MPA MaterialsMatter

September 2008

INSIDE

George Rodriguez of the Center for Integrated Nanotechnologies adjusts and monitors the argon gas pressure inside the two-color plasma ionization gas cell as intense terahertz (THz) radiation is generated from the optical mixing of two ultrafast optical pulses in the ionized medium. Tabletop ultrafast laser-based plasma THz sources such as these are now beginning to rival pulse energies previously only obtainable at large accelerator-based facilities such as synchrotrons.

Tabletop laser improves lab-based spectroscopy

Before, people never thought about the correlation between high harmonics and terahertz generation

By controlling the ultra-fast pulses of a tabletop laser in their laboratory, a team of Los Alamos scientists has created high-frequency terahertz radiation, the kind that could revolutionize high-resolution microscopy and spectroscopy in the lab and may one day have applications in medical imaging and security scanners.

In the past, scientists have been able to coax this high-frequency, short-wavelength generation only with large laser accelerators -—massive machines that speed up electrons often housed in huge complexes. Because only a handful of these devices exist, researchers who want to observe and use nonlinear terahertz effects—including spectroscopy to glean precise information about the compounds they were trying to identify—have been limited by access to these laser sources powerful enough to produce the energy required to eek out terahertz waves.

Tabletop laser continued on page 3

Los Alamos National Laboratory

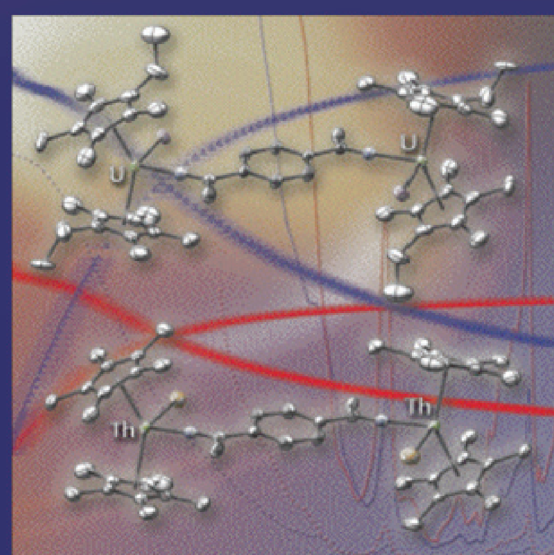
From Alex's Desk

Partnership to accomplishing our mission
MPA's mission to apply our fundamental understanding of materials properties to real world needs is indeed broad. Sure, we cannot do it alone and, in addition to our partners at LANL, we are aggressively engaging with our Technology Transfer (TT-DO) colleagues on how to extend our talents beyond our current set of industrial partners and collaborators. As I stated in previous notes, I find our collaboration with industry part of our future and I think we can grow. The problems we are poised to contribute to, from fuel cells to hydrogen storage to sensors, in general are of great interest not only from the academic prospective but also from the industrial and international ones. Related to that partnership approach, let me describe a meeting I recently attended in San Diego with our colleagues from the fuel cell (MPA-11) and hydrogen storage (MPA-MC) communities. The meeting was sponsored by DOE–EERE (Office of Energy Efficiency and Renewable Energy) and NEDO (New Energy and Industrial Technology Development Organization). NEDO is Japan's largest public R&D management organization for promoting the development of advanced industrial, environmental, new energy, and energy conservation technologies. The intent of the meeting was to focus on the "center" of partnership. Technical leaders from the U.S. (where MPA-11 and MPA-MC play a major role) and Japan discussed what they have accomplished, shared ideas, and engaged young scientists. The Japanese contingent was comprised of 40 participants; our side featured good participation from MPA-11 and MPA-MC researchers. It was great to present our leadership in the field. To address and solve the world energy demands, time is of the essence. There is a lot to be done, and we are not alone and that's a good thing!

I'm writing this note on my way (in a bumpy flight) to Oak Ridge National Laboratory with Ken Marken and Steve Ashworth (MPA-STC) and Bill Tumas (program director, Applied Energy Program Office (SPO-AE)). There we'll seek a partnership to respond to a recent DOE call where a combination of our technical expertise combined with LANL's infrastructure will play a major role. I'm looking forward to the possible collaboration with ORNL in the area of applied superconductivity.

Performance appraisal process
Well, by now you certainly have noticed we have used a different appraisal process system. Since this is the first time we are all using the new system, it took us some time to get to a point we all understood. David Watkins and I have worked diligently with your group and center leaders, assuring consistency and understanding their expectations. The scores and raise numbers you will soon been seeing from your local leadership is the results of several discussions and interactions with your group/center leadership.

