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An introduction to Nano Electro Mechanical Systems

Mr. A.Venkateswara Rao[1], Dr.Sheo Kumar yadav[2],
[1, 2,] *Dept., of physics, Magadh University, Bodh Gaya*

----------**ABSTRACT**----------

Today miniaturization of systems shows different novel properties and applications. These applications are very powerful and very useful in micro electronics and as well as nano electronics. Nano mechanical systems have the ability to change the society for better life in all spheres. After invention of MEMS, the invention of NEMS is showing a good development in this field. The present essay describes what are NEMS, how NEMS work? and their fabrication methods. It was also mentioned the materials which are used to fabricate NEMS, how they operated and modified and finally applications of NEMS. This article is useful for students, researchers and who have the interest in NEMS.

KEY WORDS: *micromachining and detection, fabrication methods, actuation.*

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I. INTRODUCTION

In 1959 Richard Feynman imagined the miniaturization of systems in his lecture of 'plenty of room at the bottom'. Now after 50 years his imaginations materialized as MEMS and NEMS. Now a days the word NEMS is being heard frequently in scientific communities. NEMS are similar to MEMS but smaller. He word NEMS stands for Nano Electro Mechanical Systems. We know the parent of NEMS is MEMS. NEMS are the composition of mechanical elements, physical and chemical sensors, and transistors like nanoelectronics with mechanical actuators, nanopumps and nano motors. Due to the powerful combination of attributes of NEMS translates directly into operability at ultra low power, high force sensitivity, and the ability to induce usable non linearity with quite modest control forces. Some problems/challenges like the size of the devices compared to their embedding circuitry their extreme surface-to-volume ratios, and their unconventional 'characteristic range of operation'. NEMS works in the range of frequencies in microwave range, masses in the femtogram range, mass sensitivity at the level of individual molecules, force sensitivities at the attonewton level, heat capacities at below a 'yocto calorie'.

How NEMS works?

The sensors in the NEMS collect all the information from its corresponding areas. Then the electronics process the information which is given by the sensors. Finally the logical decision making unit guides the actuators. The actuators act by regulating, filtering and moving.

What are the materials used to fabricate NEMS?

NEMS generally fabricated by the materials of SiO_2 ,SiC,GaN,ZnO&Graphene.

Fabrication methods of NEMS: By using compatible micro machining process the nano mechanical components are fabricated. There are three main steps in fabrication of NEMS.

1. Deposition process

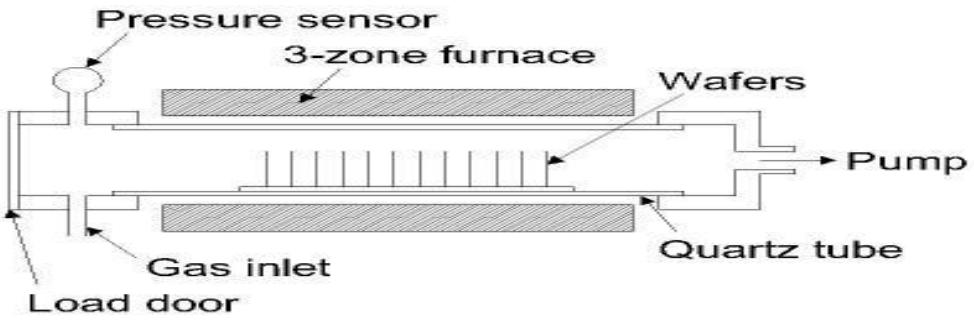
2. Lithography

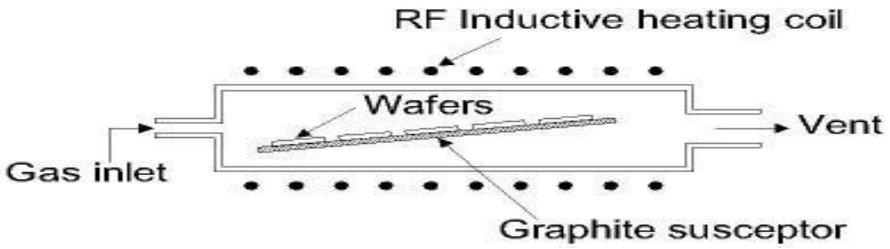
3. Etching process

1. Deposition process: NEMS uses thickness of thin films of 1nm to 100nm. NEMS uses chemical methods for deposition process. These are

A) Chemical vapor deposition

B)Epitaxial





2) Lithography: This is on a photosensitive material by selective exposure to a external radiation source. When the external radiation is to incident to the photosensitive material, it gets a change in its physical properties. The alignments and exposures are the further steps of lithography.

