A

Seminar report

on

NanoTechnology

Submitted in partial fulfillment of the requirement for the award of degree
Of CSE

SUBMITTED TO:

www.studymafia.org

SUBMITTED BY:

www.studymafia.org

Preface

I have made this report file on the topic **NanoTechnology ;** I have tried my best to elucidate all the relevant detail to the topic to be included in the report. While in the beginning I have tried to give a general view about this topic.

My efforts and wholehearted co-corporation of each and everyone has ended on a successful note. I express my sincere gratitude to …………..who assisting me throughout the preparation of this topic. I thank him for providing me the reinforcement, confidence and most importantly the track for the topic whenever I needed it.

TABLE OF CONTENTS

1. Introduction

Molecular nanotechnology or Nanotechnology is the name given to a specific sort of manufacturing technology to build things from the atom up, and to rearrange matter with atomic precision. In other words, we can say that nanotechnology is a three dimensional structural control of material and devices at molecular level. The nanoscale structures can be prepared, characterized, manipulated, and even visualized with tools.

“Nanotechnology is a tool-driven field."

Other terms, such as molecular engineering or molecular manufacturing are also often applied when describing this emerging technology. This technology does not yet exist. But, scientists have recently gained the ability to observe and manipulate atoms directly. However, this is only one small aspect of a growing array of techniques in nanoscale science and technology. The ability to make commercial products may yet be a few decades away.

“Nanotechnology is Engineering, Not Science.”

The central thesis of nanotechnology is that almost any chemically stable structure that is not specifically disallowed by the laws of physics can in fact be built. Theoretical and computational models indicate that molecular manufacturing systems are possible — that they do not violate existing physical law. These models also give us a feel for what a molecular manufacturing system might look like. Melting pot of science combining applications of physics, chemistry, biology, electronics and computers. Today, scientists are devising numerous tools and techniques that will be needed to transform nanotechnology from computer models into reality.

Nanotechnology is often called the science of the small. It is concerned with manipulating particles at the atomic level, usually in order to form new compounds or make changes to existing substances. Nanotechnology is being applied to problems in electronics, biology, genetics and a wide range of business applications.

Matter is composed of small atoms that are closely bound together, making up the molecular structure, which, in turn determines the density of the concerned material. Since different factors such as molecular density, malleability, ductility and surface tension come into play, nanosystems have to be designed in a cost effective manner that overrides these conditions and helps to create machines capable of withstanding the vagaries of the environment.

Let us take the case of metals. Metals, solids in particular, consist of atoms held together by strong structural forces, which enable metals to withstand high temperatures. Depending upon the exertion of force or heat, the molecular structure bends in a particular fashion, thereby acquiring a definite space in the form of a lattice structure. When the bonding is strong, the metal is able to withstand pressure. Else it becomes brittle and finally breaks up. So, only the strongest, the hardest, the highest melting point metals are worth considering as parts of nanomachines.

The trick is to manipulate atoms individually and place them exactly where needed, to produce the desired structure. It is a challenge for the scientists to understand the size, shape, strength, force, motion and other properties while designing the nano machines. The idea of nanotechnology is therefore to master over the characteristics of matter in an intelligent manner to develop highly efficient systems.

The key aspect of nanotechnology is that **nanoscale materials offer different chemical and physical properties than the bulk materials, and that these properties could form the basis of new technologies.**

For example, scientists have

learned that the electronic--and hence optical--properties of nanometer-size particles can be tuned by adjusting the particle size. According to a recent study by a group at Georgia Institute of Technology, when gold metal is reduced to nanosize rods, its fluorescence intensity is enhanced over 10 million-fold. The study found that the wavelength of the emitted light increases linearly with the rod length, while the light intensity increases with the square of the rod length.

2. HISTORY OF NANOTECHNOLOGY

Any advanced research carries inherent risks but nanotechnology bears a special burden. The field's bid for respectability is colored by the association of the word with a cabal of futurist who foresee nano as a pathway to a techno-utopia: unparalleled prosperity, pollution-free industry, even something resembling eternal life.

In 1986-five years after IBM researchers Gerd Binnig and Heinrich Rohrer invented the scanning tunneling microscope, which garnered them the Nobel Prize-the book Engines of Creation, by K. Eric Drexler, created a sensation for its depiction of godlike control over matter. The book describes self-replicating nanomachines that could produce virtually any material good, while reversing global warming, curing disease and dramatically extending life spans. Scientists with tenured faculty positions and NSF grants ridiculed these visions, noting that their fundamental improbability made them an absurd projection of what the future holds.