Recent science highlights
Eric Schelter, Jackie Kiplinger (MPA-10), and collaborators have their actinide work captured on the cover of *CHEMISTRY* (*Chem. Eur. J.* **14**, 7782 – 7790 2008), a prestigious European chemistry journal. They have shown that multimetallic uranium and thorium architectures can be easily assembled by using nitrile insertion chemistry into actinide–carbon bonds. The result provides a useful platform for the study of metal–metal interactions.



Newly synthesized bimetallic complexes of U(IV) and Th(IV) with covalently-bound bridging ligands enable the Kiplinger team to explore the origins and strength of magnetic and electronic communication between metals.

***From the Desk** continued on page 3*

Congratulations
Clay Macomber (MPA-MC); 2008 LANL Distinguished Performance Award. Clay investigates reaction mechanisms and degradation pathways of solid-state materials. He used diffuse reflectance to identify a link between the optical properties of materials and their decomposition kinetics. The materials chemistry team has been able to apply his observations to the establishment of a similar correlation for a material of interest to the weapons program. Such a correlation has been elusive to researchers concerned with establishing the production variables of this material for many years. Extension of Macomber's work to materials production will enable an optical diagnostic of the material's quality before the material is subjected to further processing. The result is a significant savings in both time and money

Among the eight LANL recipients of the 2008 Outstanding Mentor Awards from the Women's Diversity Working Group, three were from MPA Division: ***Marcelo Jaime (MPA-NHMFL), Quanxi Jia (MPA-STC)***, and ***Piotr Zelenay (MPA-11)***. Thank you for your dedication to mentoring the next generation of technical leaders.

And…., please keep engaging with MPA's WSST team members. Any team member would be happy discussing and working with you on any safety issues. (MPA-WSST) team members include Chris Sheehan (chair), (MPA-STC); Carmen Espinoza, (MPA-10); Roger Lujan, (MPA-11); Clay Macomber, (MPA-MC); Chuck Mielke, (MPA-NHMFL); Darrell Roybal, (MPA-NHMFL), and Darrick Williams, (MPA-CINT). For more information about MPA-WSST, please visit int.lanl.gov/orgs/mpa/mpa_wsst/index.shtml.

—Alex Lacerda, Interim MPA Division Leader

Tabletop laser . . . *continued from page 1*

"We used a laser you can have in your lab, rather than having to go to a large user facility," said Laboratory physicist Toni Taylor, leader of Los Alamos's Center for Integrated Nanotechnologies (MPA-CINT). "It's a very practical source for a research tool."

Taylor and her colleagues published their work in the current edition of *Nature Photonics*. Their technique would allow researchers the opportunity to produce this type of radiation using a laser small enough that it could be housed in the laboratory of a single investigator. To accomplish this, the team focused speedy laser pulses through a lens and into a cylinder filled with gas. The energy from the laser knocked some of the gas's electrons free in a process called ionization to create plasma. The liberation of the electrons in turn released radiation—in this case, with a frequency of up to 75 terahertz.

The researchers experimented with several gases, including air, nitrogen, and helium, but in the end, krypton proved to be the best source of the terahertz generation. Krypton's outer-most electrons are farther from the nucleus than those in helium, for example, and the element is therefore more easily ionized. Scientists studying light and other electromagnetic waves often use what's called a beta barium borate crystal in the gas cell. In effect, this crystal shortens the wavelength of the radiation and doubles its frequency. The team found that by changing the location of the crystal inside the cell, they could control the balance between terahertz and high-harmonic radiation.

"Before, people never thought about the correlation between high harmonics and terahertz generation," said Ki-Yong Kim, lead author on the paper and formerly a physicist at Los Alamos (now at the University of Maryland).

High harmonics also are used in microscopic imaging, and scientists know that terahertz and high-harmonic radiation are generated from antipodal processes. While terahertz generation arises from electrons floating away from the gas atoms, high harmonics are generated when the liberated electrons slam back into the newly formed ions.

But no one had proposed a mechanism that related the two types of radiation. Kim and his colleagues show that they are anti-correlated—that is, as one type increases, the other decreases.

