NISTTech

NANOFABRICATION PROCESS AND NANODEVICE [3D Nanofabrication Process & Nanoparticle Sorting Device]

Complex nanostructure fabrication resulting in the first 3D nanofluidic device for on-chip, high-resolution, high-range, high-throughput nanoparticle sorting and metrology

Description

Nanofluidic structures are usually fabricated by etching a channel pattern into a glass or silicon wafer with the same procedures used to manufacture circuit patterns on computer chips. Because of the limitations inherent to conventional nanofabrication processes, almost all nanofluidic devices to date have had simple geometries with only a few depths. This limits their ability to separate and measure mixtures of nanoparticles with different sizes or study the nanoscale behavior of biomolecules (such as DNA) in detail. Other types of lithographic nanostructures have been similarly limited in form and function by planar fabrication processes.

To solve this problem, NIST and Cornell University researchers teamed up to develop a process to fabricate nanostructures with complex three dimensional surfaces. As a demonstration of their method, the researchers constructed a nanofluidic chamber with a "descending staircase" geometry etched into the floor.

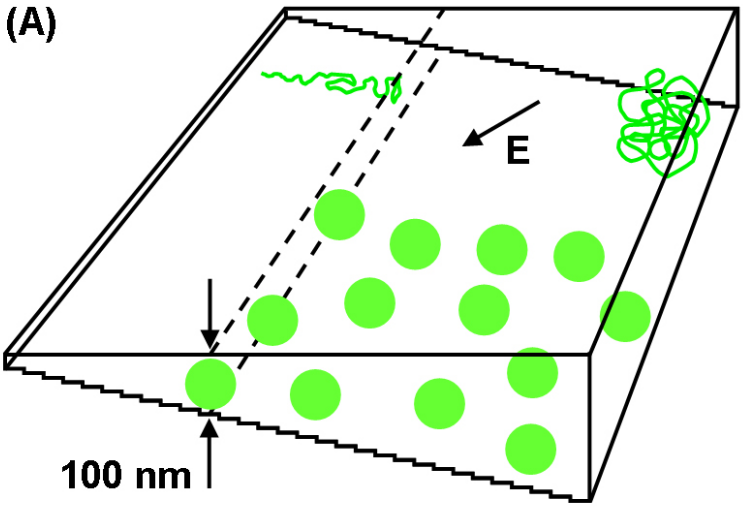
3D Nanofabrication Process

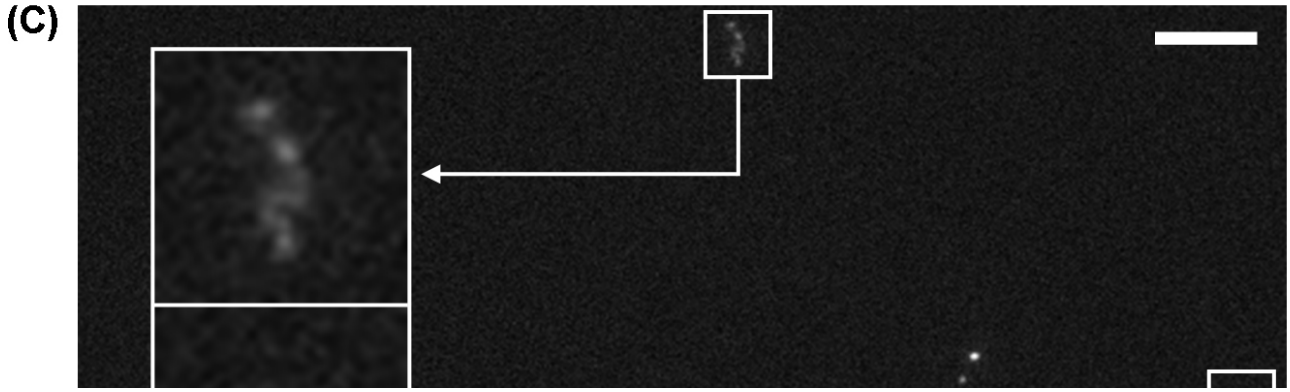
The 3D Nanofabrication Process utilizes a single layer of grayscale photolithography in conjunction with a novel nanoscale pattern transfer procedure to build 3D nanofluidic devices. This enables the fabrication of nanostructures with numerous depths controlled with nanometer precision across the nanometer length scale over large substrate areas.

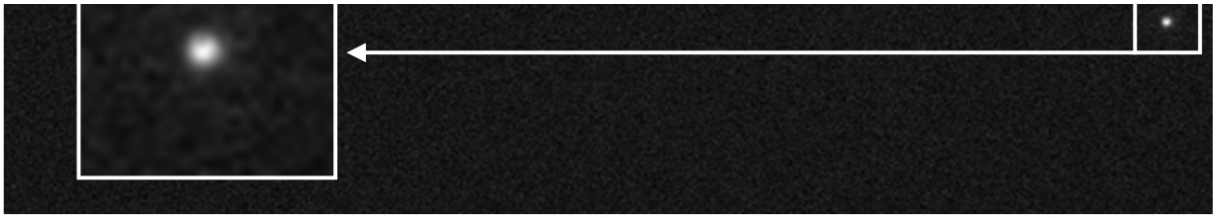
Nanoparticle Sorting Device

The fabricated 3D nanofluidic device has a "staircase" structure for sorting nanoparticles. Each "step" in this staircase gives the device a progressively increasing depth from 10 nanometers (approximately 6,000 times smaller than the width of a human hair) at the top to 620 nanometers (slightly smaller than an average bacterium) at the bottom. This gives the device the ability to manipulate nanoparticles by size in the same way that a coin sorter separates nickels, dimes and quarters.

Images







A.) Schematic of 3D nanofluidic device operation B.) Fluorescence micrograph of nanoparticle size exclusion C.) Fluorescence micrograph of DNA manipulation

Applications

- **Manufacturing**
  Rapidly improve the sorting of nanomaterials in various manufacturing processes
- **Medicine**
  Separate and measure complex nanoparticle mixtures for drug delivery, gene therapy, and nanoparticle toxicology
- **DNA Analysis**
  Enhance the confinement and analysis of individual strands of DNA that are forced to unwind and elongate in the shallowest passages of the device

Advantages

- **Complex Geometries**
  The 3D Nanofabrication Process enables the creation of nanofluidic devices with complex channel or well geometries to improve the sorting and measurement of nanomaterials

Abstract

A nanofabrication Process for use with a photoresist that is disposed on a substrate includes the steps of exposing the photoresist to a grayscale radiation pattern, developing the photoresist to remove the irradiated portions and form a patterned topography having a plurality of nanoscale critical dimensions, and selectively etching the photoresist and the substrate to transfer a corresponding topography having a plurality of nanoscale critical dimensions into the substrate.

Inventors

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Citations

1. S.M. Stavis, E.A. Strychalski and M.Gaitan. Nanofluidic structures with complex three-dimensional surfaces. Nanotechnology, Vol. 20, Issue 16 April 22, 2009.
2. E.A. Strychalski, S.M. Stavis and H.G. Craighead. Non-planar nanofluidic devices for single molecule analysis fabricated using nanoglassblowing. Nanotechnology, 19, p. 315301, 2008. doi:10.1088/0957 4484/19/31/315301

Related Items

- Article: World's First Nanofluidic Device with Complex 3-D Surfaces Built
- MERWYN Business Simulation Report
- MERWYN Business Simulation Report

References

- Serial #12/625,077 dtd 11/24/2009;pub # US 2011-0123771A1 dtd 5/26/2011
- Docket: 09-001

Status of Availability

available for licensing

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