June 2008

MPA MaterialsMatter

INSIDE

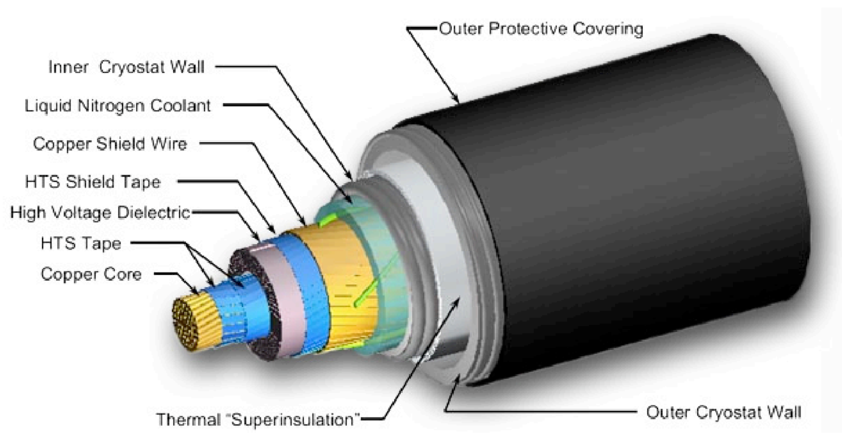
World's first transmission voltage superconductor cable energized in a commercial power grid

MPA-STC industrial partner American Superconductor recently announced the successful operation of the world's first high temperature superconductor power transmission cable system in a commercial power grid. The 138,000 volt system, which consists of three individual HTS power cable phases, running in parallel is operating successfully on Long Island, NY. This achievement represents another important step towards a national superconducting electric grid based in part on Los Alamos-developed technologies.

This achievement represents another important step towards a national superconducting electric grid

MPA-STC's Power Applications Team Leader Steve Ashworth led a readiness review team that advised this DOE project on behalf of the DOE. Los Alamos staff made major contributions to AMSC superconductor wire development. Leonardo Civale and Terry Holesinger have led this materials development effort which dramatically improved wire performance through flux pinning optimization and multi-scale characterization.

A typical HTS cable cross-section



Contributing team members include Boris Maiorov, Jeff Willis, Yates Coulter, and John Rowley (MPA-STC), John Bingert (MST-8), and Dave Korzekwa (MST-6). Funding for the project was shared 50/50 between the DOE HTS program and the industrial partners in the project.

***Superconductor** continued on page 3*

From Alex's Desk

MPA: We are not alone

I'm taking this opportunity to describe to you a recent trip abroad in which I participated with Susan Seestrom and Kurt Schoenberg. We visited major user facilities in Europe, particularly in France, Germany and the United Kingdom. The good news is our capabilities and science are indeed strong and competitive; the interesting news is we have very strong competition, which I see as a good thing.

Our first stop was in Grenoble, France. There we visited the Centre de l'Energie Atomique (CEA), several labs within CEA, the Neutron Scattering Facility (Institute Leon Langevin (ILL) and the European Synchrotron Radiation Facility (ESRF), the Grenoble High Field Laboratory, and the Institute Louis Neel. Since I left Grenoble in 1990 the facilities have grown and the breadth of scientific programs expanded. Grenoble continues to impress me. And yes, they also face budget and compliances issues.

I saw a great scientific integration, particularly with major user facilities. The expansion plans of ESRF and ILL, in combination with experimental tools where materials will be investigated under extreme conditions, taking advantage of experimental and theoretical expertise, is indeed strong. In Grenoble I gave a colloquium on MPA's energy-related programs, where I focused on new materials discovery, fuel cells, superconductivity and its application. and our major user facilities.

Our next stop was Dresden, Germany. In Dresden we visited Forschungszentrum Dresden-Rossendorf (FZR). FZR is a member of the Leibniz Association focusing on basic and applied research. It scientific complex host two large user facilities: a superconducting linear accelerator operating a "free-electron laser" (ELBE) with a 13 MHz pulse repetition rate and with an average beam current of 1mA. In addition, FZR also hosts a Pulsed Field User Facility (DHMFL). DHMFL operates several capacitor bank-based pulsed magnets with magnetic fields in excess of 65T. The core of DHMFL is a 50 MJoules capacitor bank allowing a lot of flexibility on magnet designs. ELBE and DHMFL are connected by an underground tunnel and experiments are underway coupling the free-electron laser to high magnetic fields.

