NANO-ELECTRO-MECHANICAL SYSTEM(NEMS)

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- Introduction
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- Advantages
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INTRODUCTION

- Nano-Electro-Mechanical system (NEMS) is the integration of mechanical elements, sensors, actuators and electronics on a common silicon substrate.
- The Nano mechanical components are fabricated using compatible "**micromachining**" process.
- NEMS is the enabling technology allowing the development of smart products.

- Nano electro mechanical devices promise to revolutionize measurements of extremely small displacement and extremely weak forces, particularly at the molecular level.
- NEMS devices can be so small that hundreds of them can be fit in the same space as one single micro device that performs same function.

- In Nems devices the sensors gather the information from surrounding environment through measuring mechanical, chemical, biological, chemical and optical phenomenon.
- The electronics then process the information derived form the sensors.
- Through some decision making capability direct the actuators to respond by moving, regulating and filtering.

- Can built with the masses approaching a few attograms(10^{-18}g) and with the cross section of 10nm.
- A second important attribute Nano machines is that they dissipate less energy.
- NEMS are extremely sensitive for the external damping mechanisms which is crucial for building sensors.
- The Geometry of a NEMS device can be tailored so that the vibrating elements reacts only to external forces in a specific direction.
- NEMS are ultra low power devices.

Nanoelectromechanical fabrication technology may well open the way for break-throughs in the areas of environmental sensing, detection, and transduction of physical quantities, such as force, heat, and biomolecules, or even improve, in an evolutionary fashion, the performance of current technology.

The distinct aim to produce the hardware that will be at the core of the computers (e.g., mainframes, personal computers, laptops, PDAs, etc.) and wireless communications appliances (e.g., cell phones, satellites, etc.) of the future

NEMS AS MULTITERMINALELECTROMECHANICAL DEVICES

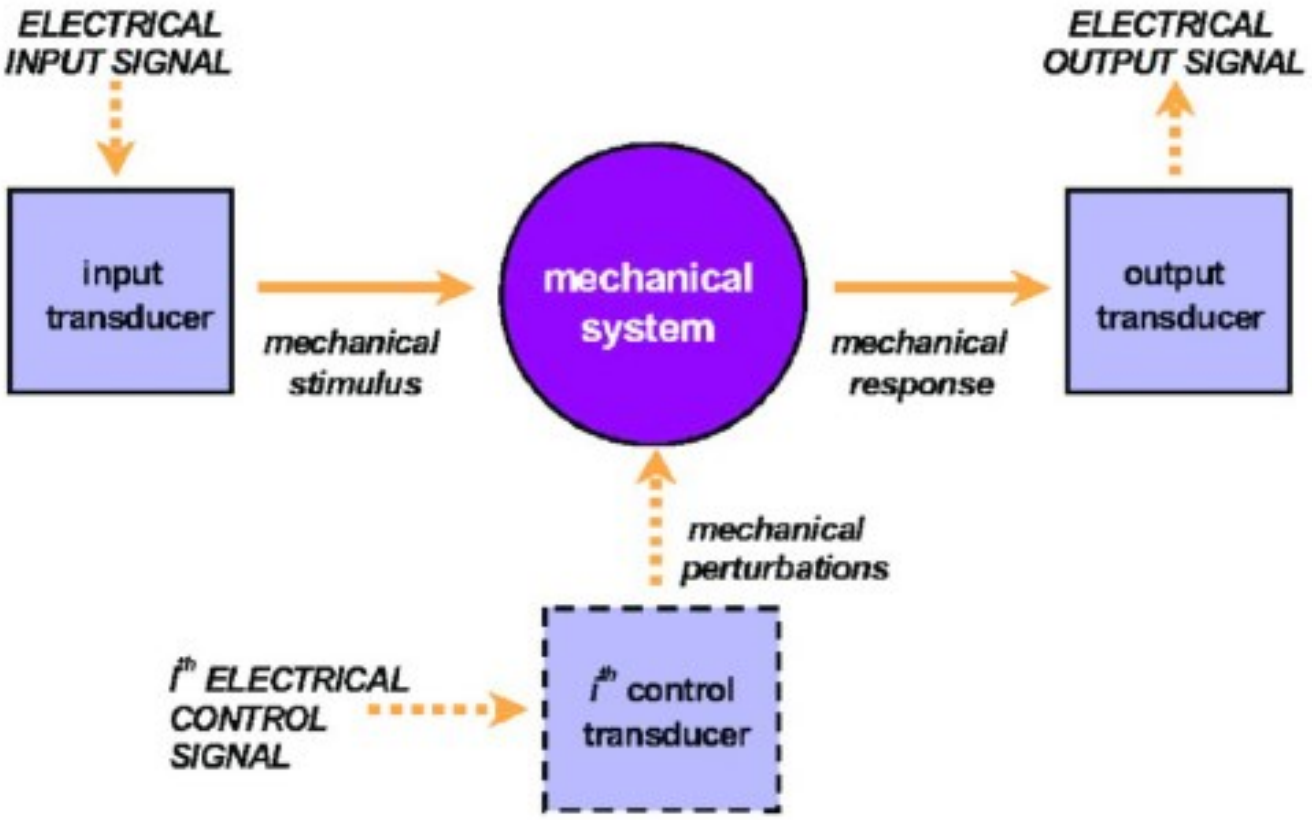
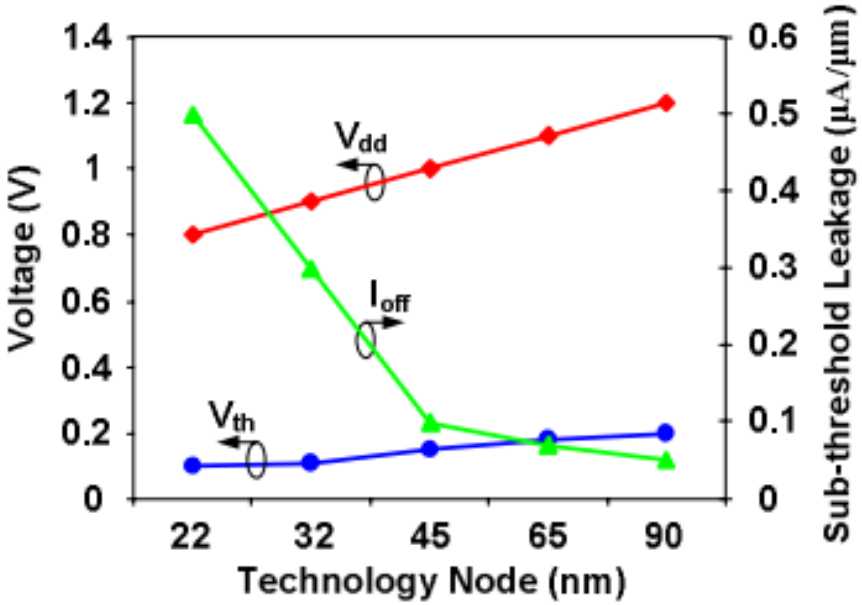
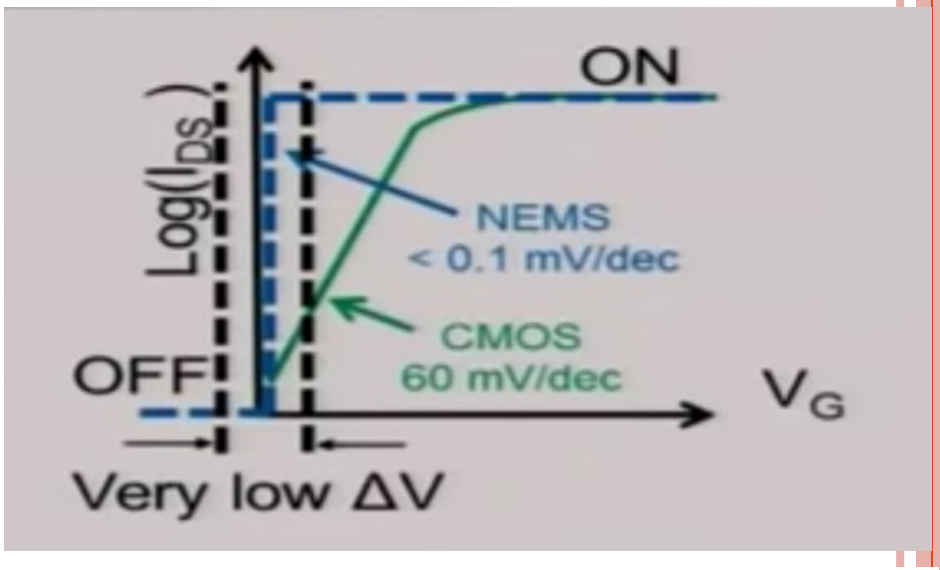


