A STUDY OF ENERGY CONSERVATION WITH NANOTECHNOLOGY

Upendra Sharan Gupta[1], Abhishek Chaurvedi[2] , Jayesh Jain[3]

[1] Reader Dept. of Mech. Engineering , SVITS, Indore, (India)

[23]UG Scholar Dept. of Mech. Engineering ,SVITS, Indore,(India)

ABSTRACT

Enhanced abilities to understand and manipulate matter at the molecular and atomic levels promise a wave of significant new technologies over the next five decades. Dramatic breakthroughs will occur in diverse areas such as medicine, communications, computing, energy, and robotics. These changes will generate large amounts of wealth and force wrenching changes in existing markets and institutions .This paper discusses the range of energy conservation currently covered by nanotechnology. It begins with a description of what nanotechnology is and how it relates to previous energy conservation advances. It then describes the most likely future development of different technologies in a variety of fields and multidisciplinary nature of nanotechnology. The paper also reviews the government's current nanotechnology policy and makes some suggestions for improvement. It is an enabling technology, allowing us to do new things in almost every conceivable technological discipline.

Keywords- Carbon Nanotubes, Synthesis, Nanostructure.

I. INTRODUCTION

The world has perceived in recent years, the most difficult energy market Among the most important technical challenge facing in the world in 21st century is providing clean, affordable energy whose supply is sustainable and universally acceptable.

The following areas where Nanotechnology would make a greater impact in the power industry:

1. Nano structured devices as Fuel Cells, molecularly tailored catalysts, electricity storage and electosynthesis for both portable power sources and distributed fabrication for reduced transportation infrastructure.
2. Extensive real-time sensing for better conventional resource extraction and cheap nano-fabrication which will make use of artificial photosynthesis and low power hydropower for better energy management
3. Solar power using photo voltaics, thermo-electric conversions and piezo-electric conversions.

II. APPLICATION

Probably the two most useful ways of organizing the nanotech world are through the technology, i.e. what is being made, and through applications, i.e. where these products will find a home. For our concise introduction, we use a mixture:

1. Tools
2. Materials
3. Devices
4. Techniques for Building Nanoscale Structures
5. Electronics and Information Technology
6. Life Sciences
7. Power and Processes and the Environment

Any attempt to categorize the world in such a crude way is necessarily imperfect and there will always be certain technologies that span groups or do not fit neatly into one or the other. Furthermore, the multidisciplinary nature of nanotechnology means that is difficult to separate advances in, for example, tools, from their effect on life sciences .

