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Optical Tweezers Array System Based on 2D Photonic Crystals

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Abstract

A simple optical interference method for creating multiple optical tweezers from a single laser beam, using two dimentional photonic crystals (PhCs) as a diffractive beam splitter, was described. To obtained clear periodic traps, all diffracted beams sould be used and the intensity of each splitted beam should be same. So the period and the surface features of PhCs was adjusted in the present study As a demonstration of this technique, using 2D PhCs with 700 nanometer period, hexagonal lattice patterns with one micrometer period have been implemented. The image of periodic intensity gradient of light fabricated by this method is presented.

Keywords: optical tweezers; multiple optical traps; a diffractive beam splitter; photonic crystals; interference

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1. Introduction

Since Ashkin et al. introduced optical traps in 1986[1], single beam optical tweezers have become indispensable tools for a wide range of interdisciplinary research, such as the exploration of small interaction forces [2], the manipulation of single cells [3], and the assembly of microstructures on the micro- and nanoscales [4]. Optical tweezers work on the principle of creating an intensity gradient that is exerted by tightly focused laser beams to trap and move objects. When a number of particles have to be trapped simultaneously, some techniques to create multiple optical traps have been reported [5]. For instance, dynamic holographic optical tweezers were used to transfer particles along arbitrary paths [6], and an approach based on computer-generated holograms (CGH) was demonstrated [7].

A photonic crystal (PhC) is an artificial structure whose refractive index is periodically modulated. A PhC can alter the propagation property of light with a wavelength of roughly twice that of its period [8]. Due to its promising applications, PhCs have been intensively investigated. [9]

In this paper we demonstrate a simple and effective means to create multiple optical tweezers in hexagonal lattice patterns from a single laser beam using 2D PhCs. These tweezers arrays and their variants should have immediate applications for probing phenomena in biological systems and complex fluids, and in organizing soft matter into mesoscopically textured composite materials. The image of periodic intensity gradient of light fabricated by this method is presented.

2. Methods and data

In 2001, T. Kondo demonstrated a simple optical interference method to fabricate microperiodic structures [9]. The optical setup is schematically shown in Fig. 1. Femtosecond laser pulse was split by a diffractive beam splitter (DBS) and overlapped with two lenses. Temporal overlap of the split femtosecond pulses was automatically achieved by this optical setup. One-, two-, and three-dimensional periodic microstructures with micrometer-order periods were fabricated using this method.

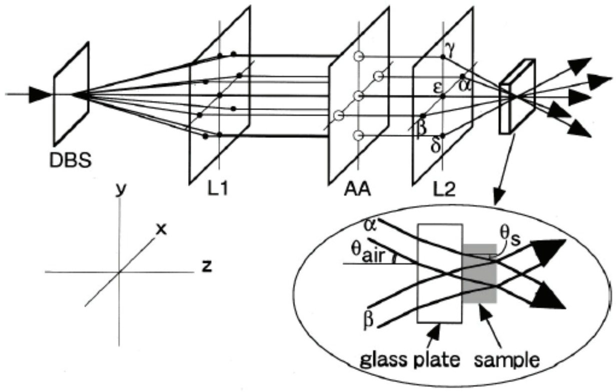

Fig.1. Optical setup. DBS: diffractive beam splitter, L1 and L2: lenses, and AA: aperture array. The inset shows beam configuration around the sample.

So according to the techniques presented by T. Kondo [9] and Eric R. Dufresne [10], 2D PhCs is used as a diffractive beam splitter in our paper. In their methods, not all diffracted beams can be used and the intensity of each splitted beam was not same. If the period and surface features of PhCs should be