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Nanotechnology Higher Education–A High Potential Education for Engineers

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Abstract—*Nanotechnology is a new emerging technology that stands forefront in the multidisciplinary field such as science, research and technological development. The present paper reports the nanotechnology higher education provides a high potential for engineers. It is estimated that about 3 millions engineers will be needed worldwide in 5 to 10 years now[1]. The preparation of nanotechnology workforce for the next decade is a major challenge for the progress of this new technology educatio. Most of the major disciplines converge at the nanoscale towards the same building blocks, principles and tools of investigations. This paper outlines key Indian education and training activities in the general context of the National Nanotechnology Initiative. Investigation of systems at the nanoscale requires an increase role of engineer's education[2]. The required education model and institutionalization of nanotechnology curricula in Diploma and B Tech Institutions are recommended for achieving a modern education system. An analysis is made to demands for laboratory facilities, faculty and functions of other service departments to deliver an engineering curriculum in nanotechnology [3]. Guidelines are provided for an innovative curriculum that draws upon collaboration among faculty, department and laboratories. The suggested guideline can modified to address the evolving needs of nanotechnology higher education without loss of focus on engineering technology education[4].*

Keywords*: Nanotechnology: higher education: potential: engineer: forefront.*

INTRODUCTION;

Nanotechnology;-Nanotechnology a most recent technology that provides the ability to work at the atomic, molecular and supramolecular levels, in the length scale of about 1 to 100 nm range, in order to create, manipulate and use materials, devices and systems with fundamentally new properties and functions because of their small structures[5]. It includes understanding of phenomena and processes at the nanoscale, and integration of nanostructures along larger scale[6].

Educational need of nanotechnology

All materials and system establish their foundation at the nanoscale. A water molecule is about 1nm in size, a single wall nanotube is about 1.2 nm in diameter, the diameter of the man-made arm of a T4 phase is about 3 nm, a typical pyramid quantum dot of germanium on a silicon substrate is about 10 nm wide, and the smallest transistors are few nanometres in laboratory and about 15 nm in prototypes. DNA molecules are about 2.5 nm wide, a typical protein is between 1 and 20 nm, and an ATP biochemical motor encountered in living cells is about 10 nm in diameter. A molecular machine may be dwarfed by the size of a human cell. Size confinement effects, quantum phenomena and Coulomb block-age are relevant under 30 nm feature size. Large surface area and high reactivity are dominant in the same region[7].

With the increase of impact of nanotechnology on all aspect of our daily and the increased demand for work force trained in nano science and technology fields, the educational institutions the world being face big challenge- how to increase and integrate the nano science and technology content into existing curriculum to developed a new curriculum for the development of work force and potential of world workers scientists and lovely engineers[8].NATIONAL NANOTECHNOLOGY INITIATIVE TO INTERNATIONAL FOCUS

The National Nanotechnology Initiative (NNI) is characterized by:

- High-risk, high-return;
- Interdisciplinary nature of R&D;
- Broad societal implications etc.

Presidential speech introduced NNI to the Nation during a speech on nanotechnology in January 2000. The International Congress approved the NNI budget of $422 million in fiscal year 2001 (October 2000 to September 2001), a 56% increase over the previous year[9].

The letter sent in summer 2000 by the Office of Science and Technology Policy and the Office of Management and Budget to all agencies has placed nanotechnology at the top of the national R&D priorities for the fiscal year 2001. The increase of nanotechnology investment in fiscal year 2002 is by 182 million dollars or about 43%. The investments made in seven International level departments and independent agencies are shown in table-1

Table 1: Summary of International. Federal nanotechnology investment in fiscal years 2000 to 2002 (in mllion dollars)

Name of departments	FY 2000 NNI Budget	FY 2001 NNI Budget	FY 2002 Budget Request
Department of Defense (DOD)	70	110	140.0
Department of Energy (DOE)	58	093	096.0
Environmental Protection Agency (EPA)	Ð	Ð	005.0
National Aeronautics and Space Admin. (NASA)	05	020	046.0
National Institutes of Health (NIH)	32	039	045.0
National Institute of Standards and Techn. (NIST)	08	010	017.5
National Science Foundation (NSF)	97	150	199.0
Total	260	422	548.5

Table 2: Estimated world government nanotechnology R&D expenditures (in million dollars/year; survey August 2001)

Area	2000	2001	(2002)
W. Europe	200	225	
Japan	245	410	
USA	270	422	543
Others	110	380	
Total	825	1577	
(% of 2000)	(100%)	(191%)	

Note: Here we introduce estimated world government expenditure in the field of nanotechnology R &D. `W. Europe' includes countries in EU and Switzerland; `Others' include Australia, Canada, China, FSU, Korea, Singapore, Taiwan, Eastern Europe and Middle East countries with nanotechnology R&D programs; this estimations use the nanotechnology definition as in NNI[10]

Appropriated by Congress a financial year begins in USA on October 1 of the previous calenderistic year, and on March 1 or April 1 of the respective calendaristic year in most other countries[11].

