Sustainable Medical Technologies

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Soft material Robots using optical tweezers

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Abstract

The optical tweezer can be utilized to achieve precise movements, like micro robots and manipulation of soft materials like biological cells and other microscopic object. It had been coupled with other technique from cell biology to aid in the elucidation of signaling pathways that regulate process such as binding and growth. Our aim is to have an insight of the physiological and pathological mechanisms of intracellular activities.

Introduction

Optical tweezer is a scientific instrument that utilizes the highly focused laser beam to trap a microscopic particle. It has been employed as powerful means to alter and control the behavior of cells. Its is a precise, flexible and minimal invasive manipulation of micro particles.

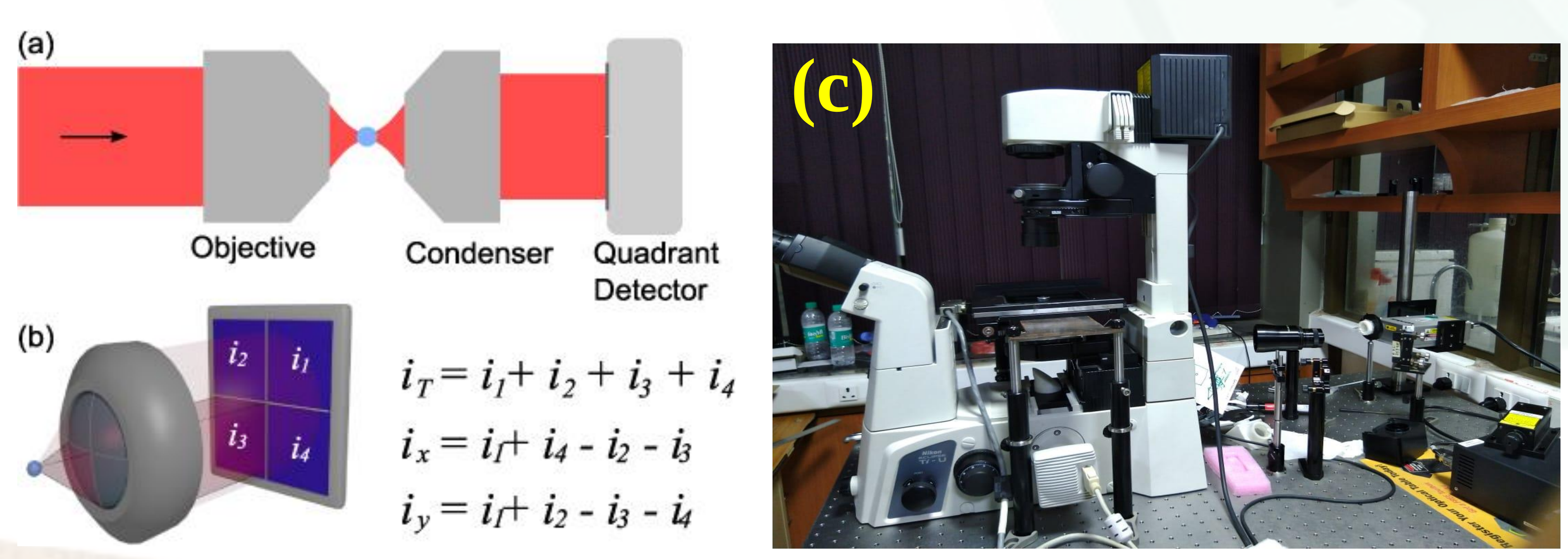

Fig. 1: (a) Position detector (b) QPD integration in experimental setup and (c) Experimental setup layout of the optical tweezer

Materials and Methods

- IR DPSS laser, micro-rotors, and other optical components, like dichroic mirror, 100x objective lens are used to perform the experiments.
- Optical trapping force can be executed by the sensor module like QPD, automatic stage, inverted microscope and camera, while the control module adjusts the focal position of the optical trap.
- Highly focused laser is used to trap the cell and can be seen in the presence of white light using the camera.

Conclusions

Experiments performed are use to characterize the mechanical properties of the trapped particles. We can further use optical tweezer to measure the speed at which RNA polymerase moves along DNA molecules during transcription while under an load can be applied in order to determine a force-velocity curve.

Industrial Significance

Disease detection at early stage, growth rate and degradation rate of cells.

Technology Readiness Level: Experiments have been successfully performed and final results are yet to obtain.