But the visionary scent that has surrounded nanotechnology ever since may provide some unforeseen benefits. To many nonscientists, Drexler's projections for nanotechnology straddled the border between science and fiction in a compelling way. Talk of cell-repair machines that would eliminate aging as we know it and of home food-growing machines that could produce victuals without killing anything helped to create a fascination with the small that genuine scientists, consciously or not, would later use to draw attention to their work on more mundane but eminently more real projects. Certainly labeling a research proposal "nanotechnology" has a more alluring ring than calling it "applied mesoscale materials science."

Less directly, Drexler's work may actually draw people into science. His imaginings have inspired a rich vein of science-fiction literature . As a subgenre of science fiction-rather than a literal prediction of the future-books about Drexlerian nanotechnology may serve the same function as Star Trek does in stimulating a teenager's interest in space, a passion that sometimes leads to a career in aeronautics or astrophysics.

The danger comes when intelligent people take Drexler's predictions at face value. Drexlerian nanotechnology drew renewed publicity last year when a morose Bill Joy, the chief scientist of Sun Microsystems, worried in the magazine Wired about the implications of nanorobots that could multiply uncontrollably.

A spreading mass of self-replicating robots-what Drexler has labeled "gray goo"-could pose enough of a threat to society, he mused, that we should consider stopping development of nanotechnology. But that suggestion diverts attention from the real nano goo: chemical and biological weapons.

3. NANOTECHNOLOGY TOOLS

What would it mean if we could inexpensively make things with every atom in the right place? For starters, we could continue the revolution in computer hardware right down to molecular gates and wires -- something that today's lithographic methods (used to make computer chips) could never hope to do. We could inexpensively make very strong and very light materials: shatterproof diamond in precisely the shapes we want, by the ton, and over fifty times lighter than steel of the same strength.

We could make a Cadillac that weighed fifty kilograms, or a full-sized sofa you could pick up with one hand. We could make surgical instruments of such precision and deftness that they could operate on the cells and even molecules from which we are made -- something well beyond today's medical technology. The list goes on -- almost any manufactured product could be improved, often by orders of magnitude.

3.1 THE ADVANTAGES OF POSITIONAL CONTROL

One of the basic principles of nanotechnology is positional control. At the macroscopic scale, the idea that we can hold parts in our hands and assemble them by properly positioning them with respect to each other goes back to prehistory:

At the molecular scale, the idea of holding and positioning molecules is new and almost shocking. However, as long ago as 1959 Richard Feynman, the Nobel prize winning physicist, said that nothing in the laws of physics prevented us from arranging atoms the way we want: "...it is something, in principle, that can be done; but in practice, it has not been done because we are too big."

Before discussing the advantages of positional control at the molecular scale, it's helpful to look at some of the methods that have been developed by chemists -- methods that don't use positional control, but still let chemists synthesize a remarkably wide range of molecules and molecular structures.

3.2 SELF ASSEMBLY

The ability of chemists to synthesize what they want by stirring things together is truly remarkable. Imagine building a radio by putting all the parts in a bag, shaking, and pulling out the radio -- fully assembled and ready to work! Self assembly -- the art and science of arranging conditions so that the parts themselves spontaneously assemble into the desired structure -- is a well established and powerful method of synthesizing complex molecular structures.

A basic principle in self assembly is selective stickiness: if two molecular parts have complementary shapes and charge patterns -- one part has a hollow where the other part has a bump, and one part has a positive charge where the other part has a negative charge -- then they will tend to stick together in one particular way. By shaking these parts around -- something which thermal noise does for us quite naturally if the parts are floating in solution -- the parts will eventually, purely by chance, be brought together in just the right way and combine into a bigger part. This bigger part can combine in the same way with other parts, letting us gradually build a complex whole from molecular pieces by stirring them together and shaking.

Many viruses use this approach to make more viruses -- if you stir the parts of the T4 bacteriophage together in a test tube, they will self assemble into fully functional viruses.

3.3 POSITIONAL DEVICES AND POSITIONALLY CONTROLLED REACTIONS

While self assembly is a *path* to nanotechnology, by itself it would be hard pressed to make the very wide range of products promised by nanotechnology. We don't know how to self assemble shatterproof diamond, for example. During self assembly the parts bounce around and bump into each other in all kinds of ways, and if they stick together when we don't *want* them to stick together, we'll get unwanted globs of random parts. Many types of parts have this problem, so self assembly won't work for them. To make diamond, it seems as though we need to use indiscriminately sticky parts (such as radicals, carbenes and the like). These parts can't be allowed to randomly bump into each other (or much of anything else, for that matter) because they'd stick together when we didn't want them to stick together and form messy blobs instead of precise molecular machines.

We can avoid this problem if we can hold and position the parts. Even though the molecular parts that are used to make diamond are both randomly and *very* sticky (more technically, the barriers to bond formation are low and the resulting covalent bonds are quite strong), if we can position them we can prevent them from bumping into each other in the wrong way. When two sticky parts do come into contact with each other, they'll do so in the right orientation because we're *holding* them in the right orientation. In short, positional control at the molecular scale should let us make things which would be difficult or impossible to make without it. If we are to position molecular parts we must develop the molecular equivalent of "arms" and "hands." We'll need to learn what it means to "pick up" such parts and "snap them together."

