Design and Implementation of Nano Controller based Actuation Techniques Incorporating Fabrication and Synthesis of Nanomaterials

Nishu Gupta

Master of Technology Scholar (M.Tech. Final Year), NanoScience and Technology
Department of Applied Physics,
Delhi Technological University (formerly Delhi College of Engineering), Delhi
Tel: +919651508346
Email: dce.nishu@gmail.com

Abstract

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There has been a significant increase in the use and application of nana controller based actuation techniques in wide spheres of scientific advancements. Miniaturization of materials to nano range dimensions alters their activity and properties. Increased presence of nanoparticles in environment necessitates a basic understanding about their interactions with physical and biological systems. Nanofabrication is the design and manufacture of devices with dimensions measured in nanometers. Fabrication of nanomaterials is of interest to engineers in diversified and interdisciplinary fields because it not only opens the door to super-high-density microprocessors and memory chips but it has also caught the attention of the medical industry, the military, and the aerospace industry. It has been suggested that each data bit could be stored in a single atom . Carrying this further, a single atom might even be able to represent a byte or word of data. Typical technologies involved in Nanofabrication are:

- Thin Film Deposition
- Patterning
  –Lithography
- Modification
  –Etching

The formation of patterned structures on the micro-/nanoscale is essential for the fabrication of many electronic, optical, and mechanical devices. The lithography techniques currently used to pattern surfaces typically require lithography masks and multiple etching or deposition steps, along with significant environmental and safety precautions. For example, electron beam and X-ray lithography allow for high-resolution and precise patterning, but these techniques require clean rooms and expensive instruments and are not scalable in production. Techniques like imprint lithography, soft lithography, nanosphere lithography, and block copolymer lithography require masks and complicated fabrication steps such as resist development, wet etching, or reactive ion etching.

The nanowell fabrication process is relatively safe and simple. The technique offers several advantages:

(i) The nanowell structures are monodisperse and highly uniform in shape and size.
(ii) The size and the depth of the nanowells are easily controlled by varying only the size of the particle.
(iii) The method is inexpensive, simple and no clean room or expensive equipment is needed.
(iv) The materials used for this work are safe and readily available

Introduction to Nano positioning System

If smallest parts or samples have to be moved or positioned with nanometer precision in the millimetre range, nanopositioning systems with piezo inertial drive are used. Research on designing of very compact actuators with appropriate control units are in process for rotational and linear movements. The compatibility to each other allows the assembly of multi-axes combinations for complex movements.

Recent advances in precision engineering and the subsequent development of advanced manufacturing techniques have resulted in such smart techniques where machined and manufactured components are no longer restricted to micrometer scale, but can now be fabricated at nanometer scale. The advanced technologies have given rise to an urgent requirement for the development of precise positioning systems capable of executing displacements with nano scale resolution. So, nanopositioning has become an important developing aim for meeting the requirements of the semiconductor, optical communication, biomedical applications, precise industrial applications [1].

Piezoelectric actuators are chosen to design precise positioning systems for achieving the sub-micro or nanopositioning applications such as scanning tunneling microscopy, biomedical equipments, nano robots, automotive industry, …etc [2-3]. Piezoelectric material is used to convert electrical energy to mechanical energy and vice-versa. Piezoelectric sensors are used in a variety of applications to convert mechanical energy to electrical energy such as: pressure-sensing applications, detecting imbalances of rotating machine parts, ultrasonic level measurement, flow rate measurement, sound transmitters sound receivers, etc. However, piezoelectric actuators convert electrical energy to mechanical energy, and are used in many applications such as: scanning microscopy, patch clamp, gene manipulation, vibration cancellation, R/W head testing, hydraulic valves, drilling equipment, etc. PZT actuators have many advantages such as:

- Piezoelectric actuators have excellent resolution in displacement, high stiffness, high electrical mechanical coupling efficiency, small size, small heat expansion, low power consumption and fast response.
- The piezoelectric actuators make motion in micrometer range with sub-nanometer precision.
- There are no moving parts in contact with each other to limit the resolution.
- The piezoelectric actuators capable of moving loads of several tons and cover travel ranges of several (100 μm) with resolutions in the sub-nanometer range.
- The piezoelectric actuators behave pure capacitive load, so they consumes virtually no power.
- The piezoelectric actuators do not produce magnetic field nor are they affected by them.

References

1. Shiuh-Jer Huang, Su-Shan Wang, "*Mechatronics and control of a longrange nanometer positioning servomechanism*", Mechatronics Journal, Elsevier, vol.19, issue 1, pp. 14-28, 2009.
2. *Applications of PZT*, available: http://www.physikinstrumente.com /en/pdf_extra/PI_designing_with 20_piezo_actuators_tutorial_2005c.
3. S. O. Reza Moheimani and Andrew J. Fleming, "*Piezoelectric Transducers for Vibration Control and Damping*". Springer, 2006.