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Disciplinary Analyses: CHAPTER TWENTY SEVEN

Materials Research in the FY 2016 Budget

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HIGHLIGHTS

The Administration's budget proposes increases in materials science research in FY 2016 for the National Science Foundation, Department of Energy Office of Science, National Institute of Standards and Technology, and Department of Defense Basic Research. However, basic research in the Department of Defense will be significantly lower than it has been in previous years. Proposed materials research budgets vary considerably, but generally follow the overall trends for each agency. Comparisons are provided in reference to enacted FY 2015 budgets:

- National Science Foundation (NSF) - Overall, the President's budget proposes a 5.2 percent increase for the Foundation, while the Mathematical and Physical Sciences Directorate will receive a 2.2 percent increase. This includes an increase of 2.9 percent for the Division of Materials Research (DMR).
- Department of Energy (DOE) Office of Science - Overall, the budget proposes a 5.4 percent increase, which includes a 6.7 percent increase for Basic Energy Sciences (BES), and Materials Sciences and Engineering (MSE) within BES will receive an increase of 3.0 percent.
- Department of Defense (DOD) - Overall, the budget proposes an 8.3 percent decrease for basic research and a 1.4 percent increase for applied research. Funding for the Defense Advanced Research Projects Agency (DARPA) will increase by 6.0 percent in all defense research science programs.

- Department of Commerce, National Institute of Standards and Technology (NIST) - Scientific and Technical Research and Services within NIST will receive an overall 11.7 percent increase.

INTRODUCTION

Materials science is a broad interdisciplinary field supported by funding from a number of federal departments and agencies. The discipline includes elements of physics [6], chemistry [7], engineering, biology, and medicine, as well as research in emerging fields such as nanoscience [8] and nanotechnology [9]. Materials research is conducted in universities, government laboratories, and industry.

Materials scientists and engineers conduct research that results in fundamental breakthroughs in electronics, energy systems, aerospace, biomedical devices, nanotechnology, transportation, and advanced computation and communication technologies. Federal materials research programs support scientific research, state-of-the-art facilities, and analytical techniques, as well as programs that advance innovation and train the next generation of materials scientists and engineers.

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NATIONAL SCIENCE FOUNDATION (NSF)

Materials Science in the FY 2016 Budget
(budget authority in millions of dollars)

	FY 2014 Actual	FY 2015 Estimate	**FY 2016 Budget**	Change FY 15-16 Amount	Change FY 15-16 Percent
National Science Foundation				0	- -
Math and Physical Sci	1,268	1,337	**1,366**	30	2.2%
Materials Research	267	307	**316**	9	2.9%
National Nanotech Initiative	465	413	**416**	3	0.7%
Department of Energy					
Office of Science	5,131	5,068	**5,340**	272	5.4%
Basic Energy Sci	1,663	1,733	**1,849**	116	6.7%
Mat Sci and Eng	344	364	**375**	11	3.1%
Chem, Geo, and Bio Sci	313	314	**322**	8	2.4%
Office of EERE	1,825	1,914	**2,723**	809	42.3%
ARPA-E	280	280	**325**	45	16.1%
National Nanotech Initiative	309	330	**342**	13	3.8%
Department of Defense					
Basic Research	2,096	2,278	**2,089**	-189	-8.3%
Applied Research	4,523	4,648	**4,713**	65	1.4%
DARPA	2,753	2,916	**2,973**	57	1.9%
Defense Research Sci	293	332	**333**	1	0.3%
Materials & Bio	159	150	**220**	70	46.4%
Electronics Tech	222	169	**175**	6	3.3%
National Nanotech Initiative	190	142	**130**	-11	-8.0%
Nat'l Institute of Standards and Tech					
Science & Tech Res and Serv	651	676	**755**	79	11.7%
National Nanotech Initiative	98	84	**86**	3	3.2%
National Institutes of Health					
Bio Imaging and Bio Eng	327	327	**337**	10	3.1%
National Nanotech Initiative	410	411	**423**	12	2.9%

Source: Agency budget justifications and other budget documents.
Figures rounded to nearest million. Changes calculated from unrounded figures.