We'll have to understand the precise chemical reactions that such a device would use. One of the first questions we'll need to answer is: what does a molecular-scale positional device look like? Current proposals are similar to macroscopic robotic devices but on a much smaller scale. The illustrations (Fig 1 & 2) show a design for a molecular-scale robotic arm proposed by Eric Drexler, a pioneering researcher in the field. Only 100 nanometers high and 30 nanometers in diameter, this rather squat design has a few million atoms and roughly a hundred moving parts. It uses no lubricants, for at this scale a lubricant molecule is more like a piece of grit. Instead, the bearings are "run dry" as described in the following paragraph.

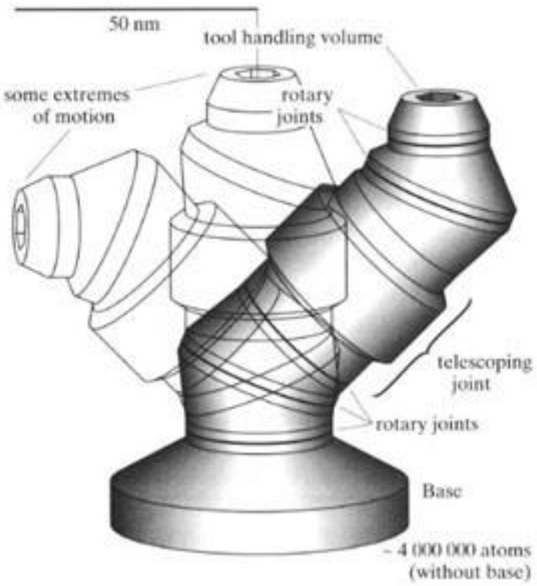


Fig 1 Drexler’s proposed robotic arm

Running bearings dry should work both because the diamond surface is very slippery and because we can make the surface very smooth -- so smooth that there wouldn't even be molecular-sized asperities or imperfections that might catch or grind against each other. Computer models support our intuition: analysis of the bearings shown here using computational chemistry programs shows they should rotate easily.

3.4 STIFFNESS

Molecular arms will be buffeted by something we don't worry about at the macroscopic scale: thermal noise. This makes molecular-scale objects wiggle and jiggle, just as Brownian motion makes small dust particles bounce around at random. The critical property we need here is *stiffness*. Stiffness is a measure of how far something moves when you push on it. If it moves a lot when you push on it a little, it's not very stiff. If it doesn't budge when you push hard, it's very stiff.

3.5 SCANNING TUNNELING MICROSCOPE (STM)

The STM is a device that can position a tip to atomic precision near a surface and can move it around. The scanning tunneling microscope is conceptually quite simple. It uses a sharp, electrically conductive needle to scan a surface. The position of the tip of the needle is controlled to within 0.1 angstrom (less than the radius of a hydrogen atom) using a voltage-controlled piezoelectric drive. When the tip is within a few angstroms of the surface and a small voltage is applied to the needle, a tunneling current flows from the tip to the surface. This tunneling current is then detected and amplified, and can be used to map the shape of the surface, such as a blind man tapping in front of him with his cane, we can tell that the tip is approaching the surface and so can "feel" the outlines of the surface in front of us.

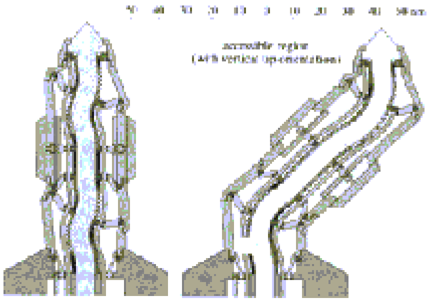


Fig. 2 Cross section of a stiff manipulator arm showing its range of motion
Many different types of physical interactions with the surface are used to detect its presence. Some scanning tunneling microscopes literally push on the surface -- and note how hard the surface pushes back. Others connect the surface and probe to a voltage source, and measure the current flow when the probe gets close to the surface. A host of other probe-surface interactions can be measured, and are used to make different types of STMs. But in all of them, the basic idea is the same: when the sharp tip of the probe approaches the surface a signal is generated -- a signal which lets us map out the surface being probed.

The STM cannot only map a surface; in many cases the probe-surface interaction changes the surface as well. This has already been used experimentally to spell out molecular words, and the obvious opportunities to modify the surface in a controlled way are being investigated both experimentally and theoretically.