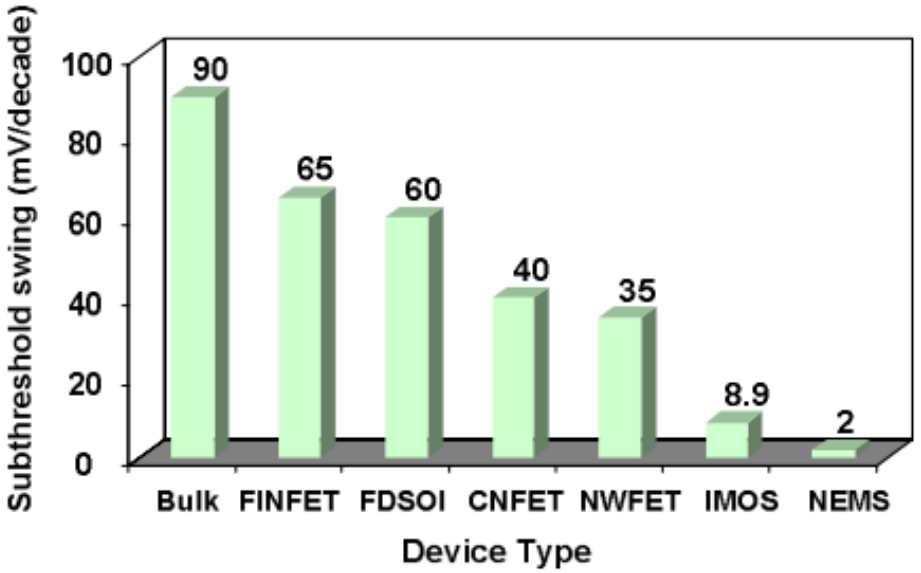
FIG. 2. (Color online). Schematic representation of a multiterminal electro-mechanical device.

WHY COMPUTING WITH NEMS SWITCHES

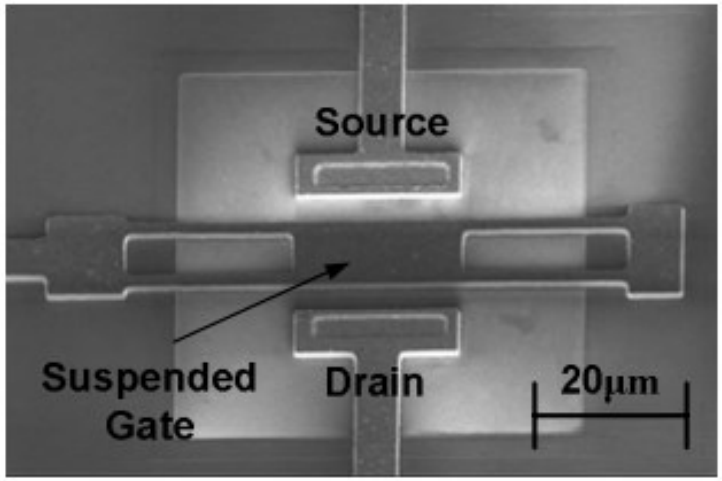




- NEMS' Merits:
  - No Leakage
  - High ON/OFF
  - Fast (High f_0)
  - High-T OK
  - Radiation OK
  - Size Good (< MOSFET)
  - Low Op. Power
- Possibilities:
  - All Mechanical
  - Hybrid NEMS-CMOS



NANO-ELECTRO-MECHANICAL SWITCHES (NEMS)



SEM picture of a SG-MOSFET switch with a 20μm long and 10μm wide suspended gate with four arms.

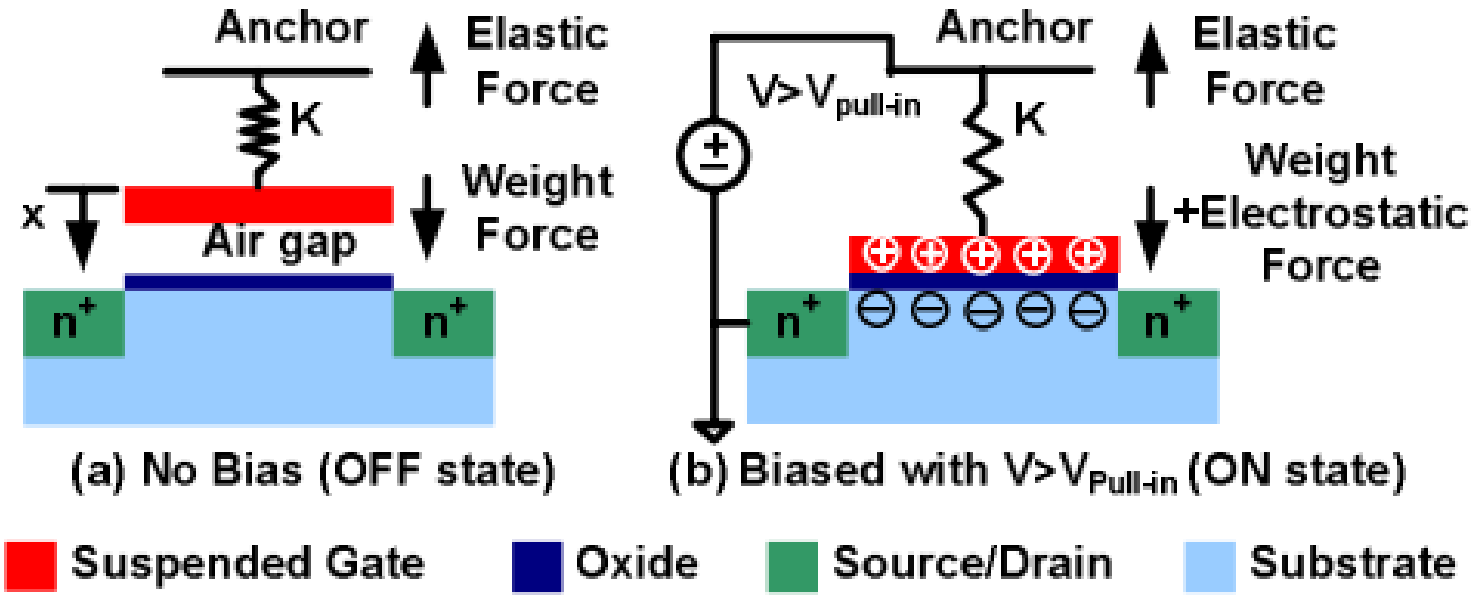


Figure 4. Basic operation of suspended gate NEMFET in ON and OFF states.

Alternative NEMFET Implementation

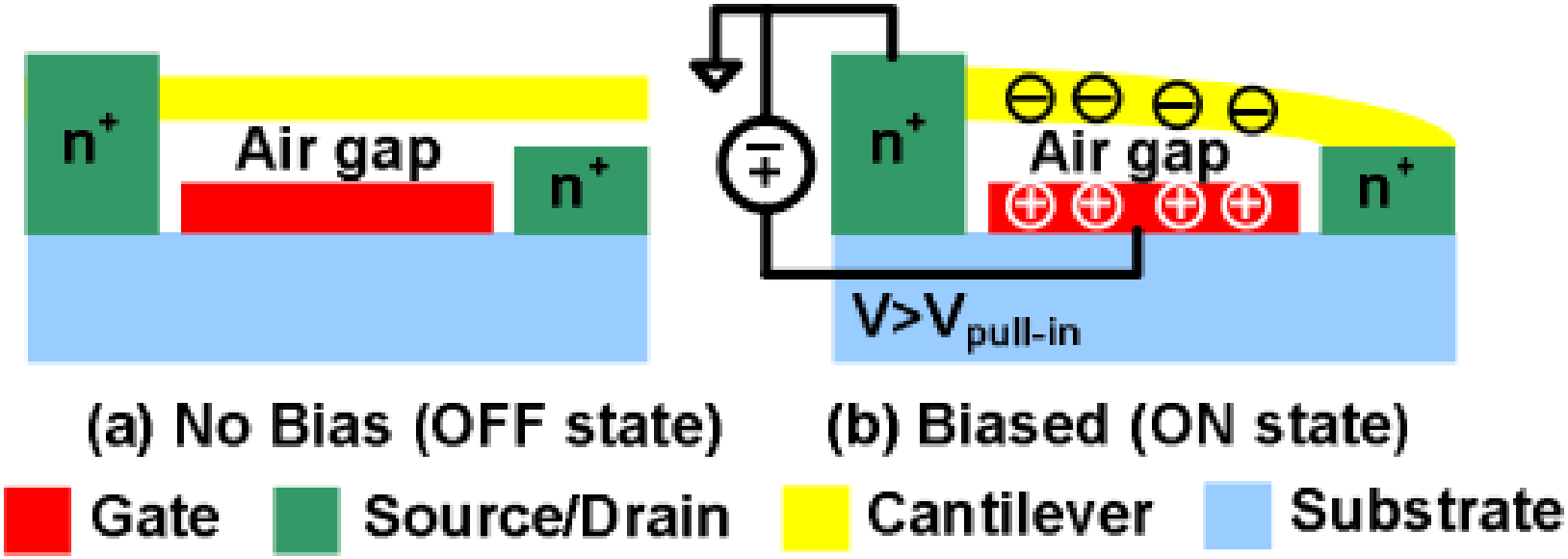
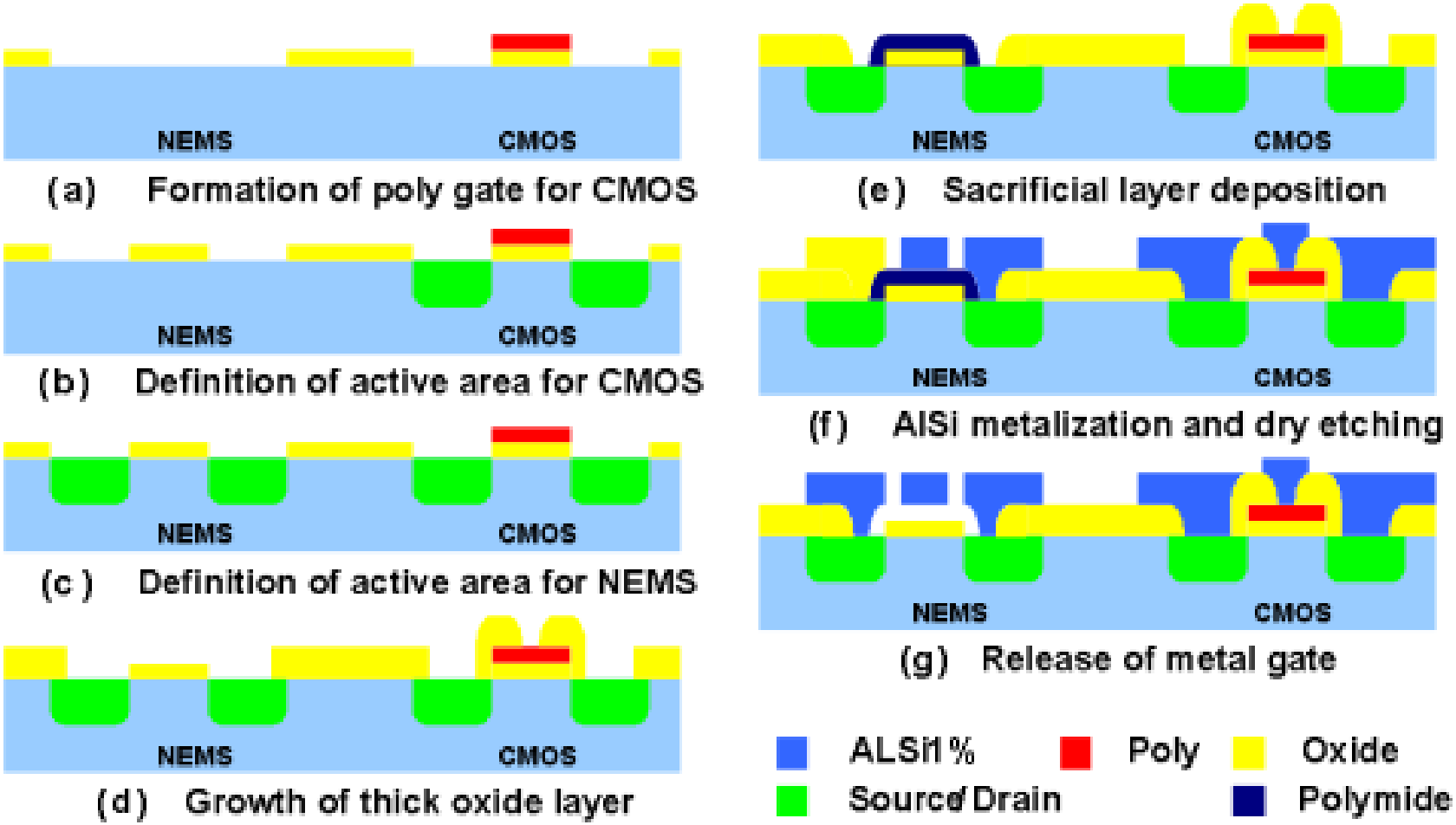


Figure 5. Cantilever or carbon nanotube based NEMFET in *ON* and *OFF* states.

Table 1. The I_{ON} and I_{OFF} values for NEMS and CMOS devices.

Device	I_{ON}	I_{OFF}
CMOS [4]	*1110 μA/μm*	*50 nA/μm*
NEMS [13]	*330 μA/μm*	*110 pA/μm*

FABRICATION OF HYBRID NEMS-CMOS CIRCUITS.



Application of Hybrid NEMS-CMOS in Dynamic Circuits

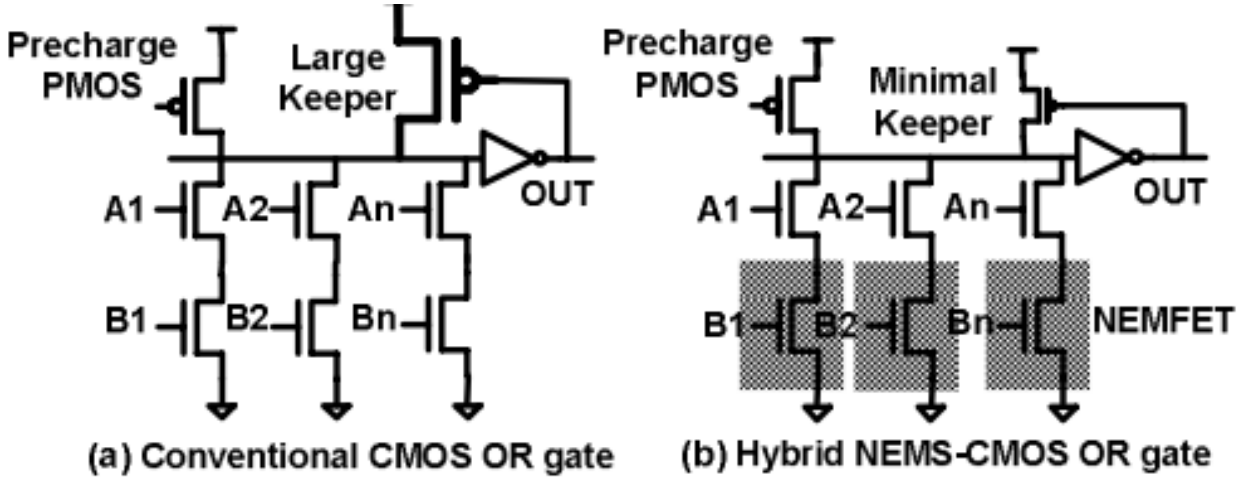
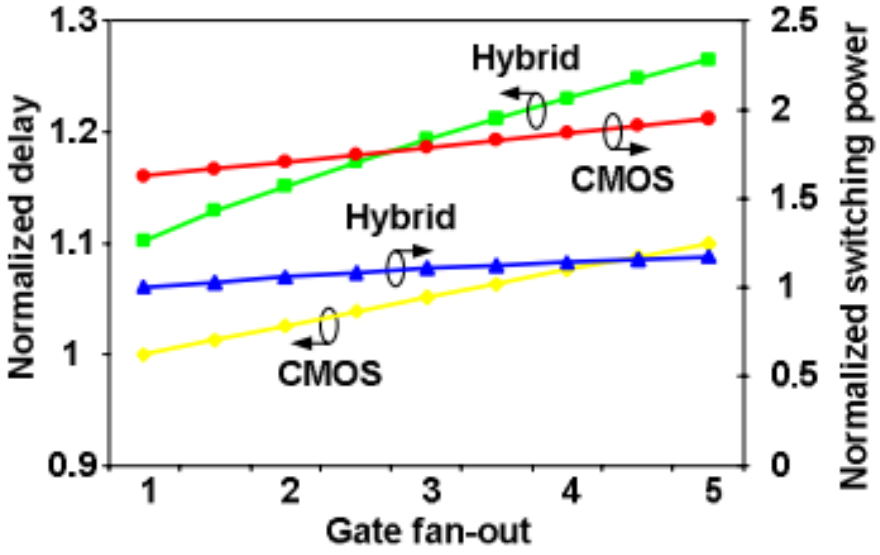
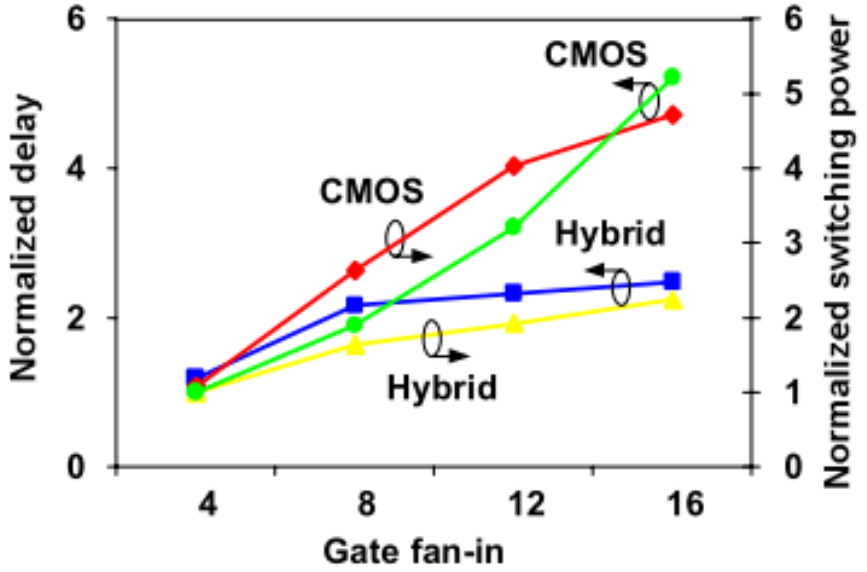
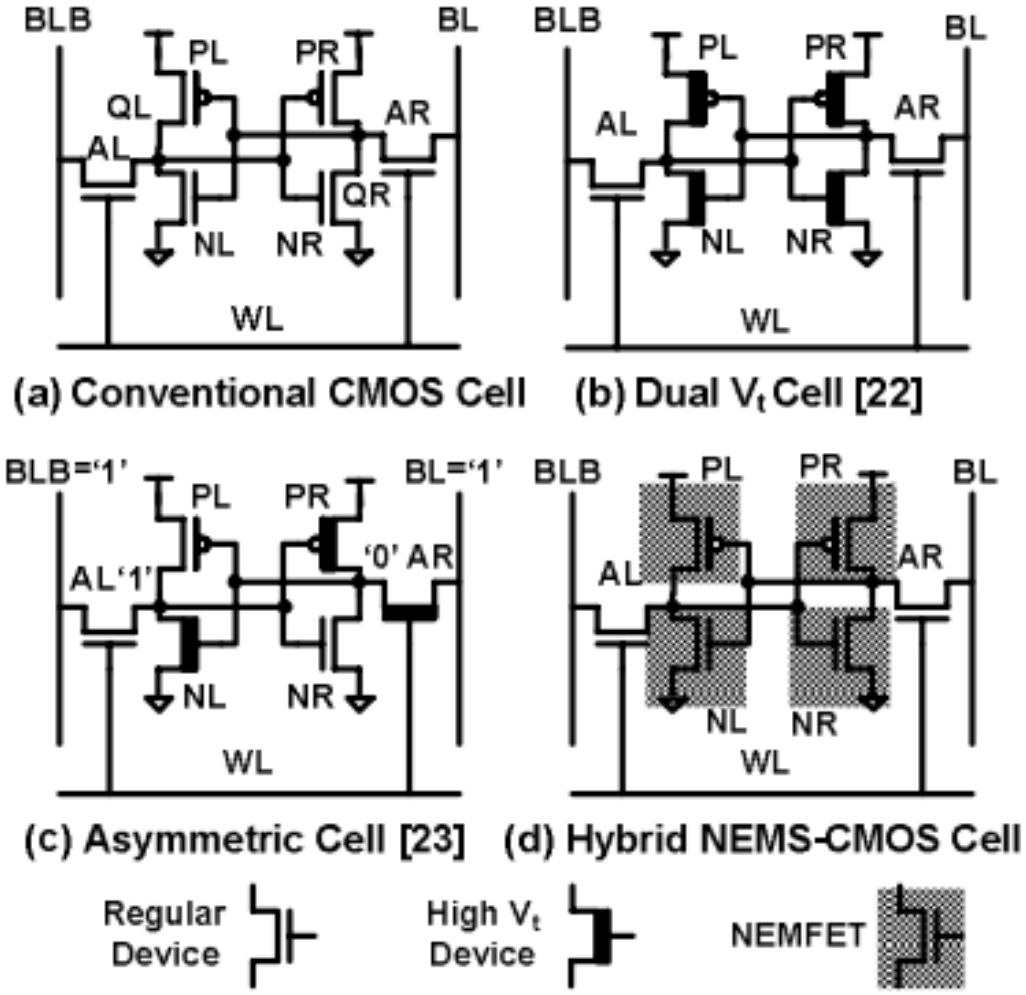


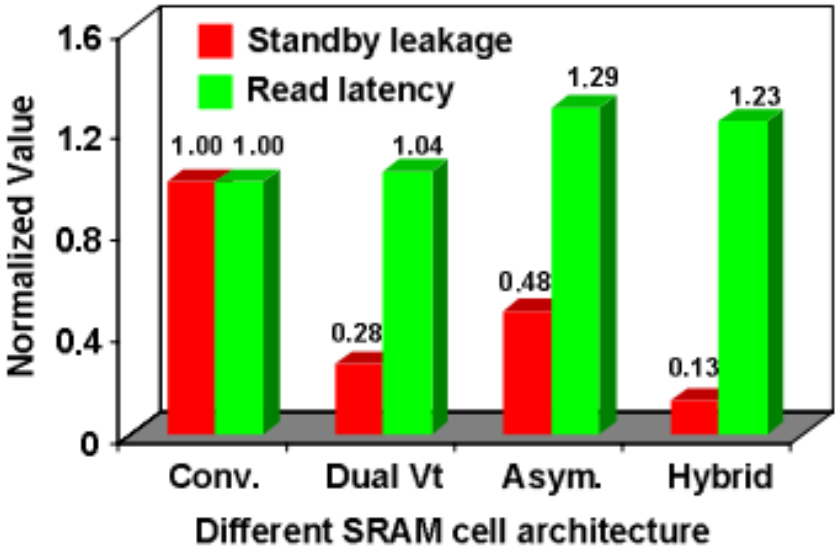
Figure 8. Conventional and proposed dynamic OR gates.



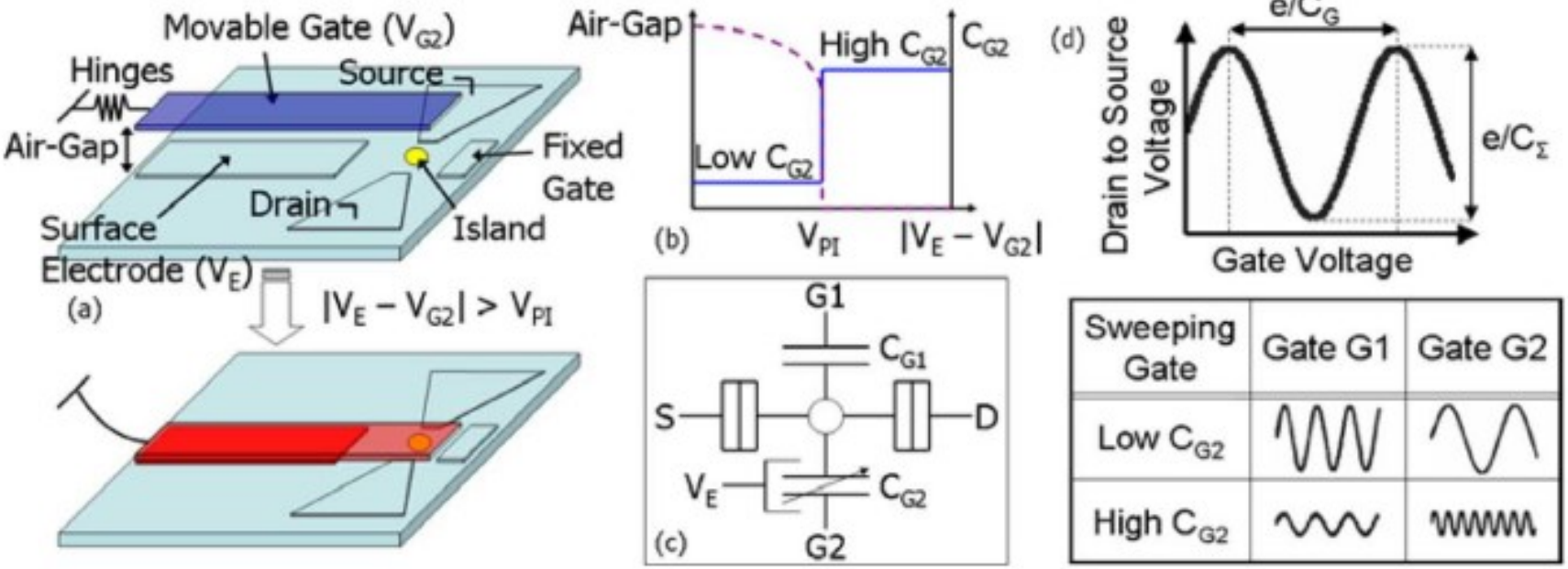


HYBRID NEMS-CMOS SRAM CELLS





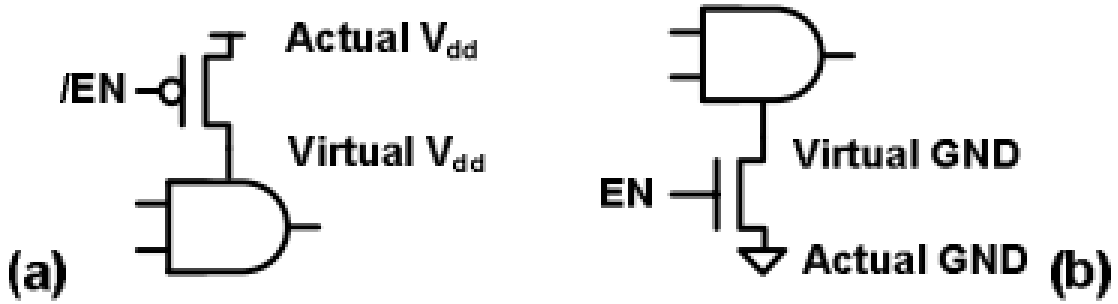
NEMS-GATE SET DEVICE



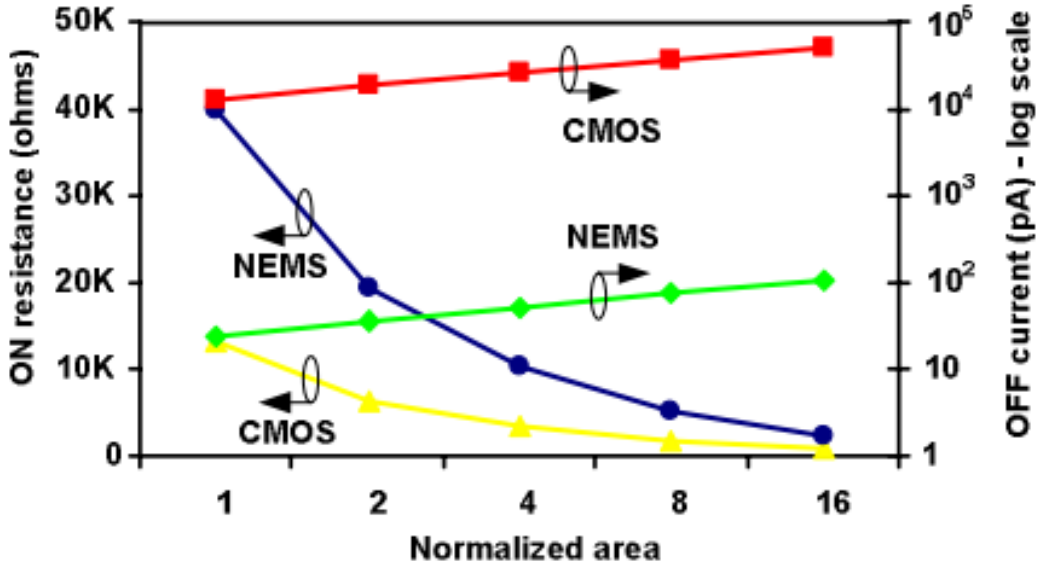
(a) Concept of NEMS-gate SET device. (b) Gate displacement (left axis) and corresponding capacitance (right axis) versus actuation voltage. (c) Electrical equivalent schematic. (d) Information encoding principle: sweeping gate G1: encoding in amplitude; sweeping gate G2: encoding in periodicity.

Application of NEMS Devices as Sleep Transistors

Sleep transistors refer to switches which are placed between the power supply and the circuit to reduce leakage current.



Different types of sleep transistors: (a) a header-type, (b) a footer-type,



Comparison between on resistance and off current of NEMS and CMOS sleep transistors. All areas are normalized w.r.t the area of a CMOS device with W/L=5 in 90 nm technology.

NEMS resonators are generally used inside electronic components. Therefore the mechanical vibration (resonance) need to be transferred into an electrical signal

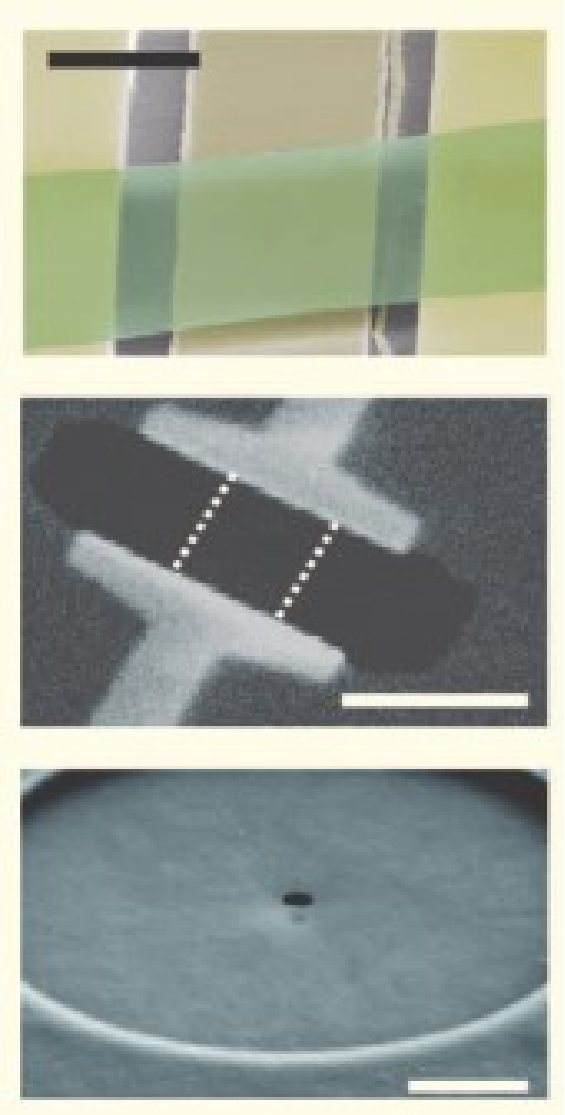
A transducer is used to convert mechanical into electrical signal (and vice versa) so that the resonator can be directly interfaced with electronics.

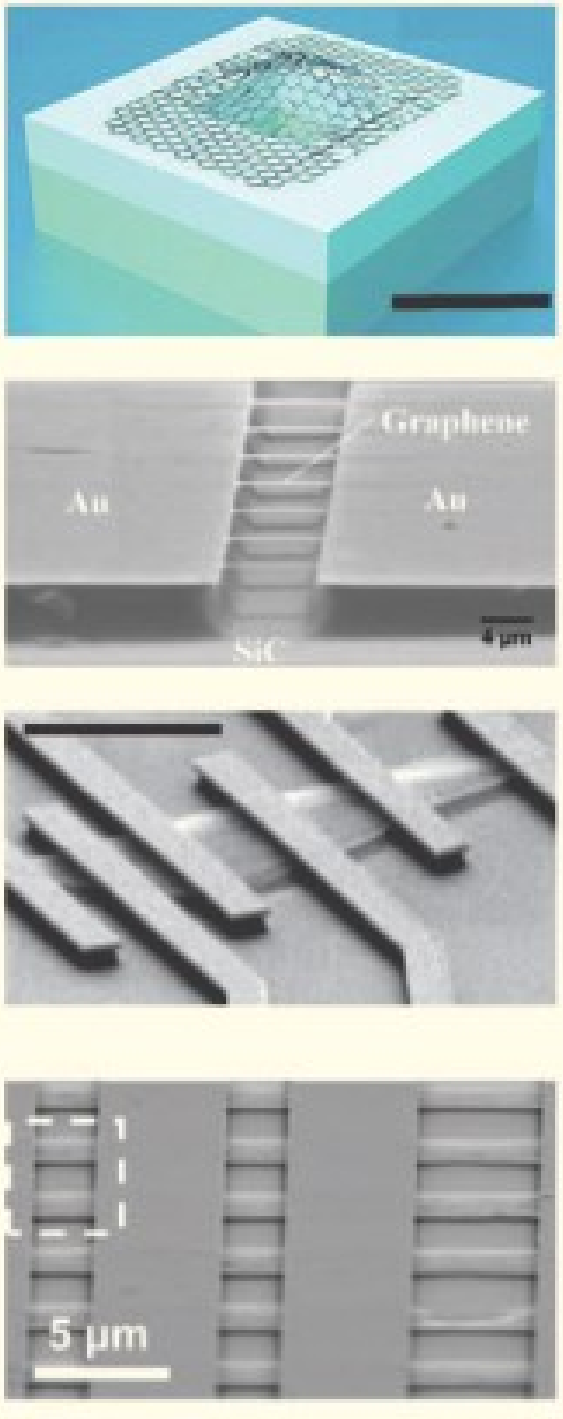
APPLICATIONS

- Mass Detection Using Variation in Resonance Frequency
- Oscillators
- Filters

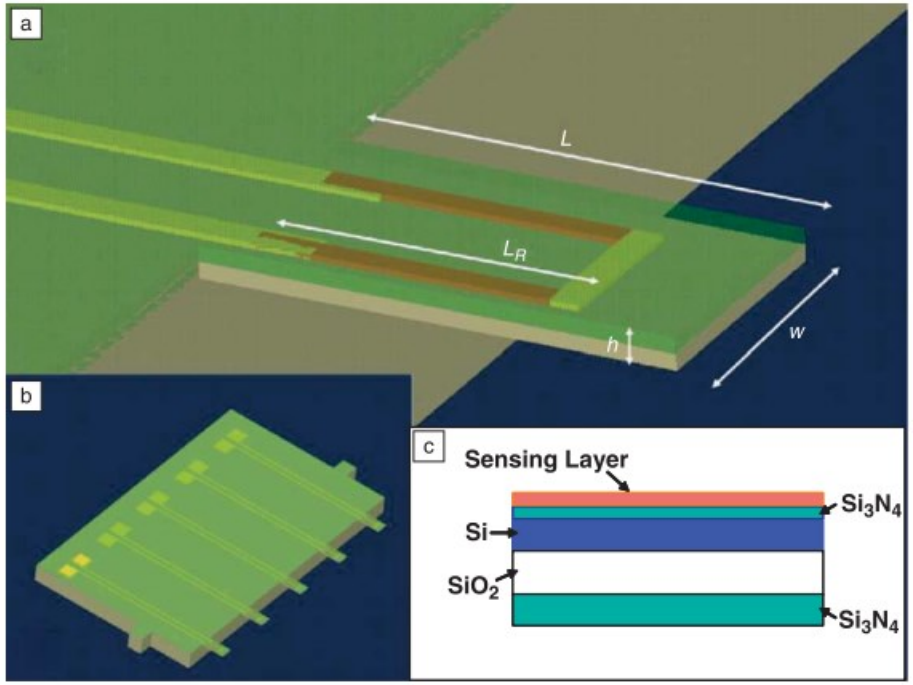
Natural frequency is what happens when you give a system a kick and then leave it alone: it may oscillate at a natural frequency, if one exists. Resonance is about what happens when you drive a system at a series of different frequencies: the response peaks near one particular frequency.

Graphene Mechanical Resonators

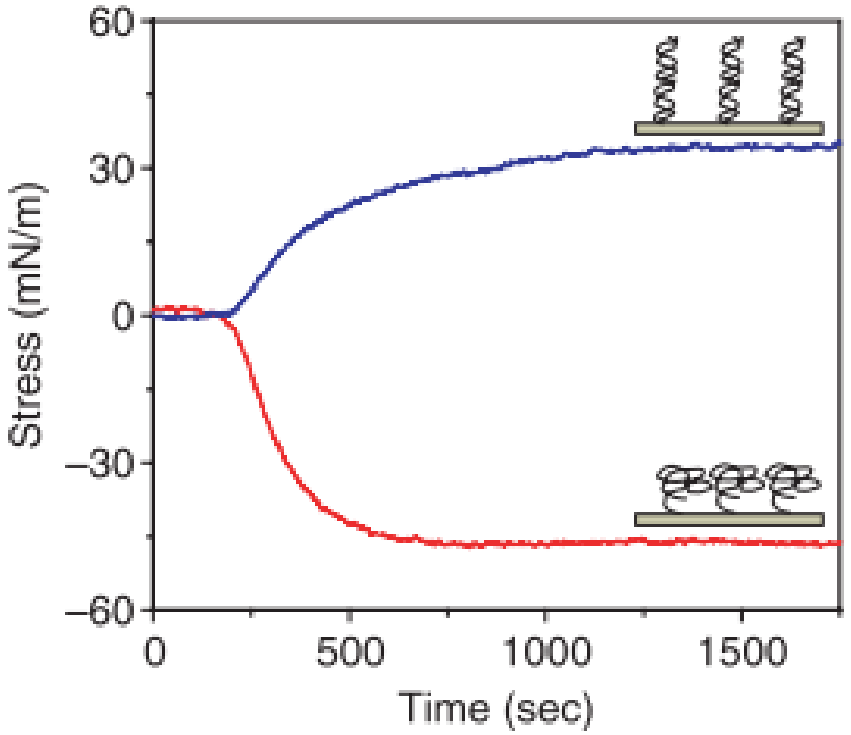




Detection of Specific DNA Sequences



(a) Schematic diagram of a cantilever
(b) An array of piezoresistive cantilevers
(c) Cross-sectional diagram through the layers of the cantilever sensors



A plot of the surface stress variations of a piezoresistive cantilever as a function of time. Inset schematics show configurations of ssDNA (below) and double stranded DNA (above).