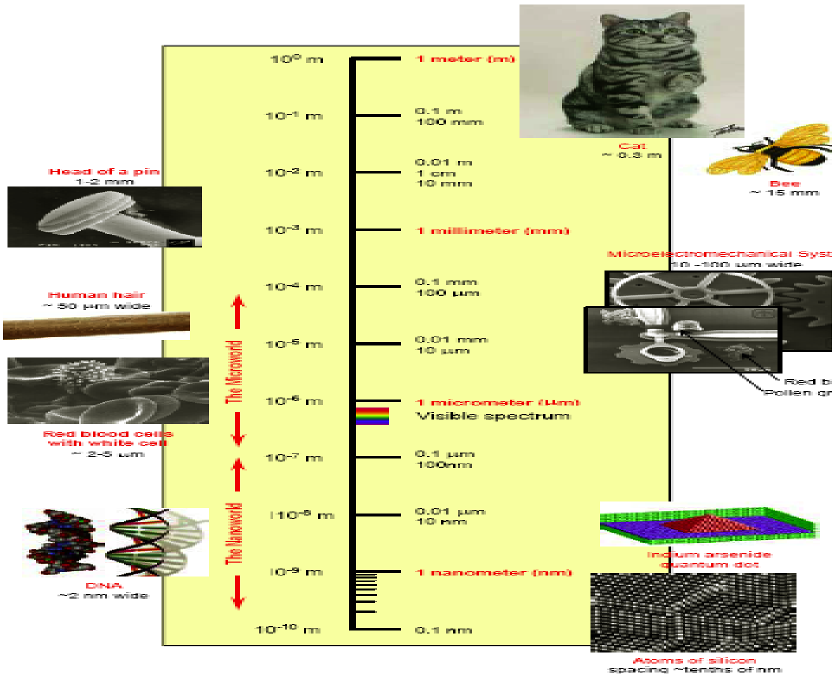

Figure 1 Application of Nanotechnology

III. IMPORTANCE OF NANOTECHNOLOGY

It is important to realize the diversity of nanotechnology. It is an enabling technology, allowing us to do new things in almost every conceivable technological discipline. Like other enabling technologies, such as the internet, the internal combustion engine, or electricity, its impact on society will be broad and often unanticipated (electricity was initially promoted as an alternative to gas lights, but from it we have developed telephones, computers, and the internet, and most of our lives would be impossible without it). Unlike these examples, nanotechnology is not so easy to pin down—it is a general capability that impacts on many scientific disciplines; it is multidisciplinary. This multidisciplinary nature presents a challenge for the scientific community and the R&D bodies of governments and industry but it also a reason to expect the unexpected, as scientists used to living separate lives lea rn to converse and work together.

Breakdown of spending on the US's National Nanotechnology Initiative from 2001 to 2003 (all figures in millions of dollars)

	2001 actual	2002 estimate	2003 proposed	Change: 2002 to 2003	Percent change 2002 to 2003
National Science Foundation	150	199	221	22	11%
Defense	125	180	201	21	12%
Energy	88	91	139	48	53%
Commerce	33	38	44	6	16%
National Institutes of Health	40	41	43	2	6%
National Aeronautics and Space Administration	22	22	22	0	0%
Environmental Protection Agency	5	5	5	0	0%
Department of Transportation	0	2	2	0	0%
Department of Justice	1	1	1	0	0%
Total	**464**	**579**	**679**	**100**	**17%**

IV. ENERGY STORAGE

Portable Energy Sources: The inadequacies of current batteries to supply power to the new electronic devices for a sufficient period has led to its limitations in its use. Nanotechnology can contribute further in this field for fabrication of batteries and the materials required so as to make them compatible enough to supply expected power for longer durations.

Batteries*:* Intercalation-based batteries, generally using the small Li+ ion, have attracted a great deal of attention in recent years because of their higher energy densities. In such batteries, at least one redoxactive electrode has an open crystal structure with voids capable of intercalating Li+ ions. In commercial batteries, for example, oxidation of Co in LiCoO2 expels Li+, which is taken up in a graphite anode. Recharge of the battery involves re-reduction of Co with concomitant take-up of Li+. The fabrication of crystal structure must be made in such a way as to permit redox-active crystal structure capable of reversiblity of intercalating small ions. This would make fabrication of batteries cheaper and more practical.

Capacitors: Even though capacitors are less efficient than batteries at energy storage at the same voltage, the voltage of batteries is limited by the potential of redox reactions. But the voltage across a capacitor cannot increase arbitrarily because at some voltage the capacitor "breaks down" through charge crossing the gap *d.* Improved dielectrics provide both a way to boost the dielectric constant and minimize *d.* BaTiO3 compound has a distorted perovskite structure (Figure 2), which consists of apex-sharing TiO6

octahedra with the large voids between the octahedra occupied by the Ba++ ions. The TiO6 octahedra are sufficiently distorted that the Ti4+ ions can "rattle around," which leads to very high polarizability or dipole moment, and hence to a large dielectric constant as well as to ferroelectricity.

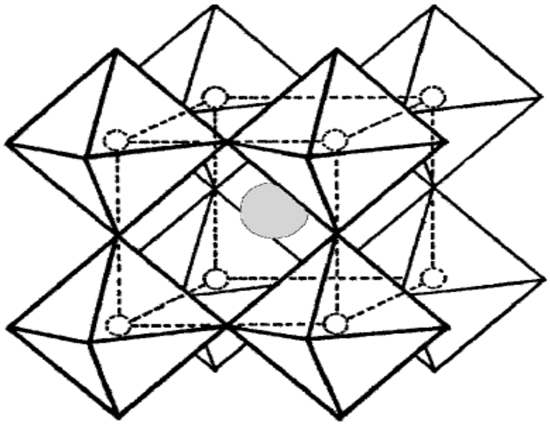

Figure 2.