4. NANOTECHNOLOGY SIZE CONCERNS

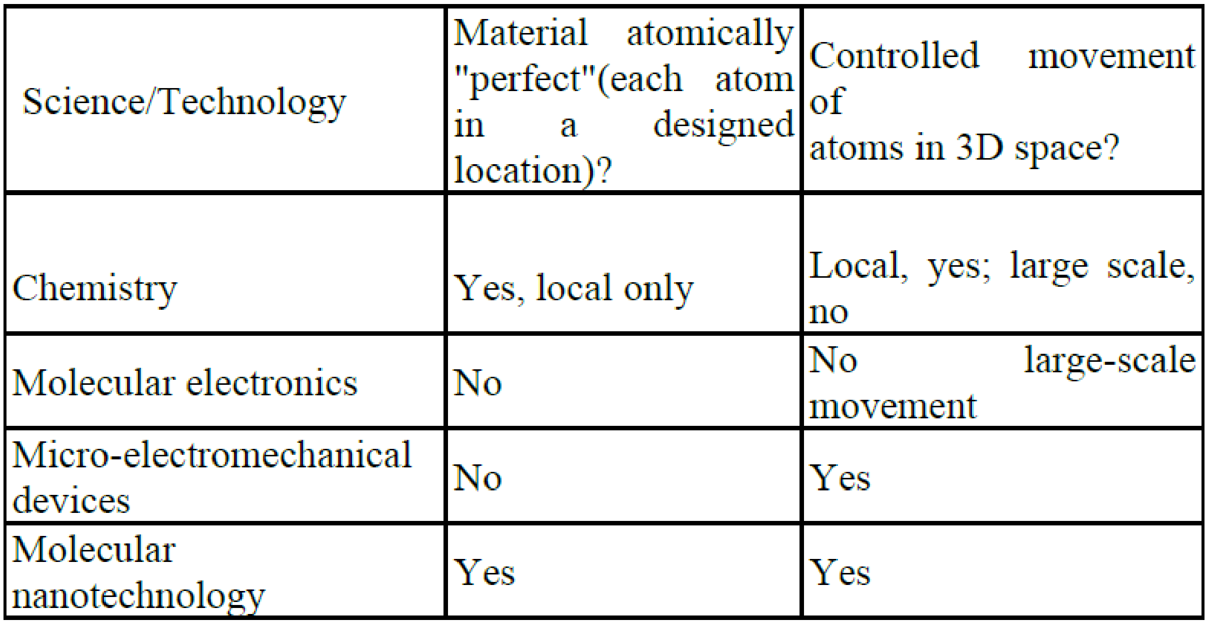
4.1 MEMS: MICRO INFORMATION SEEKERS

Micro-electromechanical system (MEMS) combines computers with tiny mechanical devices such as sensors, valves, gears, and actuators embedded in semiconductor chips. These elements are embedded in the mainframe of the system for carrying out the bigger task. As the elements are capable of carrying out varying tasks, they are usually reffered to as ‘smart matter’.

Nanotechnology is often confused with related fields such as MicroElectroMechanical Systems (MEMS) and molecular electronics. Table below, illustrates the most basic differences among these various efforts, which do have some overlap. In the case of MEMS, it helps to remember that while the two technologies differ by a factor of about 1000 in linear dimension, this translates to a factor of a billion in volume—very different indeed. Also, as MEMS researchers point out**, MEMS is not a goal but a working technology, rapidly growing into a major industry.**

Table: How micro- and nanotechnologies compare

It may be pointed out that making an organic compound using traditional synthetic chemistry is not an example of nanotechnology. By contrast, the use of self-assembly techniques to make small molecular components coalesce or unite into a macro-cyclic molecule having multi-nanometer dimensions can legitimately be considered nanotechnology.



Science/Technology	Material atomically "perfect"(each atom in a designed location)?	Controlled movement of atoms in 3D space?
Chemistry	Yes, local only	Local, yes; large scale, no
Molecular electronics	No	No large-scale movement
Micro-electromechanical devices	No	Yes
Molecular nanotechnology	Yes	Yes

4.2 QUANTUM UNCERTAINTY PRINCIPLE

An early concern regarding the feasibility of nanotechnology involved quantum uncertainty: would it make these systems unreliable? **Quantum uncertainty says that particles must be described as small smears of probability, not as points with perfectly defined locations.** This is, in fact, why the atoms and molecules in the simulations felt so soft and smooth: their electrons are smeared out over the whole volume of the molecule, and these electron clouds taper off smoothly and softly toward the edges. Atoms themselves are a bit uncertain in position, but this is a small effect compared to thermal vibrations.

Initially, it will be possible to build nanomachines and molecular-manufacturing systems that work a particular sort of environment, say, an electric or magnetic field (biological mechanisms are an existence proof), but in the long run, there will be no need to do so. Nanomachines can be built from the more stable sorts of structure. This has been demonstrated by control of molecular electric dipoles, nanoswitches, nanowires and devices like Scanning Tunneling Microscope. Molecular nanotechnology falls entirely within the realm of the possible.