Result

To perform cell manipulation with high complexity, diversity, and precision, which contributes to acquiring multidimensional information about biological cells at the subcellular level to characterize the physical and physiological properties of the cell and, furthermore, to insight into the mechanisms of intracellular activities

Target objects are tracked in real time which incorporate a closed-loop hydrodynamic feedback control system (in-house LABVIEW code) to automatically position optical traps. In this figure, the suspended silica bead particle is trapped in deionized water. The trapping of silica bead can visualized as a dark spot in the image. The force acting on the trapped particle is calculated from

$$F = kx,$$

where k is the stiffness of the particle and x is the displacement from the mean position. Herein, k is determined from equipartition theorem. The force acting on the particle depends upon various experiment setup like, viscosity of the deionized water, density and size of the particle and the numerical aperture of the objective.

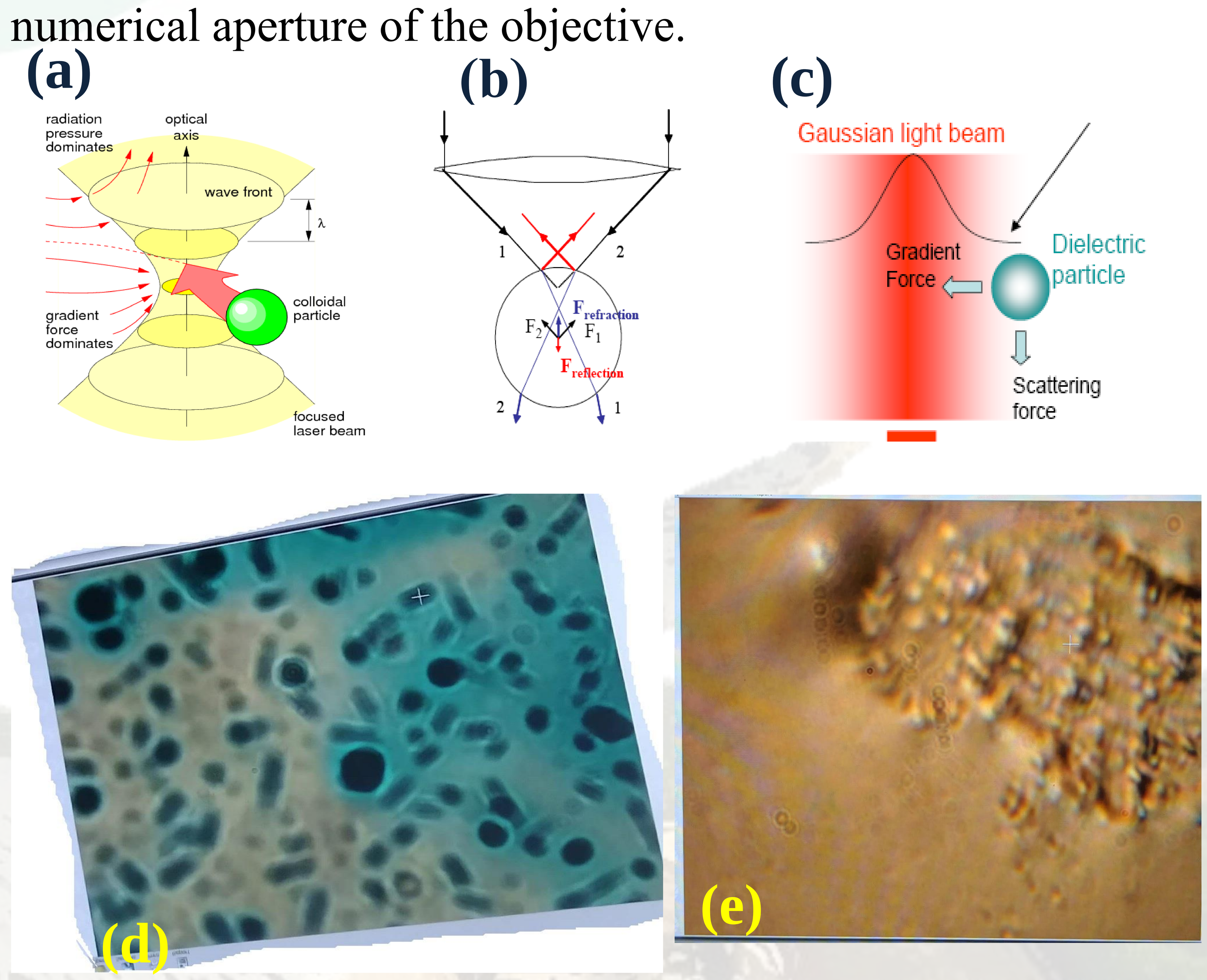

Fig. 2: (a), (b), and (c) Schematic diagram showing the force on a dielectric sphere due to both reflection and refraction of ray of light.
(d) Suspended silica beads in deionized water and (e) Optically trapped silica bead.

References

Jones, P.H., Maragò, O.M. and Volpe, G., 2015. *Optical tweezers: Principles and applications*. Cambridge University Press.

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