Next stop Abingdon, UK, where we visited ISIS. ISIS is a pulsed neutron and muon source located at the Rutherford Appleton Laboratory near Oxford. It is an impressive facility, with a very large user program, and they are about to finish a second target where additional instrumentation will be added.

And finally (after changing countries three times in six days) we stopped by Laboratoire Léon Brillouin (LLB) in Saclay, near Paris. LLB is a reactor-based neutron scattering facility operating a user facility with its main focus on physical chemistry, structural and phase transition studies, magnetism and superconductivity.

Bottom line, we have learned a lot, and I am proud in reporting to you that MPA's scientific endeavors are forward-looking, strong, and competitive; however, we shall not slow down.

Brief update on compensation program design (CPD) phases I and II

By designing a new compensation program, the Laboratory's intent is to better serve our workforce by offering more competitive salaries and a more clear career path at all levels. We have just finished the first phase of the Institution's new compensation design. In Phase we have "mapped" our administration, technician, and non-R&D TSM population. This is important and we have tried to be fair and uniform across the entire EPS Directorate. If you have concerns about your mapping, contact your line manager. He/she will be able to let you know how to proceed. Please note, however, that you have 30 days (since your mapping notification) to file the appeal process.

We have now started Phase II, where we have "mapped" all R&D TSM jobs. We have had good discussions with MPA's group/center management. I have personally discussed our mapping approach with division leaders and colleagues inside and outside EPS. In order to map the MPA R&D TSM population from Levels I through VI, in addition of a great deal of discussion with MPA's Council, we have used the following set of criteria (in no particular order and with relative equal weight graded one to five for each TSM):

From the Desk *continued on page 5*

Frequency agile metamaterials extend terahertz usage

Metamaterials are composite structures fabricated to have a designed resonant response to electromagnetic radiation. The building block of metamaterials is the subwavelength split-ring resonator, which acts analogously to an atom in natural materials. Circulating currents in the resonators are driven by either the electric or the magnetic component of the electromagnetic wave, or both, resulting in a strong resonant response. The resonance frequency is mainly determined by the effective inductance and capacitance of the split-ring resonator, which is tunable by scaling and shaping the resonators.

MPA-CINT researchers and colleagues have created a hybrid terahertz metamaterial whose resonance frequency in the terahertz region can be optically tuned, thus providing a new technique for "designing" the optical response of a material and possibly extending the usage of metamaterials. The researchers' creation of dynamically tunable metamaterials could eventually lead to THz applications in frequency agile filters, switching and modulation, spectroscopy and sensing, imaging, communications, as well as contribute to full control and manipulation of THz waves.

The metamaterial is based on a two-dimensional array of split-ring resonators fabricated on a silicon-on-sapphire wafer, in which the silicon is selectively etched in such a way to incorporate two silicon strips within each split-ring resonator element acting as variable capacitor plates [Fig. 1(a) and (b)]. When the metamaterial is illuminated by near-infrared laser pulses, photo-excitation of free charge carriers in the silicon stripes causes the silicon to behave like a metal. This behavior changes the effective capacitance in the split-ring resonator elements thereby tuning the metamaterial's resonance frequency. In the first attempt, the authors have experimentally demonstrated a tuning range of 20%, from 1.06 THz to 850 GHz [see Fig. 1(c)], which is in good agreement with numerical simulations [Fig. 1(d)].

Metamaterials *continued on page 5*

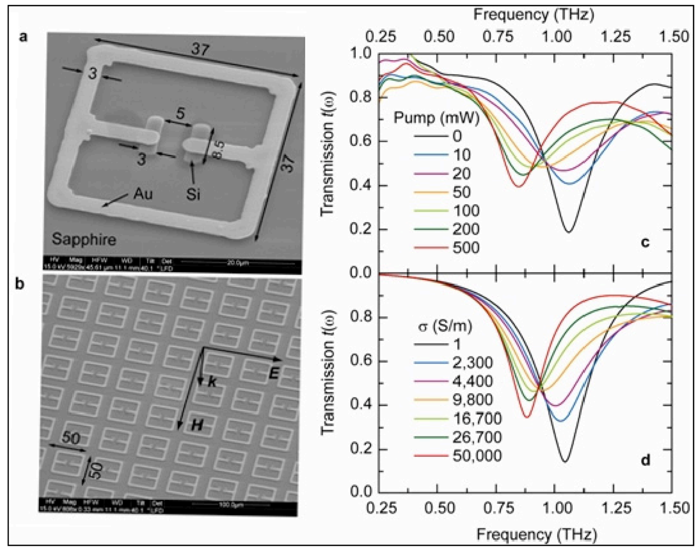


Figure 1: Frequency agile THz metamaterials. SEM graphs of (a) an individual unit cell and (b) periodically array with integrated silicon capacitor plates. (c) Experimental and (d) simulated THz transmission spectra.