3) Etching: There are two types of etching process, 1) Dry etching 2) Wet etching

How to observe nanoscale changes?

The changes in NEMS like stresses, chemical signals, vibrations and forces at atomic level are observed by the AFM tips. (AFM-Atomic Force Microscope). An AFM tips can heat or sense or modify the NEMS.

Actuation and detection methods of NEMS:

These methods are listed below

1) Capacitive actuation and detection

2) Tunnel spectroscopy and point contact spectroscopy

3) STM detection

4) Magneto motive method

5) Mechanically assisted transport of electrons.

Broad uses of NEMS:

- NEMS can measure extremely very small distances forces and displacements. The researchers have to find the uses of this extremely small measurements in various fields like biological, farma and engg.,.
- Mechanically controllable quantum point contacts.
- Nano machines consume very less energy.
- NEMS can be used as accelerometers which are used in airbag deployment systems in automobiles. An accelerometer is shown in below
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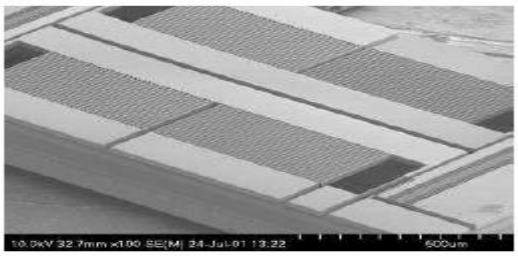
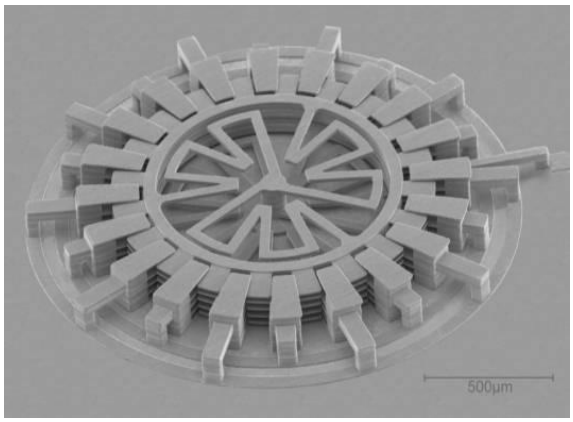


This application reduces the damage inside the automobile from sudden accidents.

- We know gyroscopes are used to find direction in aero planes and ships. These will become more cheap and accurate. Nano gyroscopes and nano robots were emerged recently.
- In inkjet printers nano nozzles directs the ink to print.
- NEMS can be used in smart phones.
- Mechanically assisted transportation of single electrons.
- NEMS based MRI(Magnetic Resonance Imaging).
- bioNEMS, bio chips for chemical force sensing. A nanoscale cantilever with biofunctionalized surfaces senses forces between bound ligand receptor pairs and the presence of a ligand in solution.
- Thermal actuator



- Nanotweezers(nanomechanical manipualation).

The upcoming development and research on NEMS:

Research and development is going on in the areas of

1) quantum-nano electro mechanics

2) Superconducting NEM devices

3) Mechanically assisted single electronics

4) Electronics and mechanics on the nanometer scale.

CONCLUSION:

In this publication it is described an introduction to NEMS, What is a NEM? How it works? What are the materials used to fabricate NEMS? In middle I provided various methods which are used to fabricate NEMS. In this Deposition, Lithography and Etching process were briefly described. To measure, sense or detect NEMS, AFM tips are useful. Methods of actuation and detection of NEMS are noted. Finally various applications involved previously and recently are also informed. This essay is useful those who want to work on NEMS.

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