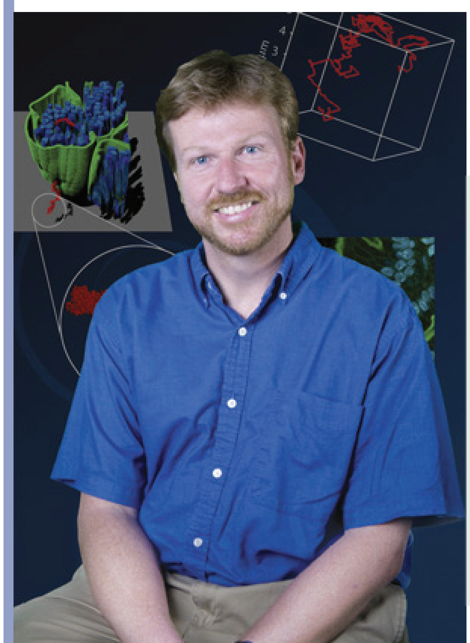
Beyond the lab bench, the technique the team developed may have applications in larger facilities with lasers capable of generating even higher energy and hence higher frequency radiation. "The question is: What if you use a really big system?" Kim said. "Will this technique be scalable?"

Researchers James Glownia and George Rodriguez of CINT are coauthors of the paper. Glownia now works at the Department of Energy's Office of Basic Energy Sciences in Germantown, Maryland.

Laboratory researchers receive two R&D 100 awards

Cutting-edge innovations garnered Los Alamos researchers two of R&D Magazine's prestigious R&D 100 Awards. The awards, which will be presented October 16 in Chicago, recognize the top 100 industrial innovations worldwide in 2008. Winning Laboratory projects are the 3-D Tracking Microscope and Laser-Weave technology.

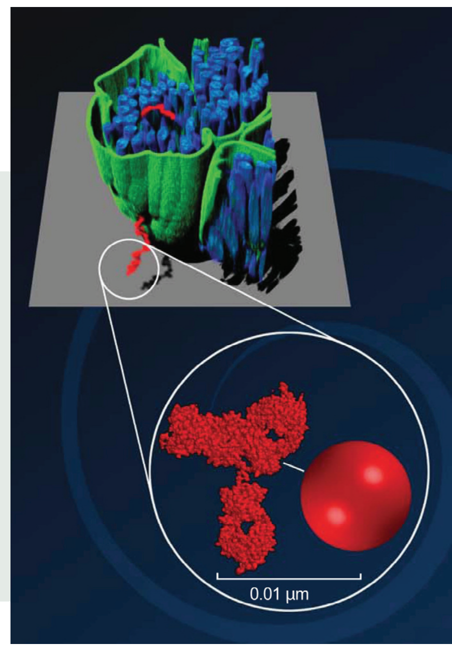
"Congratulations to our R&D 100 Award-winners for this acknowledgement of scientific excellence," said Laboratory Director Michael Anastasio. "The awards demonstrate that the Laboratory continues to be at the forefront of developing innovative concepts and translating them into practical applications." This year's awards bring the Laboratory's total to 107 since it began entering the competition in 1978.



> "I learned a long time ago that scientific discovery is driven by instrument development"

◀ ***Jim Werner, 3-D Microscope***

Photo: Sandra Valdez



Jim Werner of the Center for Integrated Nanotechnologies (MPA-CINT) who won a coveted R&D 100 award for developing a microscope capable of tracking nanometer-sized objects in three dimensions, is one of the humblest people you'll ever meet.