Nanotechnology can search further such compounds which can facilitate better (lower) capacitance with high dielectrics in it. Nanotechnology can also work further on the "supercapacitors" or "ultracapacitors" that store additional energy through surface redox reactions, a phenomenon termed as "pseudocapacitance" (Huggins, 1996; Conway et al., 1997).

Electrosynthesis. The second, related but perhaps more important electricity-storage issue is the lack of a good way of storing large amounts of electricity, the immediate output of a great many energy-conversion systems. In the future alternative fuels will be required, even though they will no longer be "primary" energy sources like petroleum but a merely a convenient form for storage and usage.

High-strength materials*:* A result from elementary materials science is that macroscopic materials are far weaker, typically by 1-2 orders of magnitude, than would be inferred from the strength of the chemical bonds making them up. The reason is that macroscopic materials are dominated by microscale and nanoscale flaws, from crystal dislocations to intracrystalline grain boundaries, and these flaws control the macroscopic strength. One of the most promising applications of nanofabrication is the construction of materials that are essentially defect-free at the atomic level, such that their strength approaches the limit set by chemical bonds. The stronger a material, the less required for a given application. This mass savings is likely to have its greatest effect on transportation by decreasing the weight of vehicles. Even though the sheer volume of transportation, particularly for bulk commodities, is likely to dwindle as nanotechnology matures, travel is unlikely to vanish. At least in the relatively near term, moreover, high-strength materials will also be useful for such macroscopic moving parts as turbines.

V. PASSIVE ENERGY CONSERVATION

Conventional incandescent lights exemplify the inefficiencies of the thermal paradigm. Even conventional fluorescent lights dump a great deal of waste heat. Thus, simply converting electricity into visible light with greater efficiency would yield energy savings, both directly in minimizing illumination costs, and indirectly in minimizing the costs of dealing with waste heat. Light-emitting diodes (LEDs) that emit white light are attracting serious attention now as low-energy alternatives to conventional lamps and again the main issue in making such alternatives practical is cheap nanofabrication. At present electricity is commonly sent long distances from its place of generation to its place of use. Because of issues of safety and land costs, the ground receivers for solar power satellites are also likely to be located far from their ultimate markets.

The large-scale fabrication of nanostructured high temperature super conducting materials could make a major contribution to energy efficiency. The transmission losses could be reduced to around 20% due to reduction in conventional high electrical resistance in the lines. The most efficient exploitation technologies will probably involve nanotechnology. Conventional heat engines use a "working fluid" (steam, combustion products) whose thermal expansion is used to convert heat into mechanical work. Consider Steam Turbines and Internal combustion Engines, these engines require high maintenance and are prone to catastrophic failures owing to macroscopic moving parts, large temperature difference and large volumetric changes. Direct nanoscale conversion of a thermal difference into another form of energy is likely to be considerably more reliable as well as more efficient. Such devices already exist in embryonic form: thermoelectric power generators, which generate an electrical potential at a junction between two dissimilar materials, typically a *p-n* junction between two highly doped semiconductors. But such devices are subjected to limitations in high cost and very low efficiencies (10% of Carnot Limit).Quite apart from the potential of developing and fabricating new piezoelectric materials, nanofabrication would help make even the present low-efficiency materials more practical for power generation. Power generation would requires nanostructuring on a large scale, not only for the sheer volume of material required, but because building up significant voltages requires nanolayered structures, in which thin layers of piezoelectric material are inter-layered with electrodes of alternating polarity connected in series.

