University of Victoria | Graduate Studies

Notice of the Final Oral Examination for the Degree of Master of Applied Science

of

ADARSH LALITHA RAVINDRANATH

BTech (Amrita Vishwa Vidyapeetham, 2012)

"Double-Nanohole Optical Trapping: Fabrication and Experimental Methods"

Department of Electrical and Computer Engineering

Tuesday, August 20, 2019
1:30 P.M.
Engineering Office Wing
Room 502

Supervisory Committee:
Dr. Reuven Gordon, Department of Electrical and Computer Engineering, University of Victoria (Supervisor)
Dr. Tao Lu, Department of Electrical and Computer Engineering, UVic (Member)

External Examiner:
Dr. Mohsen Akbari, Department of Mechanical Engineering, UVic

Chair of Oral Examination:
Dr. John Meldrum, School of Exercise Science, Physical and Health Education, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

Arthur Ashkin's Nobel Prize-winning single-beam gradient force optical tweezers have revolutionized research in many fields of science. The invention has enabled various atomic and single molecular studies, proving to be an essential tool for observing and understanding nature at the nanoscale. This dissertation showcases the uniqueness of single-beam gradient force traps and the advances necessary to overcome the limitations inherent in conventional techniques of optical trapping. Plasmonic nanoaperture optical trapping using double-nanohole apertures is introduced as a solution to over coming these limitations. Achievements in double-nanohole optical trapping made possible by the pioneering work of Gordon et al. are highlighted as well.

This thesis focuses on the advances in nanoaperture fabrication methods and improvements to experimental techniques adopted in single molecular optical trapping studies. The technique of colloidal lithography is discussed as a cost-effective high throughput alternative method for nanofabrication. The limitation in using this technique for producing double-nanohole apertures with feature sizes essential for optical trapping is analyzed. Improvements to enable tuning of aperture diameter and cusp separation is one of the main achievements of the work detailed in this thesis.

Furthermore, the thesis explains the modified fabrication process tailor-made for designing double-nanohole apertures optimized for optical trapping. Transmission characterization of various apertures fabricated using colloidal lithography is carried out experimentally and estimated by computational electrodynamics simulations using the finite-difference time-domain (FDTD) method. Optical trapping with double nanohole apertures fabricated using colloidal lithography is demonstrated with distinct results revealing trapping of a single polystyrene molecule, a rubisco enzyme and a bovine serum albumin (BSA) protein.