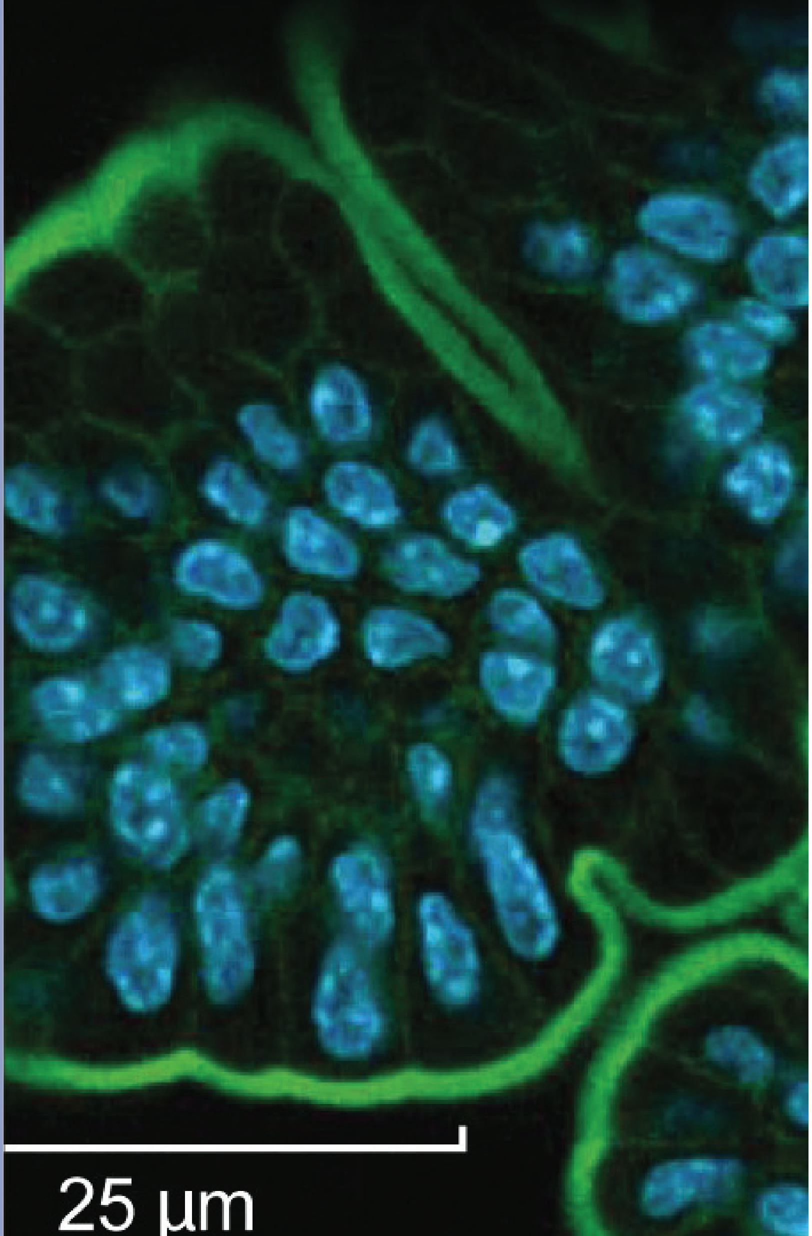
"I was singled out in the press because I happened to write the application," said Werner, who holds a doctorate in applied physics from Cornell University. "I couldn't have done it without my team." Werner said Peter Goodwin, Guillaume Lessard, and Nathan Wells, all of MPA-CINT, deserve credit for helping to create the revolutionary new instrument. The team designed the world's first confocal microscope capable of following the motion of individual molecules, quantum dots, organic fluorophores, single green fluorescent proteins, and other nanometer-sized objects as they zoom through three-dimensional space at rates faster than many intracellular transport processes. The microscope will find primary application in cellular biology, where it will help track the transportation of molecules inside cells, Werner said.

The scientist said that his interest in developing the microscope was sparked by a conference on single molecule biophysics he attended several years ago, where there were a number of interesting reports of two-dimensional single molecule tracking. "It became fairly obvious to me that the technology needed to develop into 3-D," he said. Werner spent the next five years trying to do just that. The team spent long hours performing simulations, writing software to control the microscope, and building the instrument. Werner said he decompressed by playing soccer, flyfishing, and snowboarding. "I love the outdoors," he said. "That's partly why I love living here in Los Alamos." Werner said that winning the R&D 100 Award has greatly increased awareness of the technology in the scientific community.

The experience also confirmed one of Werner's most closely held axioms. "I learned a long time ago from Dick Keller (Keller is a Laboratory Fellow and a pioneer of single molecule detection) that scientific discovery is driven by instrument development," he said. "It means so much to all of us that we were able to come up with a successful design."
—*Tatjana K. Rosev*

"Peter Goodwin and I went back and forth with methods. We finally came up with a pretty good design and strategy."

—Jim Werner



Lab collaborates with Superconductor Technologies Inc.

New superconductor materials in development

The Laboratory and Superconductor Technologies Inc. (STI) have entered into a joint collaboration to "apply STI's high-temperature superconductor (HTS) materials expertise to the Laboratory's research initiative to develop HTS-coated conductors for power transmission lines."

At a Department of Energy conference held recently in Arlington, Virginia, Vladimir Matias (MPA-STC) and Brian Moeckly of STI discussed their research in HTS materials. High-temperature superconductor-coated conductors offer the promise of replacing copper electric power applications with superconducting cables that have higher capacity while minimizing resistive cable losses.

According to Prime Newswire, conference participants discussed the research, development, and testing of prototype HTS power system applications through industry-led projects.

