

Research

HIGHLIGHTS



New Class of Composite Materials

Armed with funding from the Physics and Electronics Directorate of the Air Force Office of Scientific Research and the Defense Advanced Research Projects Agency, a team of physicists from the University of California, San Diego (UCSD) verified predictions for a new class of composite materials.

The new material could prove useful in improving communication by developing new optical lenses, novel antennas and filters, and other electromagnetic devices. It also may make possible the construction of a "perfect lens," capable of focusing light and other forms of radiation to limits not achievable by normal lenses asserted John Pendry, a physicist at Imperial College in London.

Last year, these composite materials were produced with the belief they would exhibit behaviors opposite of many fundamental

properties commonly associated with composites. Drs. Richard Shelby, David Smith and Sheldon Schultz at UCSD tested this theory.

"If these effects turn out to be possible at optical frequencies, this material would have the crazy property that a small flashlight shining on a flat slab would produce a focus at a point on the other side," says Schultz. "There's no way you can do that with just a flat sheet of ordinary material."

After building a prototype of their proposed composite from fiberglass and tiny copper wires, they sent microwaves of the same frequency used in police radar guns through the material. The microwaves emerged from the sample material in a direction opposite to that predicted by Snell's law for

story continued on page 2...

Funding by AFOSR has provided the necessary research to develop new composite materials that may allow for the creation of novel antennas and filters, new optical lenses and the ability to reverse the direction of bent light.



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story continued from page 1...

ordinary materials, thus supporting earlier theoretical predictions. Snell's law describes the angle of refraction produced by the slowing of light and other forms of electromagnetic radiation through water, glass and other ordinary materials.

"This class of materials can cause electromagnetic waves, such as radar and microwaves, to bend in a direction opposite to the way they travel through all other known materials," described Shultz, a UCSD professor of physics.

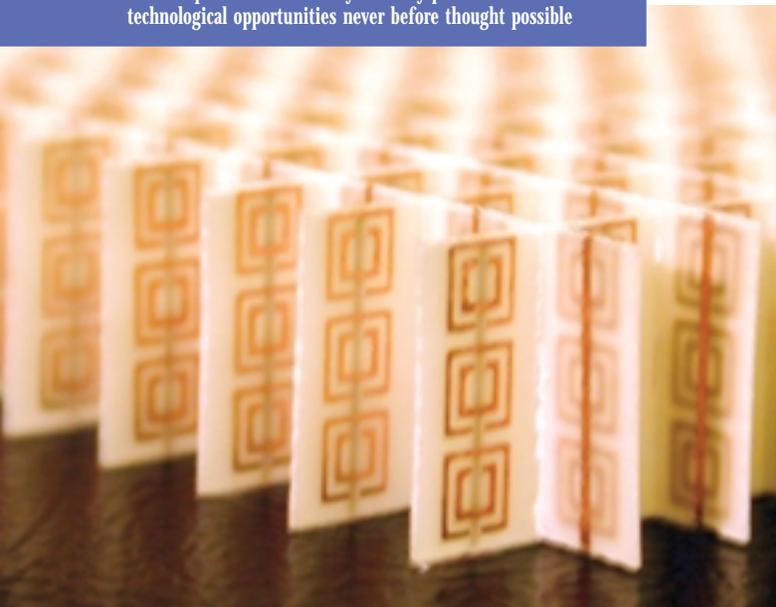
The measurement of the bending of light, microwaves and other forms of radiation is referred to by physicists as its index of refraction. Electromagnetic radiation traveling through normal materials always is deflected in the same direction, giving the materials a "positive" index of refraction. When subjected to radiation, light, microwaves, radio waves, or x-rays, the composite materials made by the UCSD physicists were found to bend in the opposite direction.

Since no existing composite has this property, the UCSD scientists had to demonstrate the effect using a "metamaterial" — a composite material fabricated from repeated elements, specifically engineered to produce a desired electromagnetic behavior.

Currently, the bigger a material's index of refraction, the slower light travels through it and the more it bends, or changes direction when going from one material to another. This bending, in combination with the curved glass surfaces, is what allows lenses to focus their light. By combining different materials or material structured in different patterns, engineers can create structures to control light. Schultz predicts future materials to overcome the inability to focus visible light and lead to new discoveries.

Although the material made by the UCSD physicists currently cannot focus visible light, that obstacle may one day be overcome. Schultz indicates it's likely not a fundamental limitation and researchers someday may find a way to focus visible light too.

New composite materials may someday provide scientists with technological opportunities never before thought possible



Helping Grow The Nation's Future

AFOSR's commitment to its mission is fulfilled through its continuing recognition and encouragement of our nation's youth as they pursue their interests in the fields of science, math and engineering



ure Scientific Leaders

In an effort to encourage the nation's brightest young minds to pursue scientific and technical fields, the Air Force Office of Scientific Research (AFOSR) supports many science fairs annually. This assistance helps reach the Department of Defense (DoD) goal to encourage today's U.S. citizen students to pursue science, math, and engineering education.

Managed under the Air Force Research Laboratory's umbrella, AFOSR historically provides doctoral level judges for the Air Force Science Fair program, the International Science and Engineering Fair, and the Junior Science and Humanities Symposium (JSHS). Col T. Jan Cerveny, Director, AFOSR's External Programs and Resources Interface Directorate (AFOSR/NI), has been the lead Air Force science fair judge for the past several years.

"These bright young students are the future for science and technology," stated Cerveny about the importance of these competitions.

Other volunteer judges, include Dr. Thomas Kim, an engineer and program manager with the AFOSR's External Programs and Resources Interface Directorate (AFOSR/NI), make these competitions credible.