5 THE TRADITIONAL APPROACH – "TOP – DOWN – APPROACH"

Today, electronic devices, sensors, motors, and many other items are fabricated using a "top down" approach. Today's computer chips are made using **photolithography**, a process that uses light and chemicals to etch lines into silicon wafers. The process requires vacuum chambers, powerful lasers and hazardous chemicals, which is why state-of-the-art chip factories tend to be billion-dollar facilities. As device features have become finer, the number of devices that can be crammed onto a chip has been doubling every 18 to 24 months.

But chipmakers will be hard-pressed to extend this miniaturization trend for another decade. As device features shrink into the low-nanometer range, the chips will not be able to perform as reliably. Moreover, the cost of constructing new fabrication lines for each new generation of chips will become prohibitive.

5.1 THE NANOTECHNOLOGY APPROACH – "BOTTOM – UP – APPROACH "

Nanotechnology promises an inexpensive "bottom up" alternative in which electronic or other devices will be assembled from simpler components such as molecules and other nano-structures. This approach is similar to the one nature uses to construct complex biological architectures. Nano-products will be smarter than the traditional devices as –

- Nano-devices operate at the most fundamental level (here atoms and molecules, instead of bits and bytes).
- Work very fast, because it works at a very small scale.
- Have plummeting costs, as the technology is applied to itself.
- And eventually, be ubiquitous. Just as today's computers are showing up in more and more products, nano-computers and nano-defined materials will be able to improve just about any object we use, including our own bodies.

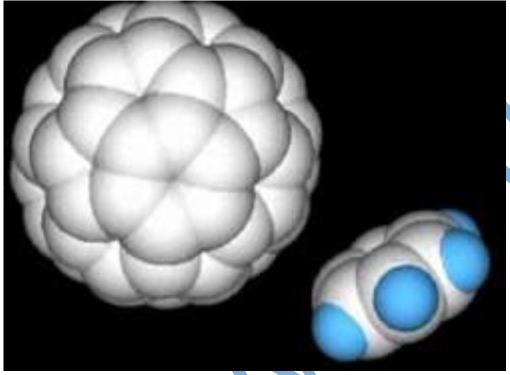
6 ACCOMPLISHMENT OF NANOTECHNOLOGY

6.1 ADVANCED ENGINEERING

The basic properties of atoms and molecules are already well understood, though routine research will be part of the development process. The existence of molecular machines in nature shows that machines at that scale are physically possible. No new fundamental science is needed; nanotechnology will be an engineering advance. This makes it foreseeable, unlike future scientific discoveries.

6.2 THE ASSEMBLER

An assembler will be a device having a submicroscopic robotic arm under computer control. It will work by applying reactive molecular tools to a work piece, building objects molecule by molecule. Assemblers will pop atoms into place with complete precision, enabling them to build virtually anything possible under natural law. With proper programming, materials, and so forth, assemblers will be able to build copies of themselves, that is, to replicate.



[Fig 1. nanobots- the tiny molecule assembling machines]

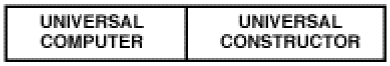
6.3 SELF REPLICATION : MAKING THINGS INEXPENSIVELY

The requirement for low cost creates an interest I self-replicating manufacturing systems. These systems are able both to make two copies of itself, and those two make two copies each and so on. We can have trillions of nanobots in no time, each one operating independently to carry out a trillionth of the job. This system will be reasonably inexpensive, effective and time saving process.

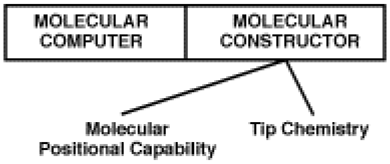
Positional control combined with appropriate molecular tools should let us build a truly staggering range of molecular structures -- but a few molecular devices built at great expense would hardly seem to qualify as a revolution in manufacturing. How can we keep the costs down?

If we could make a general purpose programmable manufacturing device which was able to make copies of itself then the manufacturing costs for both the devices and anything they made could be kept quite low -- likely no more than the costs for growing potatoes.
Drexler called such devices "assemblers."

The Von Neumann Architecture for a Self Replicating System



Drexler's Architecture for an Assembler



7 WHAT WILL WE BE ABLE TO MAKE?

7.1 IMPROVED TRANSPORTATION

□□Today, most airplanes are made from metal despite the fact that diamond has a strength-to-weight ratio over 50 times that of aerospace aluminum. Diamond is expensive, we can't make it in the shapes we want, and it shatters. Nanotechnology will let us inexpensively make shatterproof diamond (with a structure that might resemble diamond fibers) in exactly the shapes we want. This would let us make a Boeing 747 whose unloaded weight was 50 times lighter but just as strong.