Second workshop on the dual nature of f electrons held in Santa Fe

The Second International Workshop on the Dual Nature of f Electrons was held in Santa Fe, bringing together scientists involved in theoretical and experimental aspects of 4f and 5f materials. Invited talks and topical round-table sessions covered many aspects of the electronic structure and magnetic properties of strongly correlated materials in relation to the dual-nature of f-electrons. The three-day workshop, which

Workshop *continued on page 6*

25th Rare Earth Research Conference

The 25th Rare Earth Research Conference, the premier meeting for multidisciplinary basic and applied research on the f-elements, was held recently at the University of Alabama in Tuscaloosa. Scientists from more than 20 countries attended. Scientists in ADEPS, ADCLES, and ADSMS participated in the meeting, presenting a number of invited talks and poster presentations, in sessions spanning organometallic chemistry, condensed matter physics, and materials science. Jackie Kiplinger (MPA-10) organized a two-day symposium on organometallic chemistry in honor of Spedding Award winner W. J. Evans of the University of California, Irvine. Other program committee organizers include John Sarrao (SPO-SC), the program chair, and Gordon Jarvinen (ADSMS). Sarrao will serve as the conference chair and host of the 26th Rare Earth Research Conference, scheduled for 2011, in Santa Fe.

Dual nature of electrons . . . *continued from page 5*

was organized by Tomasz Durakiewicz (MPA-10), Gertrud Zwicknagl (Max Planck Institute), and Cristian Batista (T-11); featured 17 invited speakers presenting different approaches to f-electron duality in cerium, uranium and plutonium. LANL-affiliated presenters were Zachary Fisk and Yi-Feng Yan (MPA-10 affiliates), Ricardo Urbano, Tuson Park, and Tomasz Durakiewicz (MPA-10); John Mydosh (MPA-NHMFL); Cristian Batista and Jian-Xin Zhu (T-11); John Wills (T-17), and B.G. Kotilar (T-11 affiliate).

The workshop's Experimental and theoretical efforts are directed towards understanding the nature of 4f and 5f electrons in strongly correlated systems. In both uranium and plutonium compounds, hybridized electron bands are found near or at the Fermi level that appear to have 5f character—a result that must be taken into account in understanding the electronic structure, magnetic and transport properties, or superconductivity of those systems.

To explain the f–electron physical properties, scientists assume that part of the 5f electrons remain localized, while some are itinerant. Details of the localization-delocalization mechanisms, as well as hybridization, Coulomb and spin-orbit interactions in strongly correlated f-electron systems are moving beyond the traditional approaches and are receiving theoretical and experimental investigation. The third workshop on the topic will be held in Dresden in 2010, in Japan in 2012, and in Santa Fe in 2014.

Technical contact: Tomasz Durakiewicz

HeadsUP!

WHERE WILL LIGHTNING HIT?

When a lightning bolt reaches the ground, it most likely will hit tall things, metal, or water – or a person standing on open ground or on a roof. Lightning kills about 80 people in the U.S. each year and injures hundreds. Outside of Florida, Northern New Mexico's mountains receive the most recorded lightning strikes in the country.

If someone is hit by lightning it can cause burns, nervous system damage, and other health problems AND…lightning can stop the heart. So…BEFORE LIGHTNING STRIKES…PROTECT YOURSELF! Here's what you can do when you see an approaching storm:

- AVOID the high ground
- AVOID metallic objects
- AVOID solitary trees
- AVOID water
- SEEK shelter in a building
- SEEK safety inside a vehicle —without touching metal
- SEEK a cluster of small trees or bushes
- SEEK lower elevations

However, if you're caught outside and can't get to a shelter…use the lightning crouch:

- Put your feet together, squat down, tuck your head, and cover your ears.
- When the immediate threat of lightning has passed, continue heading to the safest place possible.

USE THE 30-30 RULE: You can tell how close you are to a lightning strike by counting the seconds between seeing the flash and hearing the thunder. For every five seconds you count, the lightning is one mile away. Count 30 seconds—If the time between when you see the flash and hear the thunder is 30 seconds or less, the lightning is close enough to hit you. Seek shelter immediately. Wait 30 minutes—After the last flash of lightning, wait 30 minutes before leaving your shelter. **More than one half of lightning deaths occur after a thunderstorm has passed.**

MPA MaterialsMatter
Materials Physics and Applications

Published monthly by
the Experimental Physical Sciences Directorate.
To submit news items or for more information,
contact Karen Kippen,
EPS Communications,
at 606-1822, or kkippen@lanl.gov
LALP-08-007
To read past issues see
www.lanl.gov/orgs/mpa/materialsmatter.shtml

Los Alamos National Laboratory,
an affirmative action/equal opportunity employer,
is operated by Los Alamos National Security, LLC,
for the U.S. Department of Energy under contract
DE-AC52-06NA25396.
A U.S. Department of Energy Laboratory.

Los Alamos
NATIONAL LABORATORY