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Optical confined nanoparticles on a nanofiber microring with a microparticle decorated the junction

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ABSTRACT

This work demonstrates optical trapping and transportation of nanoparticles along a nanofiber microring. The optical fiber, 800 nm in diameter, was formed to be a microring with a bending radius of about 42 μm. A microparticle, stuck to the junction of the ring, plays a critical role for confining nanoparticles on the microring. The experimental results show that, when a 650 nm laser light was launched into the ring, nanoparticles dispersed in the solution were trapped to the ring surface and delivered along the direction of the light propagation. Because the stuck microparticle on the junction for perturbation, nanoparticles can be confined over entire microring circumference. This technology offers a new degree of control for particles and lead to various nanomanipulation applictions.

1. Introduction

The use of optical forces to trap and manipulate micro/nano particles has attracted much attention recently due to its broad applications in the scientific fields of physics, biology, chemistry, medicine and photonics [1–4]. Traditionally, optical tweezers trap particles by tightly focused laser beams to generate strong optical force near the focus with high precision [5–8]. However, bulk optics and diffraction limitation are the key obstacle for this technique. Alternatively, planar waveguides [9–12], the evanescent fields of which can produce strong optical force to localize particles near their surface and transport them in the direction of light propagation. Compared to the waveguides, which are fabricated on the substrate, optical nanofibers exhibits some unique properties such as flexibility in three-dimensional geometry, extremely low coupling loss and easily manufacture [13–16]. Therefore, the nanofibers are more suitable for integrated photonic device. Although optical trapping and manipulation of particles along arbitrary bending nanofibers has been reported, the motion of particles on the fiber junction is random and uncontrollable [16]. Therefore, in this work, we report a controllable manipulation of nanoparticles confined on a nanofber microring by injecting a laser beam with a wavelength of 650 nm into the ring. This technology will broaden the range of applications of nanomanipulation.

2. Experimental setup

As illustrated in Fig. 1, the nanofiber, 800 nm in diameter, was draw from a standard telecommunication single mode optical fiber (SMF-28, Corning, Inc.) by the flame-heated technology. In the experiment, under an optical microscope, the

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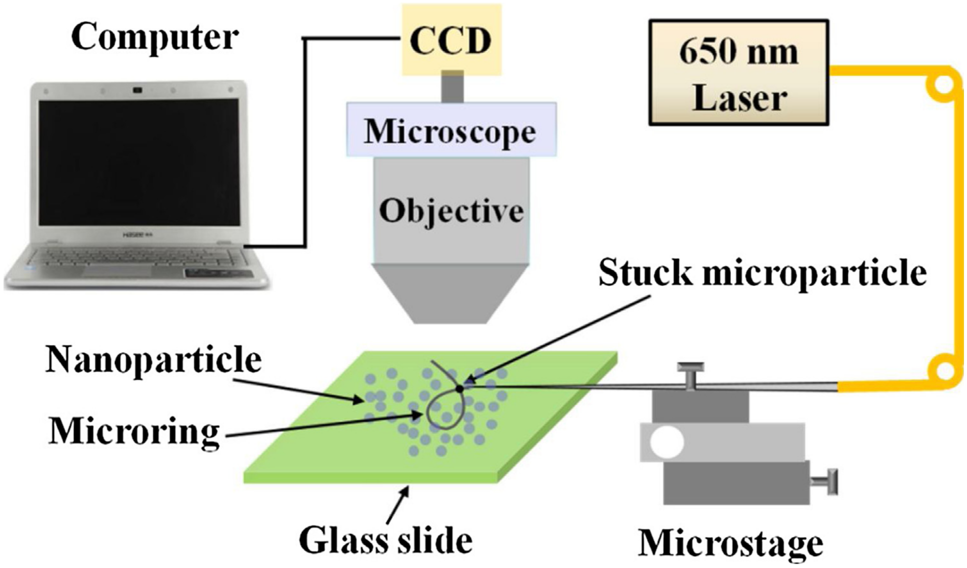

Fig. 1. Schematic of the experimental setup.

nanofiber was carefully manipulated with the help of micromanipulator and formed a microring at a radius of about 42 μm. A particle with a diameter of 2 μm was stuck on the junction of the ring and provided a perturbation for confining nanoparticles around the ring. Real-time monitoring and image capture were performed with a computer-interfaced charge coupled device (CCD) camera. 700 nm polystyrene particles were diluted in deionized water (volume ratio of spheres to water is 1:1000) with the assistance of ultrasonication. Then, a drop of the particle solution was placed on the glass slide by a pipette, and immersed the nanofiber microring into it. The nanofiber was fixed by a microstage, and the pigtail of which was connected to a 650 nm laser light.

To confine the nanoparticles on the nanofiber microring, it is very critical to realize the microparticle being stuck on the junction of the ring for perturbation. A tapered fiber probe (fiber tweezer) was utilized in the experiment [17]. Firstly, the

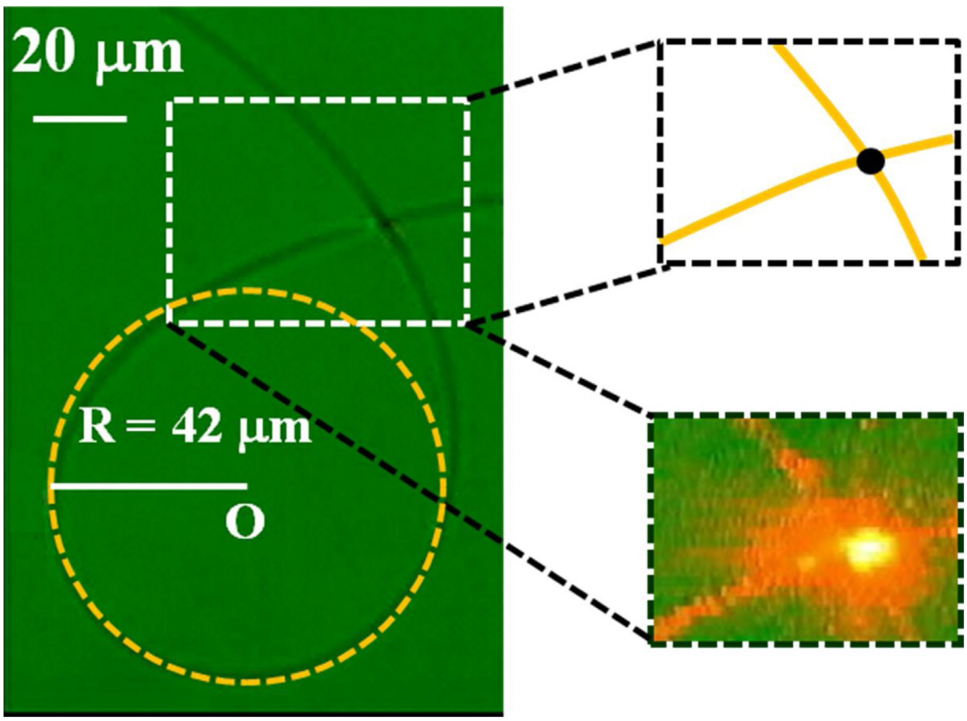

Fig. 2. Optical microscope images and sketch of the nanofiber microring with a stuck microparticle on the junction, the radius of the ring is about 42 μm.