Multifinger Coordinated Manipulation Methodology for Nanomanufacturing

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Poster

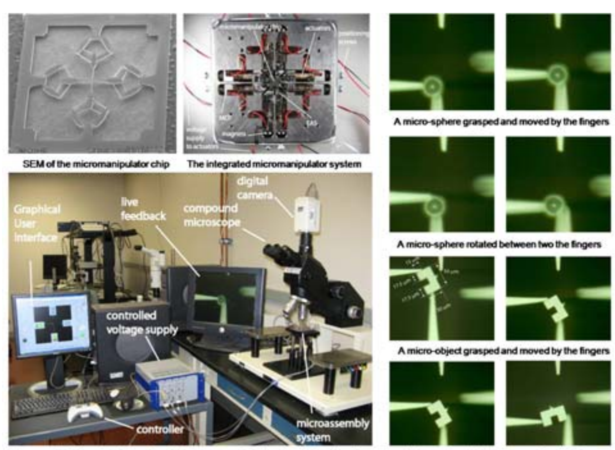
Short Description: **This project investigates a novel approach to mechanical assembly-based nanomanufacturing wherein multiple independently actuated agile fingers coordinate with each other in a defined 2D workspace on a chip to mechanically manipulate and assemble the objects.**

Keywords: Micromanipulator, Nanomanipulator, Nanoassembly, Nanomanufacturing, Microrobotics

Abstract: Fabrication of new functional and useful micro/nano-scale machines potentially involve complex asymmetric 3D arrangements of the nano-scale entities that are beyond the current capabilities of the "bottom-up" and "top-down" approaches for nanomanufacturing. To fill the void between these approaches and enable assembly of building blocks in future NEMS, the capability of mechanically manipulating micro- and nano-scale objects is highly essential. Although significant progress through a variety of strategies and tools for manipulation (pushing, pulling, bending, twisting, and even, grasping) of nano-scale objects have been reported over the last decades, currently available tools and techniques still lack sufficient of dexterity for assembling nano-scale objects. For the ultimate success of assembly-based nanomanufacturing, a manipulator tool with high-degree of dexterity beyond those provided by current simple cantilevers and parallel jaw grippers and tweezers is required.

Motivated by the need for dexterous manipulation and assembly at nano-scales, this project aims to investigate the principles and fundamental issues in a novel manipulation methodology based on the coordinated action of multiple agile fingers at a chipscale to accomplish a controlled manipulation tasks such as grasp, rotate, regrasp, move point-to-point and position micro- and nano-scale objects in a defined 2D workspace [1, 2]. The multiple fingers are capable of not only manipulating multiple objects simultaneously but also coordinating with each other to bring the grasped parts into desired alignment just as a pair of human fingers in each hand articulates to assemble small parts.

This presentation will discuss the development of a novel micromanipulator system comprising a multifingered manipulator chip (5 mm × 5 mm) and piezoelectric actuators and a specially designed compact housing (5 cm × 5 cm). The topology and shape of the miltifingered micromanipulator chip were obtained through a systematic design optimization process maximizing the operating workspace of the micromanipulator. The specially designed, precision machined housing encloses the micromanipulator chip, facilitates the integration of meso-scale piezoelectric actuators with the micromanipulator fingers and isolates the workspace area of the manipulator to minimize external disturbances. This micromanipulator system enables a highly dexterous manipulation of micro-scale objects within a defined workspace area (> 4600 μm^2) at the center of the chip by the coordinated action between the fingers, which can be controlled in a close-loop through external user inputs with visual feedback. Preliminary experiments have confirmed the predicted behavior of the micromanipulator fingers as well as the feasibility of controlling multiple fingers to achieve a coordinated action to grasp, rotate and move a micro-scale object as commanded by the user. The ultimate goal of this work is to enable coordinated nanomanipulation and assembly of nano-scale objects.



SEM of the micromanipulator chip | The integrated micromanipulator system | A micro-sphere grasped and moved by the fingers | A micro-sphere rotated between two the fingers | A micro-object grasped and moved by the fingers | The coordinated manipulation setup including user control inputs and visual feedback | A micro-object rotated between two the fingers

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References

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[2] Krishnan, S., and Saggere, L., *Journal of Micromechanics and Microengineering,* Vol. 17, No. 3, 2007, pp. 576-585.