NOVEL OPTICAL DETECTOR

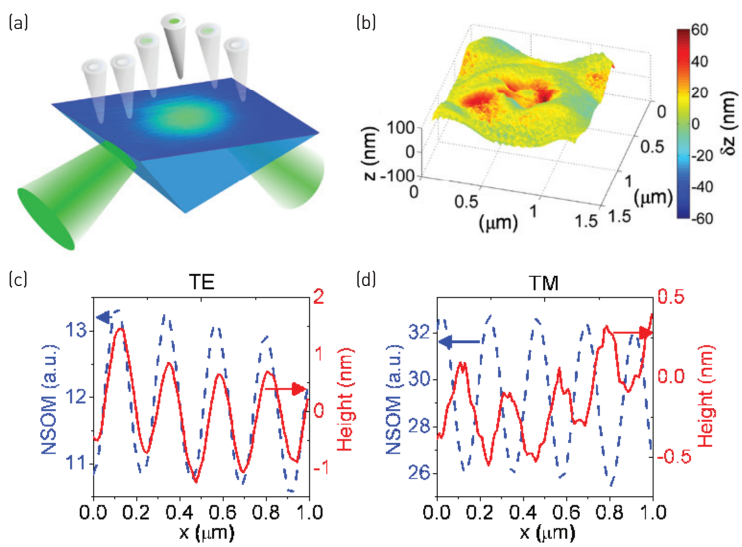
Near-Field Topography of Light

Photonics-based technologies rely on ever smaller devices and systems, which require accurate control of 3-D electromagnetic fields. Many microscopy techniques can map field characteristics by collecting radiation that is either coupled through or scattered off a subwavelength probe. What makes optical measurements challenging is that detecting radiation typically involves a photon-to-electron conversion. Moreover, guiding or scattering light at subwavelength scales involves interactions with metallic structures leading to thermal effects. We have proposed a way to overcome these challenges while maintaining the attributes of near-field scanning optical microscopy (NSOM). We showed that the mechanical action of light, i.e., the optically induced forces (OIF) exerted on a scanning probe, can be exploited for quantifying properties of electromagnetic fields.[1]

Our new measurement modality not only circumvents the need for standard photon detectors, but it also complements traditional approaches for mapping the 3-D properties of electromagnetic fields without sacrificing spatial resolution.[2] Moreover, OIF can act on purely dielectric probes, therefore minimizing potential thermal interferences in typical NSOM measurements.[1] In certain cases, OIF depend primarily on the local field gradients while conventional NSOM operation provides a measure of the local field strength.[2] Because these sensing modalities can be operated simultaneously, one can directly measure the spatial distribution of optical field magnitude and its local gradient, which offers unique tomographic capabilities.

In a variety of situations, the mechanical action exerted on the scanning probe of a standard atomic force microscopy can be used to acquire maps of the optically induced topography from which the properties of optical fields can be quantitatively extracted.[3] Because the induced force depends on the field characteristics and the structure and intimate morphology of the probe, one can create probes that respond to specific electromagnetic field properties.

As the magnitude of field-probe interaction can be conveniently controlled, OIF can also assist in reconstructing other properties, such as the profiles of weak surface forces of different origins.[4] The flexibility and efficiency of OIF add a new dimension to high-resolution imaging techniques based on scanning probes. OPN



(a) OIF causes NSOM feedback to retract from an illuminated flat surface: Optical radiation is detected by mapping OIF. (b) When the optically induced topography is overlaid onto the surface topography, the discrepancies are significant near sharp edges where the intensity gradients are strongest. This allows quantitative interpretation of the NSOM images. (c,d) The NSOM and OIF signals corresponding to complex optical fields are different when the evanescent excitation is in transverse electric or transverse magnetic mode. As the two signals are being collected simultaneously, complementary information about the field distribution can be gathered without increasing measurement complexity.

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