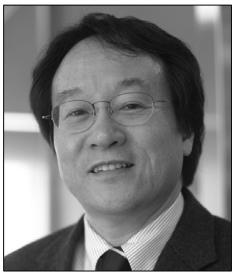
총회초청강연 I 2월 12일(목) 16:20 ~ 17:10 지하1층 B114



Nanophotonics: Manipulating Light beyond its Classical Limits

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Photonics at nano-scale has given new dimensions to several aspects of nanoscience, such as nano-imaging, nano-analysis or even nano-manipulation of several kinds of samples ranging from semiconductors to biomolecules. The interaction volume between light and sample is classically restricted by so-called diffraction limit of light, which is about half of the wavelength of the probing light. We have crossed this classical barrier in several nanophotonics technologies, such as in fabrication, in analysis and in imaging of samples at nanoscale, and have shown how light can be manipulated to interact with materials in a volume much smaller than the diffraction limits. Utilizing two-photon absorption, we demonstrated the fabrication of micro-sculpture [1], which had finer structures of the order of 100 nm, in comparison with the probing wavelength of 780 nm. Later, we showed that 3D structures with much smaller size could be fabricated by this technique. By utilizing an array of metallic nanorods, we proposed nanolens [2] that can image a nano-light-object through the plasmon resonance of the nanorods. In our proposed model, a resolution of 40 nm could be achieved for the light source of 532 nm. This was further extended in an improved design of such a metallic nanolens, which is capable of producing color and magnified image of extremely subwavelength objects [3]. We also proposed the use of metallic nano-tip in near-field optical microscopy (NSOM), and combined NSOM technique with Raman microscopy to demonstrate how the use of a metallic nano-tip can confine and enhance the probing field, which results in high-resolution Raman microscopy [4-7]. In this technique, which is called the tip-enhanced Raman spectroscopy (TERS), interesting near-field effects could be observed which could be analyzed through Raman scattering process, as the tip is brought in close proximity of the sample. We have utilized TESR to study several samples, such as carbon nanotubes, carbon-60 molecules and DNA-based adenine molecules, and were able to optically image them with a resolution better than 25 nm in linear and 15 nm in nonlinear [4] TERS experiments, far beyond the diffraction limits of the probing light. Also, a signal enhancement by a factor as high as one million was observed. In addition to this, if the tip is pressed against the sample molecules, the tip can also interact mechanically with the sample by applying a controlled pressure on the sample molecules. This effect shows up in interesting spectral changes, such as peak shift, peak broadening and new peak rising, as the AFM-controlled tip-applied pressure is sequentially changed [5,6]. Further, inclusion of chemical effects in TERS can even indicates towards the possibility of single molecule detection [7]. Due to extremely localized nature of the tip-applied pressure and chemical interaction, these techniques further advances the nano-imaging capabilities of TERS and takes it one step forward in super-resolved optical imaging far beyond the classical limits of diffraction.

[1] S. Kawata, H-B. Sun, T. Tanaka and K. Takada, Nature, **412**, 697 (2001); *Guinness Book of World Records – 2004*, p.136.
[2] A. Ono, J. Kato and S, Kawata, Phys. Rev. Lett. **95**, 267407 (2005).
[3] S. Kawata, A. Ono and P. Verma, Nature Photonics **2**, 438 (2008).
[4] T. Ichimura, et al., Phys. Rev. Lett. **92**, 220801 (2004).
[5] P. Verma, et al., Phys. Rev. B **73**, 45416 (2006).
[6] T. Yano, et al., Nano Lett. **6**, 1269 (2006).
[7] T. Ichimura, et al., J. Phys. Chem. C, **111**, 9460 (2007).

• Biography

Satoshi Kawata is the Director of the Photonics Advanced Research Center at Osaka University. He is also a Professor of Department of Applied Physics since 1993. He is jointly at RIKEN as a Chief Scientist (the head) of Nanophotonics Laboratory since 2002. He received his BSc, MSc and PhD all in Applied Physics from Osaka University in 1974, 1976 and 1979 respectively.

He has been serving as the President of Spectroscopical Society of Japan (2004-2007), the Editor for Optics Communications (2000-present), Honorary Professor at Technical Institute of Physics and Chemistry, Chinese Academy of Science, Program Officer at Japan Society for the Promotion of Science and a joint professor at the Department of Physics at Gakushuin University. He is a fellow of the Optical Society of America (OSA), Institute of Physics (IOP), the International Society for Optical Engineering (SPIE) and the Japan Society of Applied Physics (JSAP).

He received the Medal with Purple Ribbon awarded by the Emperor of Japan (2007), the Minister's Award on Science and Technology by the Ministry of Education, Culture, Sports, Science and Technology Japan (2005), Shimadzu Award (2003), Ichimura Award (1998), DaVinci Excellence, Moet Hennessy Louis Vuitton (1997) and the Japan IBM Science Award (1996).

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