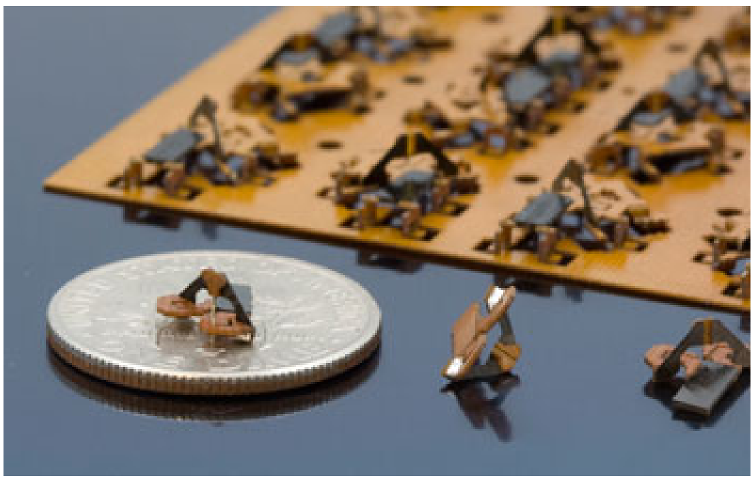
Flexible electronics, self-folding structures and controlled photosynthesis on a grand scale

August 24 2012



The objective of the EFRI project led by Daniela Rus of MIT is to create computational materials whose properties can be programmed to achieve specific shapes and/or mechanical properties, such as stiffness, upon command. The results of this research could transform the way we build machines. Credit: Daniela Rus, MIT

The National Science Foundation (NSF) has announced 15 Emerging Frontiers in Research and Innovation (EFRI) grants for fiscal year 2012, awarding nearly $30 million to 68 investigators at 26 institutions.

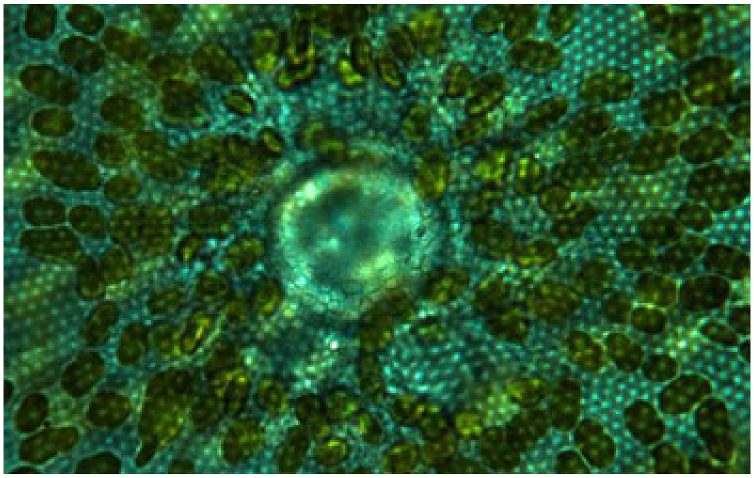
During the next four years, teams of researchers will pursue transformative, fundamental research in three emerging areas: flexible electronic systems that can better interface with the body; design of self-folding materials and structures; and optimizing large-scale chemical production from photosynthesis. Results from this research promise to improve human health, engineering design and manufacturing, and energy sustainability.

Flexible bioelectronics systems

Four EFRI research teams will pursue biocompatible electronic systems that offer new capabilities for health care. Integrating microelectronics with conformable substrates, these flexible bioelectronics systems will interact seamlessly with the body to advance medical monitoring, detection and/or treatment in a patient-friendly form.

EFRI BioFlex researchers will investigate novel devices and flexible materials, interfaces between devices and biological materials, and approaches to systems integration. Successful new concepts will also meet the challenges of biocompatability, weight, power consumption, scalability and cost. The projects aim to transform cancer screening, wound healing and emergency identification of toxins and bacteria.

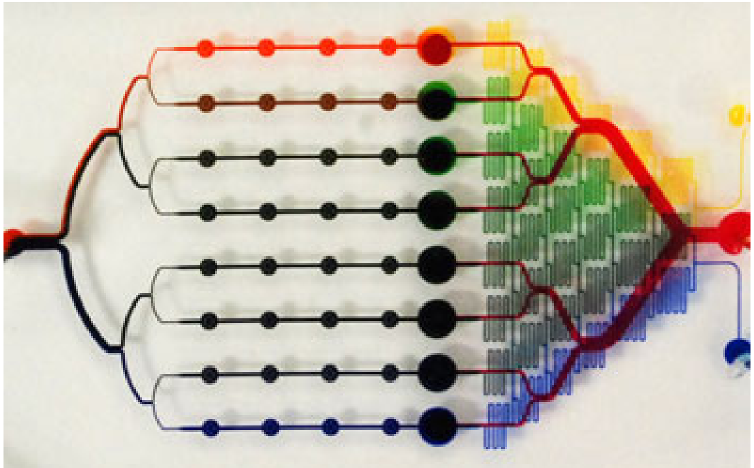
"These four projects could lead to significant improvements in patient care," said Usha Varshney, the coordinating EFRI program officer for BioFlex. "The teams will also contribute advanced scalability techniques so that, in the future, flexible bioelectronics systems can be widely available at low cost."



