Focused evanescent field under radially polarized beam illumination

Baohua Jia, Xiaosong Gan, and Min Gu

Centre for Micro-Photonics, Faculty of Engineering and Industrial Sciences,
Swinburne University of Technology, P.O. Box 218 Hawthorn, 3122 Australia

The confinement of light distribution in the focal region of an objective lens is of significant importance to many applications including microscopic imaging, optical data storage and optical nano-fabrication [1,2]. High resolution can be achieved by using a high numerical aperture (NA) objective according to the Rayleigh criteria (1.22 $\lambda/NA$). However, a focus elongation or splitting [3], as shown in Fig. 1 (a)(b), is always presented in the focal region of a high NA objective under the illumination of a linearly polarized beam due to the depolarization effect caused by the focusing of the objective. Such a deformation of the focal spot can be avoided by using a radially polarized beam, which has a symmetric distribution and a better transverse resolution as shown in Fig. 1 (c)(d), however at the cost of a poorer axial resolution (a larger depth of focus) owing to the dominant portion of the longitudinal electric field component in the focal region of a radially polarized beam [4]. Nevertheless such a poor axial resolution will not form any obstacle to near-field applications because of the fast decaying nature of the evanescent field in the direction normal to the interface.

In order to eliminate the focus deformation and at the same time localize the field near the interface, a tightly focused evanescent field combining with a radially polarized illumination, generated by interference method with a single LCD, is proposed in this paper. A scanning near-field optical microscope (SNOM) has been employed to observe the focal spot near the interface by means of directly scanning over the focal
field. It has been demonstrated that the lateral localization has been improved to approximately a quarter of the illumination wavelength, which is less than half of the size that achievable under linearly polarized illumination. And at the same time, the field is also confined within approximately 50 nm in the axial direction from the interface (Fig. 2). The technique reported in this paper can find its applications especially in the field of near-field microscopic imaging and laser trapping, where a high resolution and a high contrast are required simultaneously [5].

Fig. 1 Intensity distribution in the focal plane of a high NA objective (NA=1.65) at the cover glass (n=1.78) and air (n=1) interface (a) experimental distribution of a linearly polarized beam, (b) theoretical distribution of a linearly polarized beam (c) experimental distribution of a radially polarized beam (d) theoretical distribution of a radially polarized beam. Scale bar: 500 nm, arrow indicates the incident polarization direction for a linearly polarized beam.

Fig. 2 Experimental and theoretical intensity decay of pure evanescent focuses as a function of the tip-sample distance for ε=0.803 (normalized radius) for NA=1.65 objective.

Reference: