International Journal of Engineering Research & Technology (IJERT)
NCETECE`14 Conference Proceedings
ISSN: 2278-0181

Advancement in Nanoscale Technology

Rizwana Akhtar
B.Tech., Electronics & Communication Engineering
Shrinathji Institute of Technology & Engineering
Nathdwara, India
Akhtar.rizwana@rediffmail.com

Monika Trivedi
B.Tech., Electronics & Communication Engineering
Shrinathji Institute of Technology & Engineering
Nathdwara, India
Monikatri2010@gmail.com

Nakul Audeechya
M.tech., VLSI Design
Institute of Technology & Management
Bhilwara, India
Nakul.audeechya@gmail.com

***Abstract*— Nanoscale technology may be a branch of technology during which customary size tools are wont to manufacture easy structures and devices with dimensions on the order of a number of nm s or less, wherever one nm (1 nm) is up to a billionth of a meter (10 -9 m). Nanoscale technology encompasses all of technology except molecular manufacturing, that involves the utilization of nanoscale (extremely small) tools to create structures, devices, and systems at the molecular level. technology has potential edges throughout a range of fields, in conjunction with water purification, sanitation, agriculture, energy (particularly photovoltaic's), home and business construction, computer manufacturing, communications, and drugs. Nanoscale technology refers to our ability to utilize our understanding of nanoscale science to fabricate merchandise with new properties and capabilities. to totally understand the probabilities, it becomes crucial to know quantum interactions at the nanoscale; to be able to see nanoscale structures; and to be able to kind, manipulate, and even connect nanostructures. Advanced imaging techniques change us to image the nanoworld, and scientists are presently commencing to fashion the tools we would like to manipulate and engineer nanoscale structures.**

***Index Terms*— Nanotechnology, nanoscience**

I. INTRODUCTION

Nanoscale technologies are enabling technologies that offer new functionality to products and processes. These developing technologies have a great potential to help address a number of societal challenges that we face today. The nanoscale technologies supply chain spans a broad space from primary production and processing, to product design, fabrication, measurement and characterisation, through to integration into final products and end of-life recycling. The semiconductor trade utilizes electron and optical lithography techniques to fabricate integrated circuits with billions of nanometer-size options on 8-inch semiconductor wafers (so-called "top-down" technology). currently scientists have learned to control individual molecules or fabricate nanowires and connect them for IP (so-called "bottom-up" technology). These technologies can have a dramatic result on future advances in drugs, biology, and energy, also as in materials science, semiconductor devices and engineering. Nanoscale materials and structures are so interesting is that size constraints often produce qualitatively new behavior. We now understand, in a general way, that when the sample size, grain size, or domain size becomes comparable with a specific physical length scale such as the mean free path, the domain size in ferromagnetism or ferroelectrics, the coherence length of phonons, or the correlation length of a collective ground state like superconductivity, then the corresponding physical phenomenon will be strongly affected. Although such changes in behavior can be the dominant effects in nanoscale structures, we still have remarkably little experience or intuition for the expected phenomena and their practical implications, except for electronic systems. The physics, chemistry and biology of phenomena occurring in nanoscale systems is effectively a new subject with its own set of physical principles, theoretical descriptions, and experimental techniques, which we are only in the process of discovering. Thus, there is an urgent need for broadly based investigations of the physical phenomena associated with confined systems, especially in materials and structural contexts where the implications are not at all well understood.

.

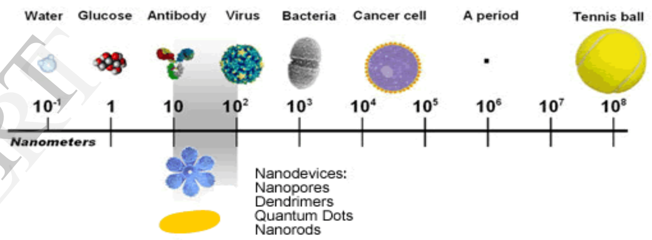

Fig 1: Nanoscale with nanodevices

Nanotechnology arises from the exploitation of latest properties, phenomena, processes, and functionalities that matter exhibits at intermediate sizes between isolated atoms or molecules (~ one nm) and bulk materials (over one hundred nm). As hostile the microscale, the nanoscale isn't simply another step towards miniaturisation, however could be a qualitatively new scale. Here quantum and size phenomena are allowed to manifest themselves either at a strictly quantum level or in an exceedingly sure "admixture" of quantum and classical parts. At the muse of nanosystems lie the quantum manifestations of matter that become relevant and measurable.

II. TECHNOLOGY OVERVIEW

In this section, we tend to discuss the categories of technology that represent nanoscale technologies. These square measure summarized because the following four areas:

•Materials
•Manufacturing of materials
•Measurement and characterization of materials and processes
•Device and system integration.

We additionally discuss a number of the present barriers to, and opportunities for, exploitation of current high-profile

ISSN: 2278-0181

nanoscale technologies, together with the queries round the potential health, safety and environmental impacts of the exploitation of nanoscale materials.

Nanoscale materials

A nanoscale material can be described as "a material having one or more external dimensions in the nanoscale (typically 1-100nm) or which is nanostructured"13, and which can exhibit properties that differ from those of the same material without nanoscale features. These specific properties can include:

- Large surface area and hence an increased active surface
- Quantum effects becoming dominant
- Changes in optical, magnetic, or electrical properties.

Nanoscale materials are:

- materials that have one dimension in the nanoscale (eg layers such as thin film coatings)
- materials that have two dimensions in the nanoscale (eg nanowires and nanotubes)
- materials that have three dimensions in the nanoscale (eg quantum dots and nanoparticles). Nanoscale materials can be, and usually are, incorporated into a final component or system (eg nanocomposites materials incorporating carbon nanotubes into a polymer matrix, or nanoparticles in personal care). The nanoscale materials which are of most concern when looking at potential health and safety issues through the material's life and its application within an occupational setting are:
- 'free' forms of two and three dimensional nanoscale materials, such as nanotubes or nanoparticles in the form of powder.
- materials containing two and three dimensional nanoscale materials, such as nanocomposites.

Moore's low

The ostensibly unshakeable accuracy of Moore's law—which states that the speed of computers, as measured by the quantity of transistors which will be placed on one chip, can double every year or two—has been credited with being the engine of the natural philosophy revolution, and is considered the premier example of a self-fulfilling prophecy and technological mechanical phenomenon in each the educational and well-liked press.

1 Predictions created exploitation the law become the premise for future production goals, that successively reinforces the validity of the law as a measuring of trade progress. during a speedily ever-changing environment, Moore's law has been delineate as "the only stable ruler" on that corporations will trust. 2 Glowing statements such as these seem curiously out of place when compared with the law's actual performance. Gordon E. Moore, a physical chemist who cofounded both Intel and Fairchild Semiconductor, first articulated what would later be identified as his law in a 1965 paper for Electronics magazine's 35th anniversary (for a biographical sketch of Moore, see the Biographies department in this issue). In his original 1965 paper, Moore asserted that the number of components that could be placed on a chip could be expected to double every year. Just 10 years later, Moore revised his prediction, stating that "the new slope might approximate a doubling every two years, rather than every year."3 Yet another form of Moore's law can be found in many recent technical and popular publications. A good representative of this version of Moore's law is the statement that appeared in one prominent business and technology journal: "Moore's law, celebrated as the defining rule of the modern world, states that the computer chip performance doubles every eighteen months."4 The apparent differences among these definitions make it difficult to view Moore's law as a single prediction, let alone an influential concept in the semiconductor industry.

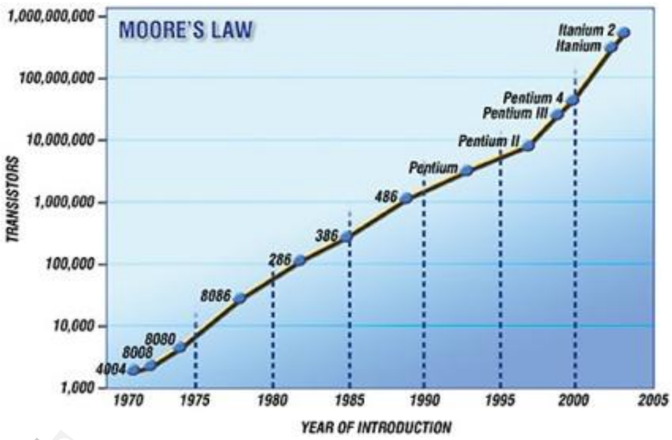

Fig. 2: Graph of Moore's low

III. Advancement in Nanoscale Technology

Nanoscale particles aren't new in either nature or science. However, the recent leaps in areas like research have given scientists new tools to grasp and make the most of phenomena that occur naturally once matter is organized at the nanoscale. In essence, these phenomena are based on "quantum effects" and alternative straightforward physical effects like swollen expanse (more on these below). Additionally, the very fact that a majority of biological processes occur at the nanoscale offers scientists models and templates to imagine and construct new processes which will enhance their add medication, imaging, computing, printing, chemical catalysis, materials synthesis, and lots of alternative fields. nanotechnology isn't merely performing at ever smaller dimensions; rather, performing at the nanoscale allows scientists to utilize the distinctive physical, chemical, mechanical, and optical properties of materials that naturally occur at that scale.

Scale at that Quantum Effects Dominate Properties of Materials-

When particle sizes of solid matter within the visible scale are compared to what is seen during a regular optical microscope, there's very little distinction within the properties of the particles. however when particles are created with dimensions of regarding 1–100 nanometers (where the particles is "seen" only with powerful specialised microscopes), the materials' properties amendment considerably from those at larger scales. this is often the dimensions scale wherever alleged quantum effects rule the behavior and properties of particles. Properties of materials are size-dependent during this scale

ISSN: 2278-0181

vary. Thus, when particle size is created to be nanoscale, properties like freezing point, visible radiation, electrical conduction, magnetic porosity, and chemical reactivity amendment as a operate of the dimensions of the particle

Scale at which much of Biology Occurs-
Over millennia, nature has formed the art of biology at the nanoscale. several of the inner workings of cells naturally occur at the nanoscale. for instance, hemoglobin, the supermolecule that carries atomic number 8 through the body, is 5.5 nanometers in diameter. A strand of deoxyribonucleic acid, one in every of the building blocks of human life, is merely regarding two nanometers in diameter. Drawing on the natural nanoscale of biology, several medical researchers ar performing on coming up with tools, treatments, and therapies that ar a lot of precise and customized than typical ones—and which will be applied earlier within the course of a illness and cause fewer adverse side-effects.

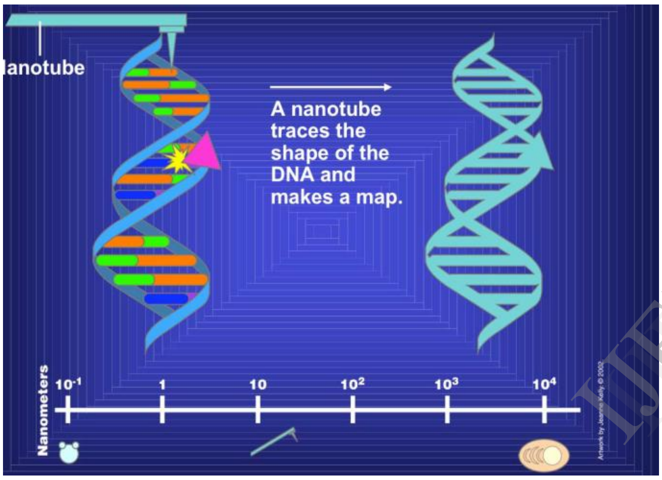

Fig. 3: DNA

One medical example of technology is that the bio-barcode assay, a comparatively cheap technique of detection disease-specific biomarkers within the blood, even once there ar only a few of them in a very sample. the essential method, that attaches "recognition" particles and deoxyribonucleic acid "amplifiers" to gold nanoparticles, was originally incontestible at Northwestern University for a prostatic adenocarcinoma biomarker following extirpation. The bio-barcode assay has tried to be significantly a lot of sensitive than typical assays for identical target biomarkers, and it will be custom-made to notice virtually any molecular target.

Scale at which Surfaces and Interfaces Play a Large Role in Materials Properties and Interactions-
Nanoscale materials have way larger surface areas than similar plenty of larger-scale materials. As area per mass of a fabric will increase, a bigger quantity of the fabric will acquire contact with close materials, so touching reactivity. a simple thought experiment shows why nanoparticles have phenomenally high surface areas. A solid cube of a fabric one cm on a aspect has half dozen sq. centimeters of area, concerning adequate one aspect of half a stick of gum. however if that volume of one cubic centimetre were stuffed with cubes one millimeter on a aspect, that will be one,000 millimeter-sized cubes (10 x 1 x 10), all of that includes a area of half dozen sq. millimeters, for a complete area of sixty sq. centimeters—about a similar in concert aspect of common fraction of a 3" x 5" note card. once the one cubic centimetre is stuffed with micrometer-sized cubes—a trillion (1012) of them, every with a area of half dozen sq. micrometers—the total area amounts to six sq. meters, or concerning the realm of the most rest room in a mean house. And once that single cubic centimetre of volume is stuffed with 1-nanometer-sized cubes—1021 of them, every with a locality of half dozen sq. nanometers—their total area involves 6,000 sq. meters.

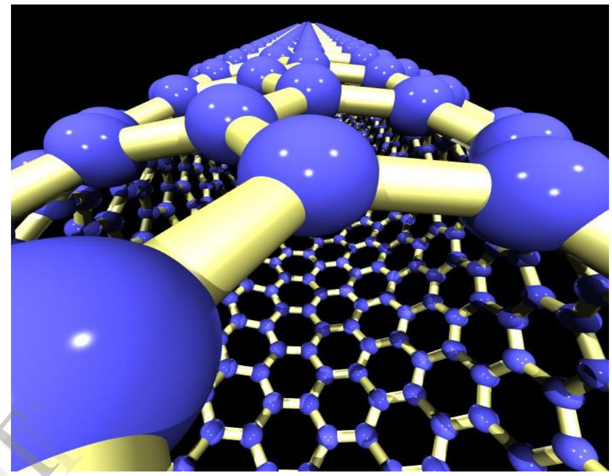
Fig. 4: Carbon nanotube

In alternative words, one milliliter of cubic nanoparticles has a total extent third larger than a athletic field.

Here authors bring out the engineering science in Si world that invariably suggests that shrinking pure mathematics of CMOS devices to nano scale. This conjointly refers to a brand new world of engineering science wherever chemists ar operating in producing of carbon nanotubes , nano devices of varius materials of nano dimensions while not even knowing however this might amendment the full world of Si and CMOS technology and also the world we tend to board.

1. **Nanotransisors**

It is needed to know and study on the carrier transport theory to know the negatron physical phenomenon behavior in transistors smaller than 20-nm. In nano-scale transistors, the amount of atoms within the active region is finite; the character of random distribution of atoms within the active region causes fluctuation in device property and deteriorates the look margins for integration. however, scientists and engineers in manufacturing plant master the variability in device

GaAs Wafers:

2" GAAs N(100) 350 M DSP

4" GaAs Si (100) 600M DSP

The materials that belong to the III and V cluster of tabular array and notice their distinguished place within the VLSI chips are GaP, GaSB, InAs, InSB and InP. the opposite wafers used are Quartz wafer, glass wafer, apires, semiconducting material compound wafers, semiconducting material wafers, semiconducting material Ga AS, coalesced silicon dioxide, Float zone silicon dioxide, undoped silicon dioxide characteristics, the mixing level of nanoscale transistors continues to rise yearly, and has exceeded 100-million transistors on a chip. Foundries have endowed heavily in Ramped and new facility to good the art of manufacturing such nanoscale devices with extraordinarily low defect density. The precise management of every step within the producing method flow ensures repeatability and uniformity. whereas devices are being miniaturized, the wafer size is enlarged to enhance productivity. The success of manufacturing such nanoscale devices in Associate in Nursing ever-increasing integration level on a much bigger size wafer and at lower defect density is that the „quiet" aspect of the nano-electronics evolution. A becoming archaic, 40-years previous, semiconducting material technology is currently being vulnerable.

2. **Nano chips**

A study of the documents from the analysis labs and promoting organization round the world reveal that idea of element wafers is undergoing a amendment slowly with the SOI and different chips. If CMOS applied science is to get replaced by CAEN, the provision of wafer spectrum for analysis wi; be as wide as follows:

A. SOI Wafers
SOI: element on material
2" SOIP(100) 500anstrom Si layer
4" SOINor P (100) Device 2-4 m
SOI layer diameter: 200mm
crystal orientation: <100> four deg off-axis
Dopant: N kind (Phosphor)
SOI layer thickness: 3.0 um
SOI layer resistivity: 5-20 ohm/cm
Buried Oxide: 1.0-1.5 um
Base Wafer Dopant: N kind (phosphor)
resistivity: 10-20 ohm/cm
thickness: 725 um

B. Si and Ga special wafers
Silicon Wafer special
DSP Silicon wafers P-type 1-0-0 Boron> 700 m-3000mm
(i) Thermal oxide layer (50.8mm-300mm) –1K-10 K of oxide
(ii) NITRIDE wafers: 4" N/Ph (100)

3. **Nano wires and Interconnects**

Stochastically assembled nanoscale architectures have the potential to realize device densities a hundred times bigger than today's CMOS. A key challenge facing nanotechnologies is dominant parallel sets of nanowires (NWs), like those in crossbars, employing a moderate range mesoscale wires. There are 3 strategies to try to this. the primary is predicated on compass point differentiation throughout manufacture, the second makes random connections between NWs and mesoscale wires, and therefore the third, a mask-based approach, interposes high-K between stuff region between NWs and mesoscale wires. every of those addressing schemes involves a random step in their implementation. The third approach is mask-based approach and shows that, when put next to the opposite 2 schemes, an outsized range of mesoscale management wires are necessary for its realization.

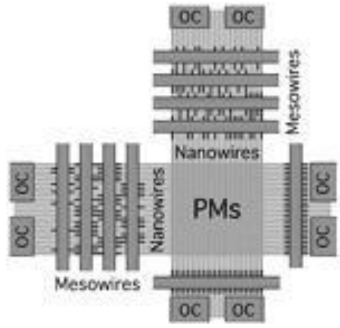

Fig. 5: Nano Interconnect

IV. WORKING AT NANOSCALE TECHNOLOGY

Nanotechnology is more than just mixing nanoscale materials together; it requires the ability to understand and to precisely manipulate and control those materials in a useful way. Nanotechnology involves a new and broad science where diverse fields such as physics, chemistry, biology, materials science, and engineering converge at the nanoscale. It is also important to understand that nanoscale materials are found in nature. For instance, hemoglobin, the oxygen-transporting protein found in red blood cells, is 5.5 nanometers in diameter. Naturally occurring nanomaterials exist all around us, such as in smoke from fire, volcanic ash, and sea spray. Some nanomaterials are a byproduct of human activity, such as bus and automobile exhaust and welding fumes. We may recall from the Size of the Nanoscale page that the nanoscale is about 1 to 100 nanometers. Working at the nanoscale requires an understanding of the various types and dimensions of nanoscale materials. Different types of nanomaterials are named for their individual shapes and dimensions. Think of these simply as particles, tubes, wires, films, flakes, or shells that have one or more nanometer-sized dimension. For example, carbon nanotubes have a diameter in the nanoscale, but can be several hundred nanometers long or even longer. Nanofilms or nanoplates have a thickness in the nanoscale, but their other two dimensions can be much larger. The key is to be able to both see and manipulate nanomaterials in order to take advantage of their special properties. As mentioned earlier, the invention of special microscopes gave scientists the ability to work at the nanoscale. The first of these new discoveries was the scanning tunneling microscope. While it's mainly designed to measure objects, it can also move tiny objects such as carbon nanotubes.

ISSN: 2278-0181

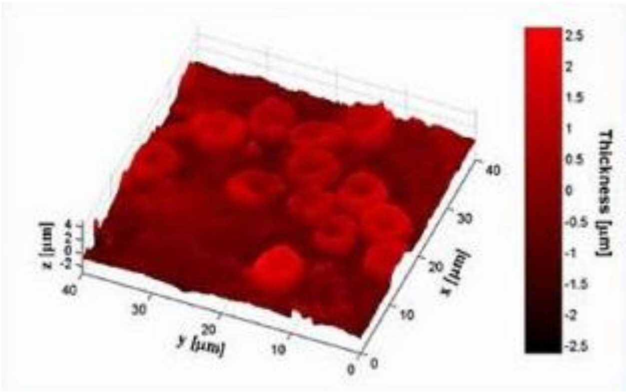

Fig. 6: Red blood cell

V. ADVANTAGES OF NANOSCALE TECHNOLOGY

As implied in "Introduction to Nanoscale Technology" this collection of technologies can benefit us in many ways, including better health, faster computers, and greater awareness of our environment. In some cases, nanoscale technologies will provide only an incremental improvement over existing technologies. But in other cases, they can open the door to new techniques, products, and even fields. Materials will become stronger; sensors will become cheaper, more sensitive, and detect a broader range of phenomena; computers will become faster and more efficient; medicine will improve in many ways.

- Processors with declining energy use and cost per gate, thus increasing efficiency of computer by 10^6
- Higher transmission frequencies and more efficient utilization of optical spectrum to provide at least 10 times the bandwidth now
- Small mass storage devices: multi-tera bit levels
- Integrated nanosensors: collecting, processing and communicating massive amounts of data with minimal size, weight, and power consumption
- Quantum computing
- Thermal barrier and wear resistant coatings
- High strength, light weight composites for increasing fuel
- Efficiency
- High temperature sensors for ‘under the hood’
- Improved displays
- Battery technology
- Automatic highways
- Wear-resistant tires

VI. APPLICATION OF NANOSCALE TECHNOLOGY

- Nanoscale additives in polymer composite materials for baseball bats, tennis rackets, motorcycle helmets, automobile bumpers, luggage, and power tool housings can make them simultaneously lightweight, stiff, durable, and resilient.
- Nanoscale additives to or surface treatments of fabrics help them resist wrinkling, staining, and bacterial growth, and provide lightweight ballistic energy deflection in personal body armor.
- Nanoscale thin films on eyeglasses, computer and camera displays, windows, and other surfaces can make them water- repellent, antireflective, self- cleaning, resistant to ultraviolet or infrared light, antifog, antimicrobial, scratch-resistant, or electrically conductive.
- Nanoscale materials in cosmetic products provide greater clarity or coverage; cleansing; absorption; personalization; and antioxidant, anti-microbial, and other health properties in sunscreens, cleansers, complexion treatments, creams and lotions, shampoos, and specialized makeup.
- Nanostructured ceramic coatings exhibit much greater toughness than conventional wear-resistant coatings for machine parts. In 2000, the U.S. Navy qualified such a coating for use on gears of air- conditioning units for its ships, saving $20 million in maintenance costs over 10 years. Such coatings can extend the lifetimes of moving parts in everything from power tools to industrial machinery.
- Nanoscale transistors that are faster, more powerful, and increasingly energy-efficient; soon your computer’s entire memory may be stored on a single tiny chip.
- Magnetic random access memory (MRAM) enabled by nanometer- scale magnetic tunnel junctions that can quickly and effectively save even encrypted data during a system shutdown or crash, enable resume-play features, and gather vehicle accident data.
- Displays for many new TVs, laptop computers, cell phones, digital cameras, and other devices incorporate nanostructured polymer films known as organic light-emitting diodes, or OLEDs. OLED screens offer brighter images in a flat format, as well as wider viewing angles, lighter weight, better picture density, lower power consumption, and longer lifetimes.