Superconductor . . .

The cable system contains hair-thin, ribbon-shaped HTS wires that conduct 150 times the electricity of similar sized copper wires. This power density advantage enables transmission-voltage HTS cables to utilize far less wire and yet conduct up to five times more power—in a smaller right of way—than traditional copper-based cables. HTS power cables are envisioned by the DOE as a component of a modern electricity superhighway, one that is free of bottlenecks and can readily transmit power to customers from remote generation sites.

The collaboration continues in a follow-on cable project, LIPA II, which uses second generation HTS wire. This second generation wire utilizes significant MPA-STC developed technology ■

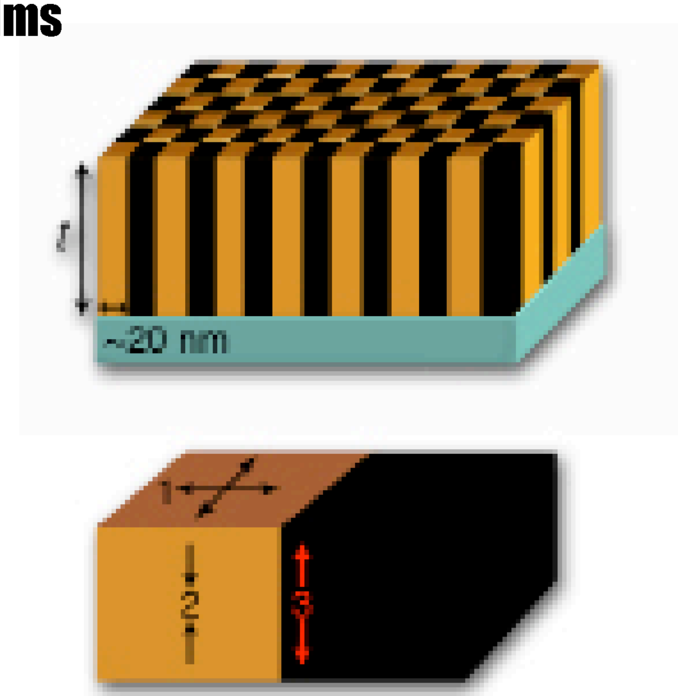
The world's first HTS power transmission cable system. The three cables shown entering the ground can carry as much power as all of the overhead lines on the far left.

Strain control and spontaneous phase ordering in vertical nanocomposite films

Two-phase, vertical nanocomposite heteroepitaxial films hold great promise for (multi)functional device applications. To achieve practical devices, many hurdles must to be overcome, including the creation of ordered structures, achieving different combinations of materials, and control of strain coupling between the phases.

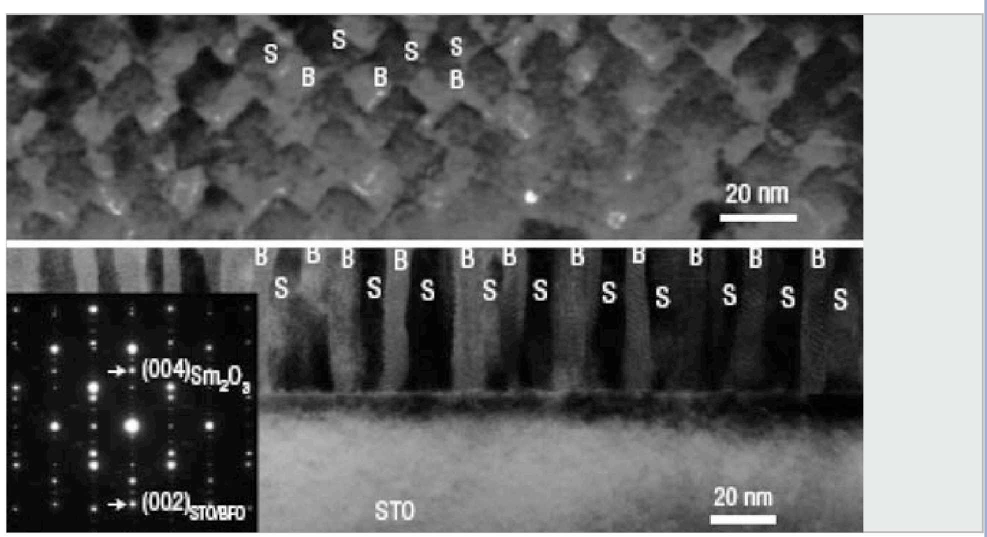
Quanxi Jia (MPA-STC) and colleagues demonstrated major advances: they produced remarkable spontaneously ordered structures in newly predicted compositions; proved that vertical strain dominates the strain state in films above 20 nm thickness; and demonstrated strain manipulation by selection of phases with the appropriate elastic moduli. This vertical strain control has potential for novel lattice-engineered functional property control that is significantly greater than the current lateral strain control. In relatively thick films this may enable tuning of materials with dielectric or optical applications by the appropriate choice of second phase. This would enable more straightforward basic studies of physical properties in strained systems. The spontaneous ordering of nanostructures over large areas has ramifications for functional materials used in photonics or magnetic data storage. The work by Jia and Hao Yang (both in MPA-STC); J. MacManus-Driscoll, P. Zerrer, A. Fouchet, R. Yu, and M.Blamire (all of the University of Cambridge); and H. Wang and J. Yoon (Texas A&M University), appears in *Nature Materials*, 7, 314-320 (2008). Laboratory Directed Research and Development supported the LANL work ■