□□Today, travel in space is very expensive and reserved for an elite few. Nanotechnology will dramatically reduce the costs and increase the capabilities of space ships and space flight. The strength-to-weight ratio and the cost of components are absolutely critical to the performance and economy of space ships: with nanotechnology, both of these parameters will be improved. Beyond inexpensively providing remarkably light and strong materials for space ships, nanotechnology will also provide extremely powerful computers with which to guide both those ships and a wide range of other activities in space.

7.1.1 INTELLIGENT CARS

In a few decades your car will know the freeway conditions on your favorite route to home. The GPS installed would take the easiest route possible and the computer system would calculate the instantaneous speed and history of every vehicle between you and your destination. The car could be set on auto mode allowing you to read your favorite novel. On the auto mode, the car would be smart enough to avoid any collisions with other vehicles and take safety measures if you happen to sleep off. You won’t have to hunt for the parking space. The car would find and reserve a parking space for you. Many prototypes of such cars have been tested in Europe, the US and Japan.

7.2 NANOCOMPOSITES

A plastic nanocomposite is being used for "step assists" in the GM Safari and Astro Vans. It is scratch-resistant, lightweight, and rustproof, and generates improvements in strength and reductions in weight, which lead to fuel savings and increased longevity. And in 2001, Toyota started using nanocomposites in a bumper that makes it 60% lighter and twice as resistant to denting and scratching impact: Will likely be used on other GM and Toyota models soon, and in other areas of their vehicles, as well as the other auto manufactures, lowering weight, increasing mileage, and creating longer-lasting autos. Likely to impact repair shops (fewer repairs needed) and auto insurance companies (fewer claims). Will also likely soon be seen everywhere weight, weatherproofing, durability, and strength are important factors. Expect NASA, the ESA, and other space-faring organizations to take a serious look, soon, which will eventually result in lower lift costs, which will result in more material being lifted into space.

[Fig 4. a nanocomposite structure as viewed under a microscope]

7.3 ATOM COMPUTERS

- Today, computer chips are made using lithography -- literally, "stone writing." If the computer hardware revolution is to continue at its current pace, in a decade or so we'll have to move beyond lithography to some new post lithographic manufacturing technology. Ultimately, each logic element will be made from just a few atoms.
- Designs for computer gates with less than 1,000 atoms have already been proposed -- but each atom in such a small device has to be in exactly the right place. To economically build and interconnect trillions upon trillions of such small and precise devices in a complex three-dimensional pattern we'll need a manufacturing technology well beyond today's lithography: we'll need nanotechnology.
- With it, we should be able to build mass storage devices that can store more than a hundred billion billion bytes in a volume the size of a sugar cube; RAM that can store a mere billion billion bytes in such a volume; and massively parallel computers of the same size that can deliver a billion billion instructions per second.

7.3.1 HIGH MEMORY STORAGE CAPACITY

The first application that comes to mind is **a very high -density memory.** The minimum spot-size demonstrated in the new work is 10 angstroms, though a somewhat larger size might be required in practice. If we assume that a single bit can be read or written into a 10 angstrom square, then a one square centimeter surface can hold 10^{14} bits. That's one hundred terabytes. The 100 nanosecond pulse time sets a 10-

megabit/second maximum write rate, though this might be degraded for other reasons. At this rate, it would take several months to a year of constant writing to fill a one square centimeter memory. Access times will probably be limited by the time needed to move the needle--which might be a significant fraction of a second to travel one centimeter--giving access times similar to those on current disk drives. The manufacturing cost of such a system is unclear, but the basic components do not seem unduly expensive. It seems safe to predict that someone in the not-too-distant future is going to build a **low-cost *very* large capacity secondary storage device** (disk replacement) based on this technology.

The larger implication of this work, however, is that it may put us on the threshold of controlled molecular manipulation. The great virtue of this technique is that we need not imagine it at all--**it is real and is being pursued in Bell Laboratory and at IBM Almaden.**

7.4 MOLECULAR ELECTRONICS

□□Molecular Electronics is a revolutionary idea to attend maximum miniaturization, instead of using transistor’s ‘on’ and ‘off’ states for implementing ones and zeros respectively, the characteristics of electrons may be used for the same. Positive and negative spins can be used to implement one and zero respectively.

□□The idea is new and it will take time for its implementation. But this will be the ultimate destination in the quest for miniaturization.

□□Molecular Electronics is based on a new organic material that may lead to a biological or chemical computer. A new radical information processing systems is being thought where organic cells or the bacteria will act as basic components.

□□Living Organisms are made up of organic compounds. And as such, thinking functions can be easily realized in such a system. Due to biological level scale the high density circuits may be made.

□□One example of a natural molecular device is the bacterial photo reaction center. Analogous devices have been successfully made through the synthesis of single and complex molecules, which release charge on photo excitation.