Suspended Micro/Nano channel Resonators

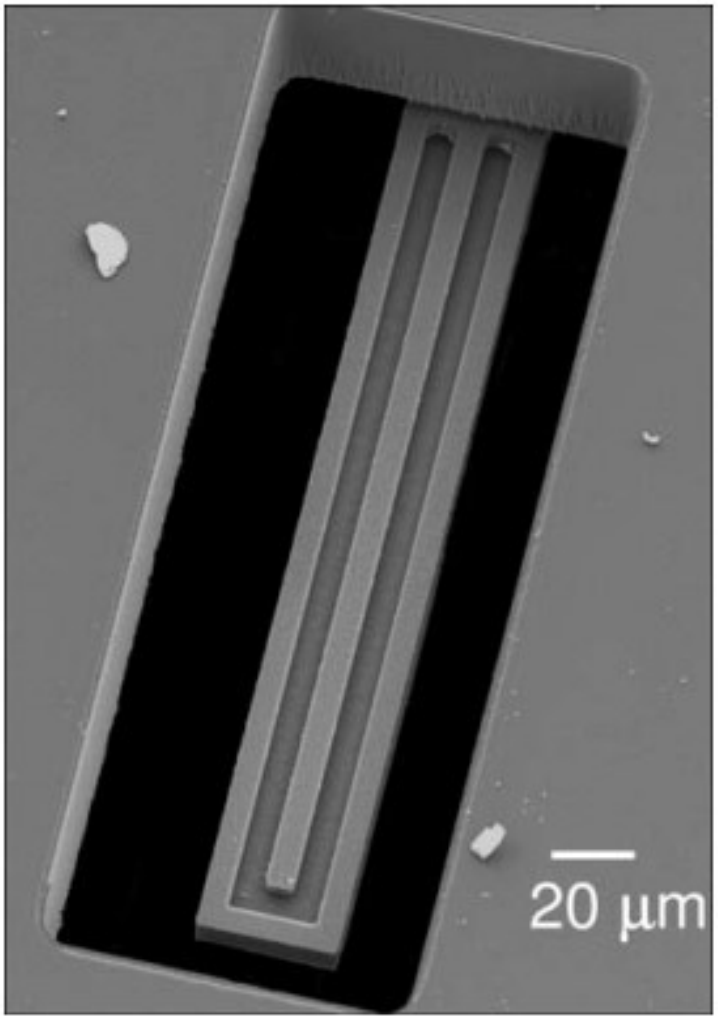


Figure 3. A scanning electron micrograph of a suspended channel microresonator. The channels can be seen inside the cantilever. The hollow cantilever vibrates inside a vacuum. (Image courtesy of S. Manalis, Massachusetts Institute of Technology.)

Changes in resonance frequency induced by the adsorption of cancer marker molecules and immobilized receptors can be used as a selective and sensitive method for monitoring the presence of cancer markers in the passing sample.

Additionally, single cells can be weighed as they pass through the suspended microchannel.

➢ APPLICATIONS OF NEMS

- **Accelerometer :**

  NEMS accelerometers are quickly replacing conventional accelerometers for crash air-bag deployment systems in automobiles.

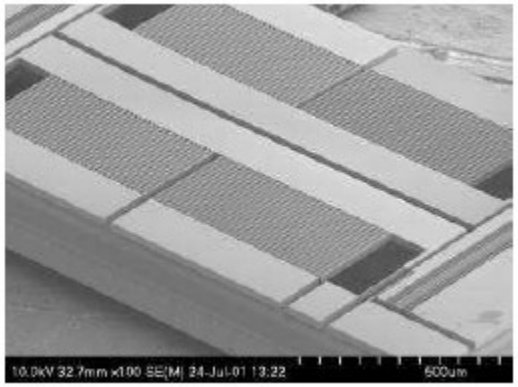


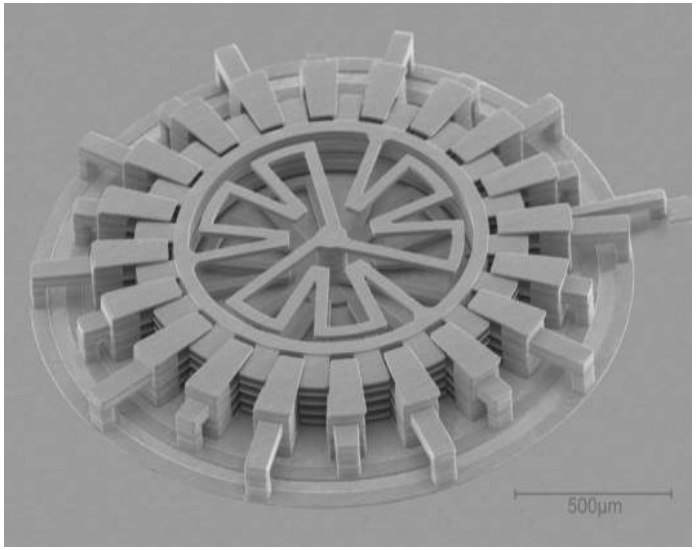
Figure 6 : Accelerometer (air bags)

- **Nano nozzles:**

- Another wide deployment of NEMS is their use as nano nozzles that direct the ink in inkjet printers.
- They are also used to create miniature robots (nano-robots) as well as nano-tweezers.
- NEMS have been rigorously tested in harsh environments for defense and aerospace where they are used as navigational gyroscopes.

- **Thermal actuator :**

- Thermal actuator is one of the most important NEMS devices, which is able to deliver a large force with large displacement.



SUMMARY

- Nano-systems have the enabling capability and potential similar to those of nano-processors .
- Since NEMS is a nascent and synergistic technology, many new applications will emerge, expanding the markets beyond that which is currently identified or known.

- NEMS is forecasted to have growth similar to its parent IC technology.
- For a great many applications, NEMS is sure to be the technology of the future.
- https://www.youtube.com/watch?v=CNmk-SeM0ZI
- https://www.youtube.com/watch?v=-EGWLkvT8LU

THANK YOU