VII. CONCLUSION

Nanotechnology is a brand new technology that has just began; it is a revolutionary science that will change all what we knew before. The future that we were watching just in science fiction movies will in the near future be real. Nanoscience and nanotechnologies incorporate exciting areas of research and development at the interface between biology, chemistry and physics. They are widely seen as having huge potential, and are attracting substantial and increasing investments from governments and from industrial companies in many parts of the world. We have defined Nanoscience as the study of phenomena and manipulation of materials at atomic, molecular and macromolecular scales, where properties of matter differ significantly from those at a larger scale; and nanotechnologies as the design, characterisation, production and application of structures, devices and systems by controlling shape and size at nanometre scale.

Much of Nanoscience is concerned with understanding the properties of materials at the nanoscale and the effects of decreasing the size of materials or the structured components of materials. Nanoscale particles can exhibit, for example, different electrical, optical or magnetic properties from larger particles of the same material. Nanoscience is truly interdisciplinary, with an understanding of the physics and chemistry of matter and processes at the nanoscale being relevant to all scientific disciplines, from chemistry and physics to biology, engineering and medicine. Collaborations between researchers in different areas have enabled the sharing of knowledge, tools and techniques.

REFERENCES

[1] N. H. Bonadeo, G. Chen, D. Gammon, D. S. Katzer, D. Park, and D. G. Steel, "Nonlinear nano–optics: probing one exciton at a time," Phys. Rev. Lett. **81**, 2759 (1998); N. H.
[2] C. M. Marcus, A. J. Rimberg, R. M. Westervelt, P. F. Hopkins, and A. C. Gossard, "Conductance fluctuations and chaotic scattering in ballistic microstructures," Phys. Rev.
[3] J. R. Weertman, D. Farkas, K. Hemker, H. Kung, M. Mayo, R. Mitra, and H. Van Swygenhoven, MRS Bulletin, February 1999, pp. 44–50.
[4] T. I. Kamins and S. Williams, "Lithographic positioning of self–assembled Ge islands on Si(001)," Appl. Phys. Lett. **71**, 1201 (1997).
[5] See e.g., C. C. Koch, in Materials Science and Technology, Vol. 15, ed. R. W. Cahn, P. Haasen, and E. J. Kramer, V. C. H Weinheim, p. 193 (1991).
[6] R. H. Magruder III, Y. Li, R. F. Haglund Jr, C. W. White, L. Yang, R. Dorsinville, R. R. Alfano "Optical properties of gold nanocluster composites formed by deep ion implantation in silica," Appl. Phys. Lett. **62**, 1730 (1993).
[7] F. Garrido, J. C. Dran, L. Thome, C. Meneghini, F. Gonella, and A. Quaranta, "High– energy ion–beam mixing: a new route to form metallic nanoclusters in a dielectric matrix," Nucl. Instr. Meths. **B115**, 561 (1996).
[8] B. Alberts, D. Bray, J. Lewis, M. Raff, K. Roberts, J. Watson Eds., "Molecular Biology of the Cell–3rd Ed.," (Garland Publishing, New York, NY), p 385–479.