7.5 MILITARY APPLICATIONS

□□Today, "smart" weapons are fairly big -- we have the "smart bomb" but not the "smart bullet". In the future, even weapons as small as a single bullet co20ld pack more computer power than the largest supercomputer in existence today, allowing them to perform real time image analysis of their surroundings and communicate with weapons tracking systems to acquire and navigate to targets with greater precision and control.

□□We'll also be able to build weapons both inexpensively and much more rapidly, at the same time taking full advantage of the remarkable materials properties of diamond. Rapid and inexpensive manufacture of great quantities of stronger more precise weapons guided by massively increased computational power will alter the way we fight wars. Changes of this magnitude could destabilize existing power structures in unpredictable ways. Military applications of nanotechnology raise a number of concerns that prudence suggests we begin to investigate before, rather than after, we develop this new technology.

7.6 SMART FURNITURE

Doctors warned against the way many people sit for hours together, and recommend a little bit of exercise. But what if the furniture itself changes its shape to accommodate us comfortably.

□□The concepts of adaptive furniture have caught the fancy of many designers who value the aesthetic design and the overall getup and feel of furniture. Smart furniture of the future could be fitted with microchips that help the furniture concerned to behave and changed accordingly depending upon the posture of the person. Nanotechnology would be the enabler of adaptive structures in furniture

.

□□Today we have furniture that adapts to the human body, but it does so in an awkward and incomplete manner. A chair adapts because it is a hinge contraption that grudgingly bends and extends in a few places to suit the preferred position.

7.7 SOLAR ENERGY

□□Nanotechnology will cut costs both of the solar cells and the equipment needed to deploy them, making solar power economical. In this application we need not make new or technically superior solar cells: making inexpensively what we already know how to make expensively would move solar power into the mainstream.

7.8 MEDICAL USES

□□It is not modern medicine that does the healing, but the cells themselves: we are but onlookers. If we had surgical tools that were molecular both in their size and precision, we could develop a medical technology that for the first time would let us directly heal the injuries at the molecular and cellular level that are the root causes of disease and ill health. With the precision of drugs combined with the intelligent guidance of the surgeon's scalpel, we can expect a quantum leap in our medical capabilities.

8. A ROLE FOR ENGINEERING

Physical, chemical, biological, materials and engineering sciences have arrived to nanoscale about the same time. Engineering plays an important role because when we refer to nanotechnology we speak about ‘systems’ at nanoscale, where the treatment of simultaneous phenomena in multibody assemblies would require integration of disciplinary methods of investigation and an engineering system approach. The manipulation of a large system of molecules is equally challenging to a thermodynamics engineer researcher as it is to a single-electron physics researcher. They need to work together. Engineering needs to redefine its domain of relevance to effectively take this role in conjunction with other disciplines. Several reasons for an increased role of engineering are:

- Nanotechnology deals with systems at nanoscale, which are hierarchically integrated in architectures at larger scales.
- Multiple phenomena act simultaneous. Nanotechnology requires the integration of the methods of investigation from various disciplines in order to understand macroscopic phenomena, define transport coefficients, optimize processes and design products.
- Nanotechnology implies the ability to manipulate the matter under control at the nanoscale and integrate manufacturing along scales. Main challenges are creation of tailored structures at the nanoscale, and combination of the bottomup and top-down approaches to generate nanostructured devices and systems.
- Development of tools and processes to measure, calibrate and manufacture.

The engineering community needs to redefine the role of engineering from analysis, design and manufacturing mainly at the macro- and micro- scales towards the ‘nanoscale engineering’; improve education and training of engineers to better understand phenomena and processes from the atomic, molecular and macromolecular levels; and address problem-driven and interdisciplinary nanotechnology R&D where engineering plays an important role.

8.1 COHERENCE WITH OTHER SCIENCE AND ENGINEERING MEGATRENDS

Six increasingly interconnected megatrends in science and engineering are perceived as dominating the scene for the next decades:

- Information and computing
- Nanoscale science and engineering
- Biology and bio-environmental approaches
- Medical sciences and eventually enhancing human physical capabilities
- Cognitive sciences concerned with exploring and enhancing intellectual abilities

9. HOW LONG?

The single most frequently asked question about nanotechnology is: How long? How long before it will let us make molecular computers? How long before inexpensive solar cells let us use clean solar power instead of oil, coal, and nuclear fuel? How long before we can explore space at a reasonable cost?

The scientifically correct answer is: *I don't know.*

From relays to vacuum tubes to transistors to integrated circuits to Very Large Scale Integrated circuits (VLSI) we have seen steady declines in the size and cost of logic elements and steady increases in their performance.[7]

□□Extrapolation of these trends suggests we will have to develop molecular manufacturing in the 2010 to 2020 time frame if we are to keep the computer hardware revolution on schedule.