VI. APPLICATIONS OF NANOTECHNOLOGY TO ENERGY SOURCES

Extraction of fossil fuels. Nanotechnology can play a major role in fossil fuel recovery in the term as “Information Intensive” extraction. For example, one form of "tertiary recovery" involves injecting steam into the field to mobilize the oil. In one case, monitoring reservoir temperatures with down hole fiber-optic thermometers while tracking the flow of oil and steam with ultra-miniaturized flow sensors inserted into the stream led to substantial (~20%) savings. Less injected steam was required, and it could be targeted more effectively. This is an example of how nanotechnology will provide incremental improvements of techniques already carried out in embryonic form with micro technology. Biotechnological approaches have been under investigation for tertiary oil recovery (e.g., Yen, 1990), and are likely to be both much cheaper and far less disruptive environmentally. Indeed, bacterial strains capable of metabolizing kerogen have recently been reported (Petsch et al., 2001). Such organisms, or the enzyme systems derived from them, may be able to carry out low-temperature cracking of kerogen or of the long-chain aliphatics in tar and asphalt. These could also provide considerably cleaner and less energy intensive approaches to processing of oil shale and tar sands.

Usage of fossil fuels. The obvious improvement here is to release their energy in fuel cells rather than via combustion. As noted, however, fuel cells that can use hydrocarbons are in their infancy Near-term fuel cell applications in vehicles rely on "reforming" the hydrocarbons to extract only the hydrogen, which obviously increases complexity and decreases efficiency. As with any fuel cell, a practical hydrocarbon cell will involve structuring at molecular scales, and its structure may even be more intricate to deal with the more complex fuel. Moreover, even when robust fuel cells are developed there remains the issue of fabricating them cheaply enough to be competitive by the use of Nanotechnology in the optimum manner.

Nuclear Fission Energy: The application of nanotechnology toward fission fuels, however, probably lies in their extraction and separation. A major resource-related application of nanotechnology lies in the low energy molecular separation of elements, most directly from aqueous solution. As for other elemental commodities, therefore, nanotechnology could vastly increase the supply of U and Th. Leaching of low-grade U- or Th-bearing rocks, for hydrometallurgical extraction, has already been carried out and selective "uranophiles" (highly selective agents for complexing the uranyl ion, UO2 2+) have been the focus of much research.

Reprocessing of nuclear fuel and separation of nuclear waste: It would be attractive to separate the components of nuclear waste, for fuel recovery and also to recover potentially valuable radionuclides. This is a more difficult problem, however, because of radiation damage to the nanomechanisms. They will have to be robust and ultimately probably self-repairing. If such systems can be developed, they will make the reprocessing of nuclear waste considerably more practical. Indeed, possibly each reactor installation could reprocess its own waste. Isotope separation is fundamental to nuclear materials. Unfortunately, separating isotopes is much more difficult than separating elements, and at least in the near term there seem to be few ways that nanotechnology can yield major improvements.

Geothermal Energy: Better thermoelectric devices would allow replacing the mechanical turbines used in the current conversion approaches. Not only would such devices minimize the problems with fouling, corrosion, and mechanical mishap that plague conventional geothermal installations, they would allow direct use of lower geothermal gradients, because the phase change necessary to drive a turbine would no longer be required.

Indirect Solar Energy. OTEC, would profit from long cables that must hang under their own weight, to reach the sea floor, and yet still be strong enough to withstand the storm risk with the advent of super strength materials through nanotechnology fabrications. Super strength materials also have obvious applications in turbine and windmill blades.

Thermoelectric conversion also see particularly relevant to OTEC, given the small
temperature difference, but thermo-electrics capable of exploiting such small temperature differences needs to be further explored. Piezoelectric materials may also prove to be practical for power generation. A few studies have proposed piezoelectric-based arrays for generating power from surf.

Solar Energy: *Artificial Photosynthesis:* Using sunlight to make fuel solves immediately the storability and transport issues that arise with making electricity. Practical technological photosynthesis probably will be based on semiconductor-driven coupled redox reactions.

