

Hybrid Femtosecond Laser 3D Processing for Fabrication of Functional Micro/Nano-Devices

Speaker:

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Venue:

Gabor Seminar Room, EENG 611

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Abstract:

The extremely high peak intensity associated with ultrashort pulse width of femtosecond (fs) laser allows us to induce nonlinear multiphoton absorption with materials that are transparent to the laser wavelength. More importantly, focusing the fs laser beam inside the transparent materials confines the nonlinear interaction only within the focal volume, enabling three-dimensional (3D) micro- and nanofabrication. This 3D capability offers three different schemes, which involve undeformative, subtractive, and additive processing. The undeformative processing preforms internal refractive index modification to construct 3D optical microcomponents including optical waveguides inside transparent materials. Subtractive processing can realize the direct fabrication of 3D microfluidics, micromechanics, and photonic microcomponents in glass. Additive processing represented by two-photon polymerization (TPP) enables the fabrication of 3D polymer micro- and nanostructures for photonic and microfluidic components. Furthermore hybrid approach of different schemes can create much more complex 3D structures and thereby promises to enhance functionality of micro- and nano-devices. For example, a successive procedure of subtractive 3D glass micromachining and the undeformative optical waveguide writing realizes optofluidics for detection, manipulation, and sorting of bio samples. Meanwhile, combination of subtractive 3D glass micromachining and additive TPP is not only an instrument that can tailor 3D structures but also a tool to fabricate biomimetic in vivo environment inside glass microfluidic chips. Specifically, the subtractive 3D glass micromachining can flexibly fabricate 3D microfluidic structures embedded in glass microchips without a complicated procedure of stacking and bonding of glass substrates. Successive TPP can then integrate complex shapes of polymer structures with a sub-micrometer feature size due to its high fabrication resolution to create biomimetic structures inside the glass microfluidics. Thus, such advanced biochips can be utilized to study the mechanism of cancer cell invasion and metastasis. Furthermore, the subtractive 3D glass micromachining followed by femtosecond laser direct write ablation and successive electroless metal plating enables selective metalization of 3D glass microfluidic chips for electrical motion control of living cells in 3D. This selective metalization technique is also applied to fabricate 3D microfluidic surface-enhanced Raman spectroscopy (SERS) sensors with an extremely high enhancement factor by formation of periodic nanodot structures on the plated metal thin films. This talk presents our recent activities on fabrication of functional 3D micro- and nano-devices including microfluidics, optofluidics, and microsensors based on hybrid approaches of femtosecond laser 3D processing.

Biography:

Koji Sugioka received his B. S., Ms. Eng., and Dr. Eng. Degrees in electronics from Waseda University (Japan) in 1984, 1986, 1993, respectively. He joined RIKEN in 1986 and is currently a Team Leader of Advanced Laser Processing Team at RIKEN Center for Advanced Photonics. He is concurrently a guest professor at Osaka University and Tokyo Denki University. His current research interests include ultrafast laser processing for microfluidic, optofluidic, microelectronic and optoelectronic

applications. He is currently a member of the board of directors of the Laser Institute of America (LIA) and Japanese Laser Processing Society (JLPS), and the Fellow of SPIE, OSA, LIA and IAPLE. He is also an editor-in-chief of Journal of the Laser Micro/Nanoengineering (JLMN).