Materials research funding at NSF is focused primarily in the Mathematical and Physical Sciences (MPS) Directorate, under the Division of Materials Research (DMR). The MPS Directorate would see an increase of 2.2 percent (or $29.5 million) over FY 2015 under the budget request [11], while funding for materials research and condensed matter science in DMR would increase by $8.8 million in FY 2016 to $315.8 million, an increase of 2.9 percent over FY 2015.

Across NSF, the Cyber-Enabled Materials, Manufacturing, and Smart Systems (CEMMSS) initiative would increases by $29.5 million to a total of $257.0 million, with a specific focus on the Designing Materials to Revolutionize and Engineer our Future (DMREF) program. In the MPS Directorate, this program would see a $9 million increase. The purpose of DMREF is to design and synthesize materials by integrating theory, computation, experimentation, and data mining. These programs are a direct response to the Administration's Materials Genome Initiative (MGI).

Materials Centers funding in the FY 2016 budget for the MPS Division of Materials Research is equivalent to FY 2015 funding at $56.0 million, which would support 21 Materials Research Science and Engineering Centers [12] MRSECs. These new and ongoing centers are interdisciplinary programs for increasing materials research and educating students.

The DMR FY 2016 request includes other NSF focus areas in which advanced materials are key. These include the Sustainable Chemistry, Engineering, and Materials (SusChEM) effort under the NSF-wide Science, Engineering, and Education for Sustainability (SEES) program area, including critical minerals and materials. SEES investments would drop $6.5 million (to a total of $16.0 million), and the remaining funding would focus on sustainable chemistry (SusChEM) research.

Programs impacting materials research are also found in two other divisions of MPS - Chemistry (an increase of 3.0 percent) and Physics (an increase of just under 1.0 percent) - and in NSF's Engineering Directorate (ENG).

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DEPARTMENT OF ENERGY (DOE)

DOE supports fundamental and applied materials research that seeks to achieve discoveries in a wide range of global energy and national security challenge areas. The DOE budget emphasizes the importance and priority of materials, chemistry, and biology by design.

The Office of Science is the largest federal sponsor of basic research in the physical sciences. Under the request [13], its budget would increase from $5.1 billion to $5.3 billion. Basic Energy Sciences (BES) is the largest of the program areas within the Office of Science, due mainly to stewardship of national user facilities, and is projected to grow by 6.7 percent. Within non-facility-based BES research programs, the Materials Sciences and Engineering (MSE) Division includes materials discovery, design, and synthesis; condensed-matter and materials physics; and scattering and instrumentation sciences. A new activity on computational materials sciences is planned to support integrated theoretical modeling and experimental research to develop codes and software for predictive design of functional materials. In FY 2016, funding for Materials Science and Engineering (MSE) would rise to $375.3 million, an increase of 3.0 percent over FY 2015.

The Department of Energy oversees 17 national laboratories through the Office of Science and the National Nuclear Security Administration (NNSA). As mentioned above, the BES program operates the Scientific User Facilities (SUF) Division, with large national user research facilities that provide researcher access to expensive and rare

instrumentation, including synchrotron and neutron sources, nanoscience centers, and smaller user facilities for materials preparation and electron microscopy. BES also operates five Nanoscale Science Research Centers within SUF at national laboratories and, through their user programs, supports a wide range of individual programs on nanoscience.

Sandia Labs' Mark Reece, left, and Don Susan examine a new shape memory alloy button they have removed from an arc-melter. | Credit: DOE

BES also manages the Energy Frontier Research Centers (EFRCs), which are multi-investigator and multidisciplinary centers that pursue projects of high priority to energy research. The scientific directions for these centers cut across materials science and engineering, chemical sciences, geosciences, and biosciences.