"Once you meet the students and see the projects," Kim explained of his volunteerism, "you can't help but be impressed."

Kim said he enjoyed meeting with students and having the opportunity to promote math, science, and engineering. He said he was encouraged because the students asked a lot of questions. Many, he added, wanted to know what it was like to be an engineer.

"While it (being an engineer) is fun, it takes a lot of hard work and dedication," Kim told the students. "Always be positive, set goals and follow your dreams."

REGIONAL SCIENCE FAIRS

In cooperation with the Air Force Recruiting Service and local recruiters, AFOSR actively participates in regional Science Fairs. Held in the United States and its territories, these fairs are arranged by the non-profit organization, Science Service, Inc. and

supported by many DoD organizations, including the Air Force.

The Air Force Science Fair program allows high school-level students to showcase their research projects. The students are evaluated on their methods of research, results and an oral interview.

Along with Kim, a total of 13 volunteers from AFOSR judged both regional and national competitions this year. The volunteer judges were Dr. Koto White, Dr. Craig Hartley, Dr. Howard Schlossberg, Dr. Jon Sjogren, Dr. Mitat Birkan, Col. Jan Cerveny, Col. Owen Gadenken, Maj. William Hilbun, Maj. Dan Johnston, Capt. Thomas Johnson, and Mr. Gary Bernesque. A high school volunteer, Sean Murphy, also helped our judges.

The students not only benefit from the satisfaction of competition, they also receive significant awards. Regional science fairs' student winners receive prizes such as day planners with calculators and medallions minted with the Air Force Research Laboratory's (AFRL) logo. Local regional first-place winners also win an AFOSR grand award and a trip to the AFRL technical directorate most closely matching their research effort.

INTERNATIONAL SCIENCE AND ENGINEERING FAIR

Select winners from each regional fair continue on to compete at the International Science and Engineering Fair held each May. This year, Cerveny represented AFOSR as the lead AF judge at this international competition.

The winners receive \$3,000 for first-place and \$1,000 for second-place honors. In addition, many students take home medallions and/or certificates.

JUNIOR SCIENCE AND HUMANITIES SYMPOSIUM

Another youth outreach program is the Junior Science and Humanities Symposium (JSHS). This tri-service program is spearheaded by the Army and funded in



Col. T. Jan Cerveny presents Caroline Gibson with a Certificate of Achievement, Senior Division, from the United States Air Force at the Fairfax Regional Science Fair held at Robinson High School on March 18, 2001.

partnership with the Navy, HQ AFRL and AFOSR. JSHS supports 47 regional competitions with winners continuing on to the national symposium competition.

A non-profit organization, the Academy of Applied Sciences organizes these high-level competitions.

Cerveny, Kim, and Hilbun were three of the judges in this year's competition in Florida. In addition to judges, AFOSR provides financial support for the JSHS competition.

Students participating in JSHS conduct original research and present it before a team of judges, as well as their peers, teachers and general audience members. JSHS challenges students to discuss the nature of their scientific inquiry, defend their reasoning and educate other participants about their findings, just as in a professional plenary session at research conferences.

Regional JSHS competition winners receive \$4,000 scholarships and an expense-paid trip to the national symposium. At the national symposium, eight first-place winners competing in such categories as biology, mathematics, and physics, receive an additional \$16,000 scholarship.

All of these outstanding students benefit from the experience and advice the scientists and engineer judges offer at these competitions. In fact, many current AFRL researchers proudly divulge that they were science fair participants and remain supportive of these programs today.

Quantifying Human Performance

A more accurate way to measure a person's performance in the work place can now be achieved as a result of newly-created Synthetic Task Environments or STEs.

Research for this landmark measuring tool was funded by the Air Force Office of Scientific Research's Chemistry and Life Sciences Directorate and Air Force Research Laboratory's Human Effectiveness Directorate. The research was accomplished at the Warfighter Training Research Division (HEA) in Mesa, Ariz., and the Information Systems Training Branch (HEAI) located at Brooks AFB, Texas from 1996 to now.

Through observing the effectiveness of Air Force personnel on the job, the STEs approach encompassed a complex array of tasks. While giving researchers a tool flexible enough to gather useful data in areas previously thought to be difficult, these tasks measure items such as computer-aided instruction, human-computer interfaces, team member interactions, and training interventions. Now, for the first time,

scientists can use STEs to compare results of these varied influences on individual and team performance.

As a result of the findings, "a real-time collaborative team research program was established on the Internet for government, university and small business participation to expand our results into information fusion, distributed decision-making, and human representation modeling," said Dr. Samuel Schiflett, principal investigator at HEAI.

Researchers tested the STEs by analyzing the tasks involved in operating unmanned aerial vehicles and by observing Air Force experts perform command and control functions in airborne warning and control aircraft. Based on the findings, computer-based simulations of operational scenarios were formulated and a benchmark for human performance, called Human Performance Units (HPUs), was established. Never before captured, the HPUs will enable experts to make scientific recommendations on how to improve a worker's performance and on the impact of new technology in the workplace.

Schiflett said he was very proud to be a part of the legacy, conceptualization and implementation of the synthetic task environment and he believes the application of STEs will really have an impact on improving warfighter performance.

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Research Highlights

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Research Highlights is published every two months by the Air Force Office of Scientific Research. This newsletter provides brief descriptions of AFOSR basic research activities including topics such as research accomplishments, examples of technology transitions and technology transfer, notable peer recognition awards and honors, and other research program achievements. The purpose is to provide Air Force, DoD, government, industry and university communities with brief accounts to illustrate AFOSR support of the Air Force mission. *Research Highlights* is available on-line at:

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