Public education (non-technical audiences)

The public is the ultimate user and sponsor of the new technology. The importance of this activity has been underlined in a recent study on societal implications of nanoscience and nano-technology [2]. Illustrations are already listed in Table 6, for example the NSEC at Harvard University has outreach activities with the Boston Museum of Science. Also, NSF has sponsored projects focused specifically on public science education. Examples are:

- The University of Wisconsin and Discovery World science museum in Milwaukee for `making nanoworld comprehensible'.
- The Arizona Science Centre for internship for undergraduate students and schoolteachers for programs with emphasis on nanotechnology
- For public and school outreach (three-year grant for Internships for Creating Presentations on Nanotechnology Topics at a Science Centre).
- In a broader context, NSF organized an out-reach activity, Small Wonders: Exploring the Vast Potential of Nanoscience, for the public and non-specialists (at the Washington, DC, World Trade Centre; see the NNI website[12].

Courses and tutorials offered by professional societies

These activities offer a unique opportunity for dissemination of the field and continuing education. Most effective courses cover basic concepts for various disciplines and broad areas of relevance, and show where is the role of the respective community and professional group in advancing nanotechnology. A second group of relatively fewer courses is addressed to industry and are focused on shorter-term nanotechnology outcomes. A third group of courses addressed to academic participants and retraining is on specialized topics, such as nanotechnology tools and manufacturing methods. Examples are the tutorials offered by American Chemical Society, American Vacuum Society, and American Society of Mechanical Engineering, as well as the educational websites established by Materials Research Society (MRS) and Institute of Electrical Engineering and Electronics[13].

International dimension

International interactions increase on an accelerating path among the nanotechnology higher education provides a better path for increase the especially potential of engineers. Exchange of information, leveraging the research efforts, and education of younger generations are the main reasons. About one third of projects in the small-group research activities under the NSF program Functional Nanostructures have international collaborations. NSF has sponsored young researchers for group travel to Japan, EU and other areas to present their work and visit centres of excellence in the field. Bilateral and international activities have been under way since 2000 with European Union, Japan, Korea, India, Switzerland, Germany, Latin America and other developed countries in the world[14].

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A HIGH POTENTIAL FOR ENGINEES

Actually the nanotechnology higher technical education provides a high potential to mainly engineers. The role of engineering,

Physical, chemical, biological and engineering sciences have arrived at the nanoscale about the same time. R&D for nanotechnology are at the confluence of many disciplines and areas of relevance, including engineering. Engineering will play an important role because when we refer to nanotechnology we speak about `systems' at the nanoscale, where the treatment of simultaneous phenomena in multimode assemblies would require integration of disciplinary methods of investigation and an engineering problem-driven 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 at the intermediate length scale.

The special role of an engineer in nanotechnology may be underlined by several reasons. At the nanoscale simultaneous phenomena can not be treated independently. Nanotechnology implies the ability to manipulate the matter at nanoscale under control, and integrate along scales to manufacture material structures, devices and systems. Main challenges are creation of tailored structures in the submicron to the 100 nm range, combination of the bottom-up and top-down approaches to

ACTIVITIES ENVISIONED FOR ENGINEERS EDUCATION

Nanotechnology Higher Education provides a better training to specially the engineers. Improving education and training of engineers to better understand phenomena and processes from the atomic, molecular and macromolecular levels. This may include introducing new course modular sections in existing engineering courses, teaching overview nanotechnology courses on nanotechnology at the freshman undergraduate. Redefining the current role of engineering from the analysis and design mainly at the macro and micro scales towards nanoscale engineering. Modern biology, electronics, and other areas have already moved their research and education areas of focus at the nanoscale. One can foresee significant rewards and challenges. Engineering has a wide net, from molecular thermodynamics, nanoparticles, nanostructured materials and nanoelectro-mechanical systems (NEMS), electronic and photonic devices to nanoscales[15].

Specific needs of training for engineers:

Nanotechnology Higher Technical Education provides more workforce due to it engineers experience opportunities. Using opportunities of partnering with the emerging nanotechnology `regional alliances'. The following specific needs have been identified for education and training. Encourage a system approach in teaching nanoscale science and engineering at all levels. Underline interdisciplinary, sharing the same basic concepts from one field to another, and creating the environment for nanoscale R&D advancements in all relevant disciplines[16].

CONCLUSION

It is expected that the foundation in engineering higher education will move from the microscopic to the molecular and supra-molecular levels in the next 5 to 10 years. Nanoscale science and engineering provides a common meeting place for disciplines towards the same basic material strutures, principles and tools of investigation, and stimulates more fundamental research and education.

FUTURE DIRECTION

Systemic changes by extending the models discussed in previous sections are envisioned in teaching the nanoscale concepts, from kindergarten to graduate schools and continuing education for retraining. Efforts should be made to institutionalize nanotechnology education in engineering and higher education academic institutions, and to encourage introduction of the new concepts in all relevant disciplinary courses including physics, chemistry, biology, materials and engineering. An important corollary activity is the retraining of teachers themselves. Interdisciplinary fellowships are to be emphasized in graduate research.

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