

From the President

By Bruce Terris, President of the Magnetics Society

The summer of 2015 saw a number of exciting events from the Magnetics Society. I had the pleasure of attending several days of the Magnetics Society Summer School in Minneapolis during June 14-19. The School was a great success, thanks to the local chairs Beth Stadler and Randy Victora and the Education Chair Chih-Huang Lai and their entire



committees. In addition to the formal education program, the students also enjoyed social activities such as the local “Gangster Tour” and a Riverboat Cruise. The Education Committee is now busy planning the next Summer School to be held in Sendai, Japan during July 10-16, 2016. See further details elsewhere in this edition of the Newsletter.

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2015 IEEE Magnetics Society Summer School

By Chih-Huang Lai, Education Committee Chair

The 8th IEEE Magnetics Society Summer School was successfully held at the University of Minnesota, Minneapolis, USA, during June 14-19, 2015. 82 graduate students from different countries and areas around the world attended the school.

Students presented their work at poster presentation sessions, and eight of them received Best Poster Awards. Those students were D. A. Bozhko (first place, Germany), Grant A. Riley (first place, USA), Pankaj Sethi (Singapore), Mukund Bapna (USA), M. Kurniawan (USA), Km Rubi (Singapore) M. Rezaeeyazdi (USA) and Monalisa Pal (India).

The school program included lectures on eight different subjects. The lecture subjects and lecturers were:

- Fundamentals of Magnetism - Laura Lewis;
- Magnetic Measurements and Imaging - Ron Goldfarb;
- Spintronics and Promising Applications - Jian-Ping Wang;
- Magnetization Dynamics – Burkard Hillebrands;
- Data Storage Technologies – MingZhong Gao;
- Modeling and Simulations - Gerrit E. W. Bauer;
- Magnetic Materials and Applications - Rudolf Schaefer;
- Magnetic Materials in Biomedical Applications - Tim St. Pierre.

The school program also included Distinguished Lecturer talks by Russell Cowburn, Bethanie Stadler, Ludwig Schultz and Ivan Schuller. The Local Organizing Committee, chaired by Bethanie Stadler, and Randy Victora made exceptional efforts in hosting the Summer School and making it a very productive, sensational, and memorable experience for all the participants.

From The President *continued from page 1*

I am very excited to see that the Distinguished Lecturers (DLs) for 2016 were recently announced. They are: Greg Carman, Josep Fontcuberta, Kazuhiro Hono and Teruo Ono, and details can be found elsewhere in the Newsletter. I wish to congratulate Sara Majetich and the DL Committee for putting together another excellent DL program, as they have done in recent years as well. The DL schedules always fill up quickly, so if your Chapter/university/company is interested in having one or more of these excellent speakers come to speak, please contact them as soon as possible.

The planning for the 13th Joint MMM/Intermag Conference to be held in San Diego January 11-15, 2016, is well underway. This will mark the 60th anniversary of MMM, so I hope we will all join in the celebration to mark this achievement. In addition to the usual events such as the afternoon Bierstubes, the Plenary Session and Reception, Women's Networking Event, the Society Annual Meeting, and the lunch with experts, the society will for the first time sponsor a Young Professionals Reception. The

reception will feature two speakers on topics of interest to young professionals. Again, see further details elsewhere in the Newsletter.

Finally, I hope that everyone voted in the Magnetics Society AdCom election which concluded on October 9. The Nominations Committee put together an excellent slate of candidates which reflects the diversity of our membership. While it is now too late to vote this year, the election of AdCom members is one of the most effective ways to voice your opinions on the directions and priorities of the Society. I encourage everyone to seek out the AdCom members, both recently elected and currently serving, and to express your views on what is important to you and to the Society. If you did not get a chance to vote, please remember to vote next year, and better yet, consider standing for election yourself.

Bruce Terris can be reached via: bruce.terris@ieee.org.