DOE supports applied materials research for energy technologies through a number of programs in the Office of Energy Efficiency and Renewable Energy (EERE), with proposed funding of $2.7 billion, and directed materials research for national security through the Science and Engineering programs within NNSA's Weapons Activities account. The Advanced Manufacturing Office in EERE focuses on materials technologies and production techniques that have broad applications for energy-intensive manufacturing methods. The Advanced Research Projects Agency-Energy (ARPA-E), which would increase in FY 2016 to $325 million from $280 million in FY 2015, is a source of funding for high-risk, high-payoff materials research projects. In addition, DOE has continued to manage Energy Innovation Hubs, including the Critical Materials Hub at Ames Laboratory as well as a multi-team Batteries and Energy Storage Hub led by

Argonne National Laboratory.

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DEPARTMENT OF DEFENSE (DOD)

DOD funds materials research through the Army, Navy, and Air Force research organizations, and through defense-wide agencies that support the entire department such as the Defense Advanced Research Projects Agency (DARPA).

Under the President's request [14], basic research ("6.1" in the military classification system for funding) for all DOD agencies would decrease in FY 2016 by 8.3 percent. The FY 2015 appropriation was $2.3 billion and the FY 2016 request is $2.1 billion, a decrease of $188.8 million. Applied research (" 6.2") would increase by 1.4 percent to $4.7 billion. **Advanced Technology Development (" 6.3")** would see an increase of $138.0 million or 2.6 percent. **Overall, Defense science and technology Programs (6.1, 6.2, and 6.3 together) would see a modest 0.1 percent increase.**

As always, materials science and technology programs are dependent on the individual defense agency mission. Army science and technology Programs would see a 13.9 percent decrease, the Navy programs a 1.9 percent decrease, and the Air Force programs a 4.2 percent increase. Overall, DARPA would be funded at $3.0 billion. In addition, programs in the MicrosystemsTechnology Office also support materials research. Electronics, engineering biology, and information technology are all areas in which materials research continues to play an important role in advancing new technologies.

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST's Scientific and Technical Research and Services budget is slated to increase by 11.7 percent, and the agency requests [15] $150 million for the newly-authorized National Network for Manufacturing Innovation (NNMI) [16]. NIST develops measurements, standards, and data needed to advance the development of metals, ceramics, polymers, nanomaterials, biomaterials, electronics, and semiconductor materials that are critical to national needs related to commerce. The budget emphasizes manufacturing technologies, network infrastructure, and support for the MGI program.

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OTHER AGENCIES

Three other agencies also provide support for materials science: the National Aeronautics and Space Administration (NASA) [17], the National Institutes of Health (NIH) [18], and the Department of Homeland Security (DHS)

[19]. These agencies do not separately report materials science budget line items. NASA's Science and Aeronautics directorates both include programs that support materials research. Within NIH, the National Institute of Biomedical Imaging and Bioengineering (NIBIB) is an important funding agency for materials research with an emphasis on health-related science and applications. At DHS, the Science and Technology Directorate conducts applied research on programs that impact materials science.

NATIONAL NANOTECHNOLOGY INITIATIVE (NNI)

Federal investment in the cross-cutting National Nanotechnology Initiative (NNI) would remain at the same level compared to FY 2015, at $1.5 billion. NNI agencies focus on research in materials, devices, and systems that exploit the unique physical, chemical, and biological properties that emerge in materials at the nanoscale. NNI programs by agency and specific signature initiatives are outlined elsewhere [20].

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http://www.aaas.org/U5V

Links:
[1] http://www.mrs.org/home/
[2] http://www.aaas.org/fy16budget/materials-research-fy-2016-budget#nsf
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[19] http://www.dhs.gov/dhs-budget

[20] http://www.aaas.org/fy16budget/national-nanotechnology-investment-fy-2016-budget