□□Of course, extrapolating past trends is a philosophically debatable method of technology forecasting. While no fundamental law of nature prevents us from developing nanotechnology on this schedule (or even faster), there is equally no law that says this schedule will not slip.

□□Much worse, though, is that such trends imply that there is some ordained schedule -- that nanotechnology will appear regardless of what we do or don't do. Nothing could be further from the truth. How long it takes to develop this technology depends very much on what we do. If we pursue it systematically, it will happen sooner. If we ignore it, or simply hope that someone will stumble over it, it will take much longer. And by using theoretical, computational and experimental approaches together, we can reach the goal more quickly and reliably than by using any single approach alone.

Like the first human landing on the moon, the Manhattan project, or the development of the modern computer, the development of molecular manufacturing will require the coordinated efforts of many people for many years. How long will it take? A lot depends on when we start.

10. INDIAN SCENARIO

IndiaNano Summit is a global forum for academic, corporate, government, & private labs, entrepreneurs, early-stage companies, investors, IP, joint ventures, service providers, start-up ventures, & strategic alliances. The initiative will support longterm nanoscale research and development leading to potential breakthroughs in areas such as materials and manufacturing, nanoelectronics, medicine and healthcare, environment, energy, chemicals, biotechnology, agriculture, information technology, and national security.

The effect of nanotechnology on the health, wealth, and lives of people could be at least as significant as the combined influences of microelectronics, medical imaging, computer-aided engineering, and man-made polymers developed in this century. IndiaNano Nanotechnology Initiative establishes Grand Challenges -- potential breakthroughs that if one day realized could provide major, broad-based economic benefits to India, as well as improve the quality of life for its citizens dramatically. Examples of these breakthroughs include: Containing the entire contents of the Library of the parliament in a device the size of a sugar cube; Making materials and products from the bottom-up, that is, by building them up from atoms and molecules.

The mission vision and objectives are:

1. To provide the government and the private sector means to outline a nanotechnology initiative for India.
2. To provide a unique and beneficial platform for initiating and exploring relationships between entrepreneurs, start-ups and investors for nanotechnology
3. To support long-term nanoscale research and development.
4. To help foster startups /initiatives in nanotechnology
5. Help stimulate development of an interdisciplinary international community of nanostructure researchers in India
6. To provide an opportunity to learn from the practical experience from nanotechnology specialists.
7. Provide the worldwide science and engineering community with a broadly inclusive and critical view of this field in India
8. Provide the worldwide science and engineering community with a broadly inclusive and critical view of this field in India Provide the worldwide science and engineering community with a broadly inclusive and critical view of this field in India
9. Identify promising areas for future research and commercial development in India
10. Help stimulate development of an interdisciplinary international community of nanostructure researchers in India

11. ADVANTAGES OF NANOTECHNOLOGY

- suitability for low cost, high volume production
- reduced size, mass and power consumption
- high functionality
- improved reliability and robustness.

12. NANO PROBLEMS & LIMITATION

Of course, all great advances come with associated problems. Before we get all these advantages from nanotechnology, we have to think about how we might solve these

Nanotechnology will not solve our problems!
How can you get millions of molecules to arrange themselves into exact arrangements?
How do you test the billion molecule electronic circuit?
Nanoscale computing is amorphous
The "price of programmability"

Nanotechnology has nothing to do with nuclear technology. There is no transmuting of nuclei as the alchemists tried to do, and as is done by nuclear technologists. Nanotechnology only does what chemists do: rearrange molecules. Nonetheless, it is a technology where the principle of exponentiation can be brought to bear: nuclear explosions come from an exponential proliferation of neutrons in a critical mass of fissile material. Here, we are talking not about an exponential growth of destroying things and releasing energy, but we are talking about a potential exponential growth of constructing complex artifacts.

13. Conclusion

The work in nanotechnology is being carried out not just on the materials of the future, but also the tools that will allow us to use these ingredients to create products.

Experimental work has already resulted in the production of scanning tunneling microscope, molecular tweezers, and logic devices. Theoretical work in the construction of nano-computers is progressing as well. Taking all of this into account, it is clear that the technology is feasible.

Nanotechnology is expected to have a profound impact on our economy and society in the 21st century, from the development of better, faster, stronger, smaller, and cheaper systems. Nanotechnology provides a far more powerful capability. We cannot make powerful computers, defense, environment and medicine, but also in a higher standard of living for everyone on the planet.

Nanotechnology- the science is good, the engineering is feasible, the paths of approach are many, the consequences are revolutionary-times-revolutionary, and the schedule is: in our lifetimes.

14. REFERENCES

www.zyvex.com

electronics for you
www.foresight.org
www.nanoelectronicsplanet.com
www.nanotechnology.com
information technology – june 2002