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근접장광학에서 광압과 광토크의 응용
Near field optics: force and torque

장 수, 이상수*
한남대학교 이과대학 물리학과, *한국과학기술원 물리학과
sjang@eve.hannam.ac.kr

Evanescent waves are mainly produced in the near-field region of scatterers and their spatial frequency on the object surface is greater than that of an ordinary wave. The large spatial frequency of the evanescent wave may provide an image with a very high resolution much exceeding the diffraction limit for the spatial frequency of an ordinary wave. Near field optics which is dominated by the evanescent field has a potential importance in the nanometric scale technology for manipulating, trapping, observing and analyzing ultra-small structures such as a single atom or molecule and a biological cell. The evanescent field generated at a dielectric interface by total internal reflection of light was used for pushing and channeling a dielectric particle in the direction of light propagation[1,2] and for rotating combined Mie particles clockwise or counter-clockwise by adjusting the position of particles in the evanescent fields.[3] Evanescent fields in the near zone of a small aperture on a conducting screen or a tapered tip in the optical fiber may be used for the formation of a evanescent wave gradient force trap (i.e., evanescent wave tweezer) to manipulate nanometer-sized particles. Also, evanescent waves produced by a circularly polarized light could be useful in the mechanical rotation of small particles close to the surface of a substrate. In this paper, optical forces exerted on a nanometer-sized particle close to a small aperture on the conducting screen are first discussed for the formation of a evanescent wave gradient force trap. Also, the optical force and torque acting on a metallic or dielectric sphere in the evanescent field of a circularly polarized Gaussian laser beam are analyzed for a potential application in the field of micromotors or microaccelerators.

The evanescent fields confined in the near zone of ultra-small structures are generated on the dielectric or metal surface at which the incident light is totally reflected, in the near-field region of subwavelength-sized slits or apertures illuminated with light, near the cladding-core interface of the optical fiber which guides light along the core, or near the surface of a very small particle that scatters light. Figure 1 shows the NSOM image for a standing evanescent wave formed on the prism surface illuminated with a He-Ne laser beam of wavelength $0.633\mu m$.[4] The evanescent wave

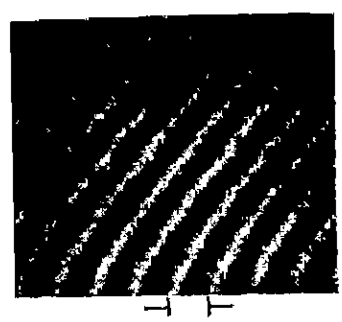

Fig. 1 NSOM image for a standing evanescent wave

has a large spatial frequency on the dielectric surface which is greater than that of an ordinary wave in air, and the decay rate is also very high in the direction normal to tne surface. The large spatial frequency of the evanescent wave may provide an image with a very high resolution much exceeding the diffraction limit for the spatial frequency of an ordinary wave, if the evanescent photons can be extracted and detected by any method. In addition, the large decay rate has the evanescent photons confined in the near zone of the object surface and the photons interact selectively with very fine structures that are located close to the object surface. The characteristics of evanescent photons can be useful for the studies of a single atom or molecule, a biological cell and mesoscopic devices in nanometric dimension. Evanescent fields in the near zone of a small slit on a conducting screen may be used for the formation of a evanescent wave gradient force trap. In addition, the particles trapped by two counter-propagating evanescent waves can be chosen as a probe in a near-field scanning optical microscope.

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