Introduction to Magnetism and Magnetic Materials

Book Review by Ron Goldfarb, Publications Committee Chair

Introduction to Magnetism and Magnetic Materials by David Jiles, now in its third edition, spans the field from basic science to engineering applications, from macroscopic phenomena to microscopic properties to quantum mechanical interactions. Its approach is distinctly pedagogical; one would expect no less from one of the world's foremost educators and academic leaders in magnetics.

Each section is headed by a rhetorical question—beginning with a word like “what,” “why,” and “how”—that encapsulates what will be learned and the mysteries to be revealed in the subsequent few paragraphs. Sprinkled throughout the text are problems and exercises, along with the solutions for most of

them. Some of the questions demand thoughtful reflection, such as, “Explain the difference between magnetic field H and magnetic induction B .” The equations are all derived consistently in SI units, the international system of units with which all students must become familiar. Basic calculus and vector operations are the only mathematical skills needed to follow the derivations. The lists of symbols and SI abbreviations, table of physical constants, author and subject indexes, and chapter references and bibliographies all help make this textbook an engaging first course in magnetics for advanced undergraduate and beginning graduate students and an excellent reference for experienced practitioners.

2016 Distinguished Lecturers

The IEEE Magnetics Society selected four Distinguished Lecturers (DLs) for 2016. They are:

- ▶ Greg Carman (University of California - Los Angeles, USA);
- ▶ Josep Fontcuberta (Institut de Ciència de Materials de Barcelona, Spain);

- ▶ Kazuhiro Hono (National Institute for Materials Science, Japan);
- ▶ Teruo Ono (Kyoto University, Japan).

Each DL manages his own schedule, so contact them early via their respective institutions.

Magnetics + Mechanics + Nanoscale = Electromagnetics Future

Greg Carman, Mechanical and Aerospace Engineering Department,
University of California - Los Angeles, Los Angeles, California, USA

Efficient control of small-scale magnetism presents a significant problem for future miniature electromagnetic devices. In most macroscale electromagnetic systems, we rely on a discovery made by Oersted 200 years ago, where an electrical current through a wire creates a distributed magnetic field. While this concept works well at large scale, it suffers significant problems at volumes below 1 mm^3 .

One approach to control nanoscale magnetic states is spin-transfer torque (STT). However, experimental measurements on STT memory devices indicates that 100 fJ is required to reorient a bit of memory with an energy barrier of about 0.5 aJ , i.e., at 0.0005% efficiency. Therefore, new nanoscale approaches are needed for future miniature electromagnetic devices.

Recently, researchers have explored strain-mediated multiferroic composites to resolve this problem. For this material class, a voltage-induced strain alters the magnetic anisotropy of the magneto-elastic elements. These strain-

mediated multiferroics consists of a piezoelectric material coupled to magneto-elastic elements to transfer electrical energy to magnetic energy through a mechanical transduction. The coupling coefficient (energy transferred) in piezoelectric materials (e.g., lead zirconate titanate, PZT) is approximately 0.8 while the coupling coefficient in magnetoelastic materials (e.g., Tb-Dy-Fe, Terfenol-D) is of similar magnitude, 0.8. Thus, the amount of energy to overcome a 0.5 aJ bit barrier is potentially only 0.8 aJ , or an efficiency of about 60 percent, neglecting line losses.

This presentation reviews the motivation, history, and recent progress in nanoscale strain-mediated multiferroics. Research descriptions include analytical and experimental work on strain-mediated multiferroic thin films, single magnetic domain structures, and superparamagnetic particles. The results indicate efficiencies orders of magnitude superior to STT approaches and presents a new approach to control magnetism. Discussions of future research opportunities and novel applications are included.

Greg Carman received the Ph.D. degree from Virginia Polytechnic Institute and State University in 1991. He joined the Mechanical and Aerospace Engineering Department at the University of California, Los Angeles, in 1991.

