Research Activity: **Transmission Electron Aberration-corrected Microscope (TEAM)**

Division: Scientific User Facilities
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Portfolio Description:

The TEAM project is a Major Item of Equipment project to construct and operate a new aberration-corrected electron microscope and make this capability widely available to the materials and nanoscience communities. The projected improvement in spatial resolution, contrast, sensitivity, and the flexibility of design of electron optical instruments will provide unprecedented opportunities to observe directly the atomic-scale order, electronic structure, and dynamics of individual nanoscale structures. The TEAM instrument will be optimized for high-resolution imaging and atomic tomography. The components and approaches developed will further provide a platform for future aberration-corrected instruments optimized for different purposes such as wide-gap in-situ experimentation, ultimate spectroscopy, ultrafast high-resolution imaging, synthesis, field-free high resolution magnetic imaging, diffraction and spectroscopy, and other extremes of temporal, spectral, spatial or environmental conditions.

Unique Aspects:

Transmission electron microscopy represents one of the few methods for obtaining local information with a spatial resolution of 0.1 nm or better from individual nanometer-scale structures. Aberrations of the electromagnetic lenses are the primary limitation on electron microscope resolution and constrain other aspects of the instrument including available space for in-situ manipulation in the sample chamber. The TEAM instrument is expected to attain direct spatial resolution of 0.05 nm, which is better than has been demonstrated for any present instrument. The project aims to redesign the transmission electron microscope around aberration-corrected optics, to develop a common platform for a powerful new nanocharacterization instrument, and to make this instrument widely available to the materials and nanoscience community via existing BES user facilities.

Relationship to Other Programs:

The project involves a collaboration of the three BES user facilities for Electron Beam Microcharacterization (at Lawrence Berkeley National Laboratory (LBNL), Argonne National Laboratory, and Oak Ridge National Laboratory) and two other BES-supported microscopy groups (at Brookhaven National Laboratory and at the University of Illinois at Urbana-Champaign). The lead organization and institution of the principal investigator is LBNL, and the completed instrument will be installed and operated within the National Center for Electron Microscopy (NCEM) at LBNL.

Mission Relevance:

The need and scientific case for TEAM have been vetted by the Basic Energy Sciences Advisory Committee (BESAC) and subgroups of BESAC on several occasions, including a review in 2000, an update in 2002, and a 2003 assessment of facilities roadmapping. The project was subsequently included as a near-term priority in the Department of Energy (DOE) Office of Science report, *Facilities for the Future of Science: A Twenty-Year Outlook*, in November 2003. Upon completion this instrument will become part of an existing user facility, the NCEM at LBNL, and will be available to users. The development of this equipment thus is relevant to a broad range of BES research elements, and has most direct impact on and interaction with the activities in Electron-beam Microcharacterization, Structure and Composition of Materials, and Nanoscience Centers.

Scientific Challenges:

A wide variety of major scientific challenges that could be uniquely addressed by electron scattering methods were outlined by keynote speakers at a series of workshops convened to discuss and determine the parameters for the TEAM project. These included:

- Synthesis and assembly of nanomaterials, and an understanding of their properties, especially through local electronic structure determination
- Numerous nanoscale materials issues that currently define the end of the roadmap in silicon-based semiconductor technology
- Atomic-scale origins of magnetism at the nanoscale
- Role of individual dopants and point defects in solid-state lighting materials, such as GaN

- Direct comparison of theory and experiment at the nanoscale, through the determination of the three-dimensional atomic-scale structure of nanostructures
- Atomic-scale mechanisms of controlled chemical processes/catalysis
- Size effects on thermodynamic properties of nanostructures
- Role of oxygen in high-temperature superconductivity
- Atomic-scale mechanisms of oxidation and corrosion
- Direct high-resolution imaging of biological materials and of the interface between hard and soft materials

These challenges provide scientific drivers for the TEAM project. While fulfilling all of these is not expected, the desired outcome for TEAM is to address a number of these grand challenges in full or in part.

Funding Summary:

	Dollars in Thousands		
	FY 2005	FY 2006	FY 2007 Request
TEAM Major Item of Equipment	5,586	6,206	5,508

Projected Evolution:

As for any instrumentation or construction effort of this magnitude, the TEAM project is managed in accordance with DOE Order 413.3, Project Management for the Acquisition of Capital Assets, which sets out procedures and major milestones in the form of critical decisions (CDs). Mission Need (CD-0) for the TEAM project was approved in June 2004; approval of the formal Acquisition Strategy and of CD-1 (Alternative Selection and Cost Range) followed in October 2005. The microscope will be designed and built on a phased schedule. An initial instrument incorporating spherical aberration correction, as well as a novel electron gun and sample chamber arrangement, is expected to be available to users in 2008. The final instrument will incorporate a more advanced corrector under development (addressing both spherical and chromatic aberration) and is to be commissioned and made available to users in 2009.