Research Activity: Engineering Physics

Division: Materials Sciences and Engineering
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Portfolio Description:

Engineering Physics advances scientific understanding underlying dynamic interactions of multicomponent systems. Areas of emphasis include microscopic and nanoscale science of the interactions of fluid, organic or biological materials with each other and with solid systems and developing the means to advance the characterization of the same. Questions of ongoing interest include, predicting behavior multi-component fluids with and without heat transfer, predicting the behavior of the solid-liquid interface, understanding the interactions of phonons with secondary phases or micro and nanoscale defects in solids, and non-linear behavior of engineering systems.

Unique Aspects:

The program provides linkage between the materials and chemical sciences with engineering application. Engineering Physics has a unique role to play in National Nanotechnology Initiative to further understanding of dynamic behavior of multiphase and biologically inspired materials, high surface area materials, consolidated nano-particulate material, nano-devices and molecular machines. This activity has and maintains a leadership role in the fundamental understanding of multiphase phase fluid flow and heat transfer and in the fundamental behavior of granular materials.

Relationship to Others:

NSF – Exploring potential joint interests in fluids flow and heat transfer
IWGN - NSTC Interagency Working Group on Nanotechnology
Interacts with the community through workshops such as the Workshop on Multiphase Fluid Flow, May, 2002.

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 in other areas:

- Research on signal processing in chaos has led to the developments of an electronic circuit that replaces neurons.
- Results of research on nonimaging optics are being applied in solar energy systems, space and ground telescopes, and other light imaging systems.

Mission Relevance:

Improved understanding of dynamic behavior at the nano and micro scale will improve materials processing and materials quality, and 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.

Scientific Challenges:

Where do the continuum approximations break down in multicomponent systems containing fluids? What are the explanations for nanoscale fluid and heat transfer behavior? Can we adequately describe, simulate and engineer macroscale systems to take advantage of nanoscale behavior?

Funding Summary:

Dollars in Thousands

FY 2002	FY 2003 Request	FY 2004 Request
16,464	16,480	16,457

The program provides funding for 58 university grants, 12 programs at national laboratories, 2 programs at other government agencies, and 1 program at industry. Funding demographics is shown below:

Performer	Funding Percentage
DOE Laboratories	38.9%
Universities	57.4%
Other	3.7%

These are percentages of the operating research expenditures in this area; they do not contain laboratory capital equipment, infrastructure, or other non-operating components.

Projected Evolution:

The program will continue to refine its core of excellence in nanotechnology and microsystems, multi-component fluid dynamics, heat transfer, and other select areas such as phonon behavior. The program will increasingly pursue understanding of the dynamics of the solid-liquid interface, of multicomponent fluids at the nanoscale, the interface of organic and biological materials with fluids and solids and the dynamic behavior of the same.