Nanofabrication. Present-day solar cells are expensive, and that expense results from their fabrication costs. The most efficient material is crystalline semiconductor-grade silicon, because electron-hole recombination is minimized, but this material is costly. The repeated cycles of purification through remelting and recrystallization required to make such material represent the thermal paradigm at an extreme. Moreover, the ultrapure silicon must be doped to yield a large-area *p-n* junction where the photons are absorbed, as the electrostatic field at this junction (Schottky barrier) causes the electron-hole separation. Alternative fabrication approaches could make a large difference in costs and nanofabrication techniques seem an obvious approach. Another route to cost minimization is through minimizing the material used.

Space Power Sattelites: The same economies of fabrication that will make ground-based PVs considerably more attractive also make SPS more feasible. The economies of mass would be particularly valuable because of the necessity to decrease costs to orbit. Thus the economics of space- vs. ground-based solar power seem poised particularly finely between the economics of production, the tradeoffs of competing technologies (e.g., photovoltaics vs. photosynthesis), and space access costs.

Super conducting Machines: Research in super conducting electrical machines is going on wherein the efficiency could be increased by reducing thermal losses. Super conducting transformers can have very high efficiency. The creeping foot of Cryogenics in Power Electronics has started off. The Massachusetts-based American Superconductor Corporation, a leading electricity solutions company, has successfully developed and filled a patent application for a nanotechnology-based manufacturing technique that delivers an immediate 30 percent increase in the electric current-carrying capability of the company’s second generation (2G) high temperature superconductor (HTS) wire. This new nanotechnology process leverages AMSC’s proprietary metal organic chemical processing methodology by producing a dispersion of ‘nanodots’ throughout the superconductor coating of the company’s 2G HTS wire. Nanodots are ultra-small particles of inorganic materials typically less than 100 atoms across. AMSC’s 2G HTS wire is being designed as a form-fit-function replacement for today’s commercial first generation (1G) HTS wire, but at two to five times lower manufacturing cost, which is expected to further expand the market for HTS applications.

VII. CONCLUSION

Conventional technology is depleting its resource base at an accelerating rate and creating an increasingly unlivable mess in doing so, even as rising expectations around the world heighten demand still further. We simply cannot maintain the standard of living in the industrialized world much longer with conventional technology, much less raise the rest of the world's. Nonetheless, it is critical to recognize that the dwindling resource base is not set by the laws of nature, despite occasional assertions to the contrary. Typically such assertions are based on misconceptions about the laws of thermodynamics, and Un surprisingly are un buttressed with any calculations of limiting thermodynamic costs.

REFRENCES

[1.] “Nanoscience Research in Energy Needs” Report of National Nanotechnology Initiative, Grand Challenge Workshop.

[2.] “Nanotech – the tiny revolutin” Paul Holister, CMP Cientifica “Energy and Nanotechnology – Strategy for the Future” Conference Report, February 2005, James A. Baker III Institute for Public Policy.

[3.] M. Haruta, Size-and support-dependency in the catalysis of gold, Catal. Today 36, 153 (1997).

[4.] J. V. Lauritsen, M. V. Bollinger, E. Laegsgaard, K. W. Jacobsen, J. K. Norskov, B. S. Clausen, H. Topsoe, F. Besenbacher, Atomic-scale insight into structure and morphology changes of MoS2 nanoclusters in hydrotreating catalysis, J. Catal. 221, 510 (2004). 3. U.S. Department of Energy, Basic Energy Sciences Advisory Committee, Basic Research Needs to Assure a Secure Energy Future (2003). Available at

[5.] B. C. H. Steele, A. Heinzel, Material for fuel cell technologies, Nature 414, 345 (2001).

[6.] M. S. Dresselhaus, I. L. Thomas, Alternative energy technologies, Nature 414, 332 (2001).

[7.] S. Haile, Materials for fuel cells, Matter. Today 6 (3), 24 (2003).

[8.] R. Adzic, Brookhaven National Laboratory, private communication.

[9.] S. Passerini, D. B. Le, W. H. Smyrl, M. Berrettoni, R. Tossici, R. Marassi, M. Giorgetti, XAS and electrochemical characterization of lithiated high surface V2 O5 aerogels, Solid State Ionics, 104 195 (1997).