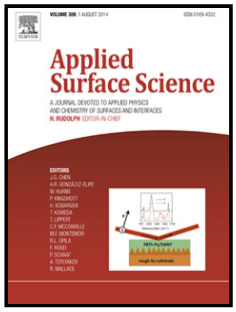

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Modification of the surface plasmon enhanced optical forces on metal nanorod pairs by axial rotation and by dielectric intralayer

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Abstract

We investigate numerically the effect of axial rotation and the presence of a dielectric intralayer on the spectral behavior of the optical force on a gold nanorod pair. The frequency spectrum of the optical force is obtained through the Maxwell stress tensor formulation and the full vectorial solution of electromagnetic waves. The common and the relative forces, which are defined through the optical force acting on each nanorod, are computed for different axial rotations and for different permittivity and thickness of the dielectric intralayer. We found that both the misaligment and the dielectric intralayer can be utilized to tailor the magnitude and direction of the relative optical force, providing a tunable attractive or repulsive response between the nanorods.

Keywords: optical force, surface plasmon, nanooptics

1. Introduction

The optically generated forces on micro- and nanostructures are becoming a dependable tool in a wide range of chemical, biomedical and integrated photonics applications [1, 2, 3, 4, 5, 6, 7]. The optical forces are usually classified as gradient- and scattering-type. The gradient force is induced by the gradient of the electric component of the electromagnetic field, and it forms the basic mechanism of optical tweezers [8]. The scattering force is imparted by the momentum of the incident light. Typically, the scattering force is utilized in cavity optomechanics [9].

At present, the utilization of these forces is matured well for manipulating micron-sized particles. At nanoscales (i.e. in the deep subwavelength regime), the excitation of the surface-plasmons (SPs) on the target particle [10, 11] can contribute significantly to the induced optical force. For instance, for two closely placed metallic nano-spheres, a strong enhancement in the optical force can be obtained when the frequency laser is around the SP resonance [12, 13, 14, 15].

The optical force on rod-shaped metallic nanostructures has been a subject of recent studies. These involve coupled nanowire pairs[16] or head-to-tail coupled nanorod dimers in the presence of a metal slab,[17] and coupled nanorod heterodimers[18]. The frequency spectrum of the relative optical force between the nanorods is investigated as a function of the geometrical parameters of the rods and attractive and repulsive regimes are found. The optical force on coupled nanorod shaped particles is relevant from various aspects. For instance, the optical force is the basic mechanism of optical bonding/antibonding between the particles. The excitation of surface-plasmons of the nanorods provides a local trapping field for other particles. The nanorod