Technical contact: Quanxi Jia



▲ *Strain concept in a heteroepitaxial vertical nanocomposite film. For simplicity, an ordered arrangement of phases is depicted. In a pure epitaxial film, the phase is simply strained to the isostructural substrate. This depicts the situation where the film is put into tension by the substrate (arrow 1); an out-of-plane compression in the film then results (arrow 2). However, with the presence of the second phase, vertical strain at the interface (arrow 3) must to be taken into account. The effectiveness of the vertical strain depends on the quality of the columnar interfaces and their area relative to that with the substrate*

TEM micrographs of nanocomposite $BiFeO_3$/Sm_2O_3 films on $SrTiO_3$ substrate. (top) High-magnification transmission electron microscopy image of $BiFeO_3$/Sm_2O_3 showing checkerboard pattern. (bottom) cross-sectional image of $BiFeO_3$/Sm_2O_3 on $SrTiO_3$. B is $BiFeO_3$ and S is Sm_2O_3. Bottom left inset is the selected-area diffraction patterns from film and substrate ▶



From the Desk . . .

- *Breadth/depth of science and technology job demands*
- *Contribution to Laboratory programs and strategies*
- *National and international recognition and technical leadership*
- *Contribution to state-of-the-art workforce*

I have submitted MPA's mapping input and I should be hearing back in a couple of weeks. For more information on the Laboratory's CPD program, please see int.lanl.gov/orgs/hr/comp/cpd/index.shtml.

Science news

***Fractalization drives crystalline states in a frustrated spin system*.**

Results of a large experimental and theoretical investigation by Suchitra Sebastian (a long-time NHMFL user and currently a researcher at the Cavendish Laboratory, University of Cambridge, UK), in collaboration with Sonia Francoual (MPA-NHMFL Postdoctoral Fellow), Pinaki Sengupta (MPA-NHMFL/T-11 Postdoctoral Fellow), Neil Harrison (MPA-NHMFL), and Cristian Batista (T-11), and other researchers from NHMFL – Florida State University and McMaster University, Canada will be soon appearing in the *Proceedings of the National Academy of Sciences*. Magnetic fields to 85T combined with very low temperatures were used to investigate the geometrically frustrated spin system $SrCu_2(BO_3)_2$. They observed a sterling demonstration of a system where bosons confined by a magnetic and lattice potential mimic the behavior of fermions in the extreme quantum limit, giving rise to a sequence of quantum Hall-like plateaux.

Congratulations

Please join me in congratulating Fernando Garzon (MPA-11) on been selected a Fellow of the Electrochemical Society (ECS). Fernando is one of the Laboratory's leaders on energy related issues.

Congratulations to Brenda Espinoza (MPA-11) for her 25 years of service to the Institution. Brenda is highly regarded for improving the performance and efficiency of Laboratory operations. She is well known as an extremely competent and dedicated administrative team leader. She deals with a wide variety of MPA-STC visitors and postdoctoral researchers from the U.S. as well as other nations. She is called frequently by other groups for her guidance and has been cited by HR Division for her outstanding organizational skills in these areas. Brenda has also done a stellar job coordinating training, personnel, equipment, and space issues for the STC in a secure and safe manner. She has developed significant enhancements in STC's departure procedures that are a model for the rest of the Laboratory.