An EFRI project led by Greg Rorrer at Oregon State will harness the unique biosynthetic capacity of the diatom--a type of algae that extracts plentiful silicate from the ocean to create cell walls of nanostructured silica. Credit: Rorrer Laboratory, Oregon State University

Origami design for self-assembling systems

A second set of EFRI research teams will explore the folding and unfolding of materials and structures to create self-assembling and multifunctional systems. The eight projects funded will build on principles and patterns from the art of origami in order to design structures that can transition between two and three dimensions. In the process, the researchers will also address challenges in modeling complex designs and behaviors, in shifting from small to large scales and in working with active, or "smart," materials.



EFRI researchers led by Arum Han of Texas A&M will create a unique microfluidic "lab-on-a-chip" platform to finely analyze microalgae growth and behavior over time. Credit: Arum Han, Texas A&M University

Active materials can change their shape, size and/or physical properties with changes in temperature, pressure, electro-magnetic fields or other aspects of their environment. With such materials, the EFRI researchers plan to create entire structures and systems out of single pieces that are flexible, elastic and resilient. With new theory and understanding, the researchers aim to predict and even program the behavior and capabilities of the origami designs.

"Engineers, scientists, artists and mathematicians will pursue profound collaboration to discover how to design single structures that can collapse and deploy and even change functions as desired," said Clark Cooper, who coordinated the origami design awards with fellow program officer Christina Bloebaum. "These eight awards could initiate a transformation in design and manufacturing, impacting technologies as diverse as information storage, space structures and medical devices."

Photosynthetic biorefineries

A third set of EFRI research teams will investigate the large-scale use of micro-organisms that harness solar energy to produce chemicals and fuels from carbon dioxide. Some single-celled algae, for example, use photosynthesis to convert atmospheric carbon dioxide and water into lipids and hydrocarbons. However, the realization of photosynthetic "biorefineries" that could accomplish this process on an industrial scale must first overcome significant challenges, including low productivity, large-scale feasibility and environmental sustainability.

The researchers will investigate the optimization of micro-organisms themselves and their growing conditions to produce easily processed hydrocarbon chemicals in large quantities. The researchers also will explore ways to obtain a variety of value-added compounds, whether by using an array of micro-organisms or by combining biological processes with chemical catalysis. Each project will pursue efficiency and sustainability in a number of ways, for example, through the use of wastewater as a low-cost nutrient source for the micro-organisms. All three of the teams funded will be studying the photosynthetic biorefineries as large and complex systems.

"Having robust scaling and control principles using a systems approach is critical to making photosynthetic biorefineries of the future productive and efficient," said George Antos, the coordinating program officer for these EFRI projects. "Using photosynthetic biorefineries as a significant source of chemicals and fuels would not only reduce greenhouse gases, but it would enhance the nation's energy security, as these products are currently made mainly from petroleum. Oil from algae is a reality, however there is much fundamental science that needs to be done before a true industry is founded, and these EFRI researchers will help make that happen."

The fiscal 2012 EFRI topics were developed with strong input from the research community and in close collaboration between the NSF Directorate for Engineering and the NSF Directorates for Biological Sciences and Mathematical and Physical Sciences. NSF also coordinated closely with the Air Force Office of Scientific Research (AFOSR) and the Department of Energy. AFOSR contributed to the funding of all origami design projects.

"Through their collaborations, the EFRI research teams will initiate new lines of inquiry and provide creative and exciting educational opportunities for young students," said Sohi Rastegar, director of the EFRI program. Beginning with the fiscal year 2012 awards, EFRI projects must provide more specific plans that enhance participation of underrepresented groups in the field of engineering and in engineering research.

Rastegar continued, "If we want to have a competitive edge for achieving innovative outcomes, it is imperative to bring to the table ideas from creative individuals from all segments of society. EFRI teams are committed to working with undergraduate and high school students and with new partners, such as teachers and museums, to help more people engage in and appreciate the exciting possibilities from research."

Provided by National Science Foundation