modification and processing. The high intensities that can be achieved in femtosecond pulses despite modest average powers lead to fundamentally different interaction between laser and matter than that observed for longer pulses and continuous-wave light.

In transparent media, intensity in a focused laser beam can be easily made high enough to cause absorption through nonlinear processes. Above a certain threshold, the material experiences a permanent structural change, which usually takes a form of ablation. It was recently discovered that many transparent media exhibit the long-lasting change in optical properties after irradiation by a femtosecond laser light at intensities below the ablation threshold. The resulting change may be in a form of increased or decreased refractive index, formation of color centers or other defects, or creation of microscopic voids.

These physical processes currently find use in an emerging, powerful technology for optoelectronic device manufacture. Applications to date include high-density data storage in three dimensions, writing of waveguides and other optical components in bulk transparent materials, formation of novel structures in non-photosensitive optical fibers, fabrication of micromechanical devices in polymers, nanosurgery inside single cells. New, exciting outcomes continue to emerge.

Presenter:
Igor Khrushchev is a lecturer in the Department of Electronic Engineering at Aston University, Birmingham, U.K., currently on an academic visit to Harvard. His main research area is the physics and applications of ultrashort optical pulses. He received his MSc and PhD degrees in Laser Physics from Moscow Institute of Physics and Technology and Russian Academy of Sciences, respectively.

Between 1986 and 2000, Dr Khrushchev worked at the General Physics Institute of Russian Academy of Sciences, and University of Bristol, U.K. He studied nonlinear behaviour of ultrashort laser pulses in optical fibers, properties of mode-locked and single-frequency fiber lasers and the ultrafast laser diodes. In particular, he carried out an early investigation of the femtosecond pulse dynamics in amplifying fibers which resulted in formulation of the design rules for advanced, short-pulse Erbium fiber amplifiers. He also contributed to a development of novel Q-switched and mode-locked laser diodes and their applications in soliton generators. He later developed a simple method for generation of high-quality femtosecond pulses "on demand" by using a nonlinear fiber transformer, which was subsequently used by a number of research groups worldwide.

Since 2000 he has been with Aston University, working on compact ultrafast lasers, high-capacity data transmission and laser inscription of optoelectronic components. He led a small research team to investigate the propagation of passively-regenerated optical signals in long-haul links and to establish several world records in high-speed data transmission over long distances.

His current research interests are primarily concerned with the laser processing of materials, with the focus on femtosecond laser inscription in dielectrics.

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