Research Activity: **Engineering Research**

Division: Materials Sciences and Engineering
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Portfolio Description:

Engineering Sciences includes research in nanotechnology and microsystems, multi-component fluid dynamics and heat transfer, and non-linear dynamic systems.

Unique Aspects:

The program is intimately linked with the materials and chemical science activities under the Basic Energy Sciences. Engineering Sciences has a unique role to play in National Nanotechnology Initiative on high surface area materials, consolidated nano-particulate material, dispersion and coatings, photonics, nano-devices and molecular machines using nano-scale building blocks.

Relationship to Others:

DOE NE - Nuclear Energy Research Initiative
DOE EM - Environmental Management Science Program
NSF – Exploring the possibilities of a joint initiative on neural electronics
IWGN - NSTC Interagency Working Group on Nanotechnology
DOD, NSF, and NASA – Joint funding of research on Molecular Motor
Represents DOE on the Interagency Quantum Information Science Coordinating Group (QISCOG)
Interacting with the community through workshops, one on nanotechnology and the other on biological information processing.

Significant Accomplishments:

Accomplishments resulting from research on multi-component fluid dynamics and heat transfer:

- Assisted in creating an energy efficient chemical industry by developing databases, estimation techniques, and design models. ASPEN Tech was founded using these tools and now has over 1500 employees worldwide.
- Oil and gas companies are using results of research for more efficient transport and exploration of crude oil and natural gas. The Syncrude pipeline would not have been built without these developments that results in a 97% saving in energy used to transport the crude.
- Research on thermal plasma chemical vapor deposition of advanced materials has led to diamond coated tools and computer components such as hard disks.

Accomplishments resulting from research on micro and nano systems:

- Research in this area has resulted in the developments of nanosize biological motor for use in MEMS and NEMS devices
- Silicon lenses that have 1/10 the diameter of human hair have been fabricated and used in microscopes for measuring infrared light absorption in single cell.
- Research on nanomotion from biomolecular interactions has led to developing instruments for detecting and identifying molecules
- Nanofluids have been created that conduct heat ten times faster than predicted possible
- Dissipating record of heat flux have been achieved with a micro-channel flow

Accomplishments resulting from research on non-linear dynamic systems:

- Research on signal processing in chaos has led to the developments of an electronic circuit that replaces neurons.
- Research on non-linear series has led to developing chaotic mathematical technique for predicting a change in a system
- Results of research on nonimaging optics are being applied in solar energy systems, space and ground telescopes, and other light imaging systems.

Mission Relevance:

New and improved capabilities at the nano and micro scale will improve materials processing and quality, increase computing speed, improve sensing and control capabilities. Together these lead to higher process efficiency and lower energy consumption. Improving the knowledge base on multi-components fluid dynamics and heat transfer will have a major impact on energy consumption, because these phenomena are an integral part of every industrial process. Advances in non-linear dynamics will lead to improved control and predictive capabilities of complex systems, thus resulting in higher efficiency and lower energy consumption.

Scientific Challenges:

Challenges in engineering sciences include identifying those scientific discoveries within the basic energy sciences program that are most appropriate to pursue within the context of the energy and environmental mission needs of the Department, while supporting developments of engineering principles that enable scientific breakthroughs to be used for:

a) Changing processes so that engineered systems are more energy efficient and environmentally friendly.
b) Developing mathematical models of systems that can be used to make them better.
c) Understanding the limitations of systems and extend those limits

Funding Summary:

Dollars in Thousands

FY 2000	FY 2001	FY 2002
$14,024	$17,352	$16,577

The program provides funding for 67 university grants, 7 programs at national laboratories, 2 programs at other government agencies, and 4 programs at industry. Funding demographics is shown below:

Performer	Funding Percentage
DOE Laboratories	28.0%
Universities	66.0%
Other	6.0%

Projected Evolution:

The program will continue to refine its core of excellence in nanotechnology and microsystems, multi-component fluid dynamics, heat transfer, and non-linear dynamic systems. The program will increasingly pursue engineering research that is coupled to scientific discoveries and advances in diverse areas such as quantum devices; photonics; sensors; modeling and simulations; magnetocaloric, thermoelectric and thermoacoustic energy conversion; or other evolving scientific areas where there have been recent significant discoveries or advances under the Materials Sciences and Engineering Division.