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 are 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 http://int.lanl.gov/orgs/mpa/mpa_wsst/index.shtml ■

Metamaterials . . .

The publication, "Experimental Demonstration of Frequency Agile Terahertz Metamaterials" appears in *Nature Photonics* 2, 295 - 298 (2008), accompanied by an interview with lead author Hou-Tong Chen (MPA-CINT) on the back cover.

In addition to Chen, authors include John F. O'Hara, Abul K. Azad, and Antoinette. J. Taylor, all MPA-CINT; Richard Averitt, formerly MPA-CINT, now at Boston University, David B. Shrekenhamer and Willie. J. Padilla (formerly MPA-CINT), both Boston College. The Los Alamos Laboratory Directed Research and Development Program and the Center for Integrated Nanotechnologies (CINT), a DOE/Office of Science Nanoscale Science Research Center, supported the research ■

Plutonium single-crystal sample growth in CMR wing-5

MPA-10, MST-16, and MPA-STC researchers have grown plutonium compound single crystals in a new transuranic crystal-growth lab in wing 5 of the CMR building. This is the first such sample grown since the wing-2 crystal growth lab was decommissioned in February 2007. Reestablishing the transuranic crystal-growth operation is an important accomplishment because it will ensure LANL's continued ability to be at the forefront of actinide and transuranic materials physics. This milestone is the result of the combined efforts of Eric Bauer (MPA-10), Jeremy Mitchell (MST-16), and Jack Kennison (MPA-STC). Samples produced by this new capability will directly support the actinide science LDRD DR lead by Jeremy Mitchell and Chuck Mielke (MPA-NHMFL) ■

HeadsUP!

Leaking hydrogen cylinders

MPA-11 workers have found five newly-delivered hydrogen cylinders in the last month with small leaks at the base of the valve; hydrogen can accumulate in the cap with the potential to be explosive/flammable. The finding coincides with a new primary gas vendor that has come in the last month: Airgas. MPA-11 has also recently had one argon bottle with damaged threads, preventing a good seal to the regulator. The vendor and the gas plant are taking actions to more carefully check for leaks and are reviewing the purchase of a combustible gas detector (CGD), which is more sensitive than using “Snoop” (soapy water).

We suggest employees check cylinders that have been delivered in the last two months for leaks. Using “Snoop” will catch small to large leaks, but only a CGD will detect the very small leaks similar to those found by MPA-11. Roger Lujan from MPA-11 is willing to assist in checking flammable gas cylinders if needed.

Other issues

Over the past month your MPA Worker Safety and Security Team (WSST) has worked on:

- Improviing management walkarounds (MOV)
- Finding subject matter experts (SMEs)
- Fixing the north MSL badge reader
- Helping staff obtain dust masks and determining when they are permitted
- Updating out of date references for the primary hazard screen

Further details can be found at our website, which is linked from the right side of the MPA homepage (http://int.lanl.gov/orgs/mpa/index.shtml). Contact your local team member if you want us to work on any environmental, safety or security issues on your behalf.

New member

MPA WSST’s newest member is Carmen Espinoza from MPA-10.

NHMFL’s Yuan awarded prestigious professorship by Chinese Ministry of Education

MPA-NHMFL’s Huiqiu Yuan has been awarded the Chang Jiang Scholar Professorship by the Chinese Ministry of Education. The “Chang Jiang Scholars” Program was jointly established in 1998 by the Chinese Ministry of Education and the Foundation of Li Ka-Shing, one of the most renowned entrepreneurs in Hong Kong. It is the highest recognition program from the Chinese Ministry of Education. Appointments are made based on a nationwide competition among the nominees by Chinese universities and are usually awarded to outstanding candidates who are already full professors working in China or faculty members working in prestigious universities abroad.

Yuan earned his PhD from the Max-Planck-Institute for Chemical Physics of Solids at Dresden in 2003 and then joined Los Alamos. An Institute for Complex Adaptive Matter (ICAM) postdoctoral fellow from 2004-2006, Yuan has had work published in *Science*, *Nature and Physical Review Letters* and has given more than 25 invited talks at international conferences, colloquia and seminars. He plans to join the Department of Physics this fall at Zhejiang University in the coastal city of Hangzhou, the capital of the Zhejiang Province ■

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