Dr. Carman is the Director of a new National Science Foundation Engineering Research Center entitled Translational Applications of Nanoscale Multiferroic Materials (TANMS) and is Engineering Director of the Center for Advanced Surgical and Interventional Technology in the Department of Surgery at UCLA. He is an associate editor for the Journal of Intelligent Material Systems Structures and for Smart Materials and Structures.

Dr. Carman received the Northrop Grumman Young Faculty Award in 1995 and three best paper awards from the American Society of Mechanical Engineers (ASME) in 1996, 2001, and 2007. He was elected Fellow of the ASME in 2003 and was

awarded the ASME Adaptive Structures and Material Systems Prize honoring his contributions to smart materials and structures in 2004. In 2015 SPIE honored him with the Smart Structures and Materials (SSM) Lifetime Achievement Award. Presently his research interests focus on analytical modeling, fabrication, and testing of multiferroic (magnetolectric) materials and developing devices for medical applications.



Contact: Greg Carman, Mechanical and Aerospace Engineering Department, UCLA, Box 951597, 48-121 E4, Los Angeles, California 90095; e-mail: carman@seas.ucla.edu

The Magnetism of Oxides

Josep Fontcuberta, Institut de Ciència de Materials de Barcelona (ICMAB-CSIC),
Campus de la Universitat Autònoma de Barcelona, Bellaterra, Catalonia, Spain

Magnetite, Fe_3O_4 , guided early explorers towards unknown frontiers. Since those days, oxides have been the backbone of many scientific and technological developments. When high-temperature superconductors were discovered, the subsequent enthusiasm stimulated an impressive development in oxide thin-film growth technologies and a deep revision of the understanding of metal oxides and strongly correlated electronic systems.

Today, oxides are fueling the discovery and development of unexpected, intriguing, and fascinating new areas of knowledge, such as magnetic ferroelectrics and magnetic monopoles. Ferromagnetic oxides are finding their way as active components in spintronics, either as spin filters for advantageous magnetic tunnel junctions or used to manipulate spins in non-magnetic materials, which could eventually lead to energy-efficient pure spin-current devices.

The tiny spin-orbit coupling interaction, responsible for the magnetic anisotropy, has emerged as a toy that allows us the

modulation of the transport properties, not only in metallic ferromagnetic systems, but also in antiferromagnetic metals and insulators. This may lead to a new generation of magnetic memory.

“Interface is the device” and interfaces between oxides and metals, and interfaces between large band-gap oxides, have led to the discovery of emerging properties such as switchable ‘on-off’ magnetization, by applying suitable electric fields, or magnetism and superconductivity in confined two-dimensional electron gas systems, which challenge our current understanding of oxides.

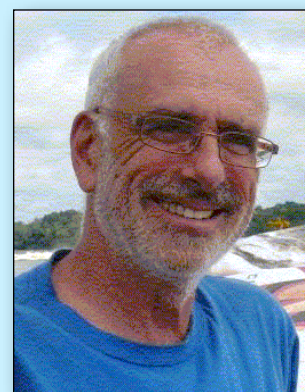
This is the playground in which we fortunately play, learn, and imagine the future while enjoying building a new science out of the *good old oxides*. In the lecture, we will travel through the new materials and ideas that make this journey possible and so successful.

Josep Fontcuberta received the Ph.D. degree in physics from the University of Barcelona in 1982. He was a postdoctoral researcher at the Inorganic Chemistry Laboratory at Oxford University and later was appointed assistant professor in the Physics Faculty of the University of Barcelona.

In 1991 Prof. Fontcuberta moved to the Institut de Ciència de Materials de Barcelona (ICMAB-CSIC), where he is a full research professor. He is mainly interested in functional oxides. These strongly correlated electronic systems display fascinating ferroic orders (i.e., magnetic, ferroelectric) and remarkable magneto-electric and optic properties, which have motivated his research and that of the Multifunctional Thin Films and Complex Structures Group he leads. Currently, the group research activities are focused on materials and devices that may contribute to a more a sustainable world.

Prof. Fontcuberta is co-author of over 400 scientific papers. He is an editor of *Advanced Electronic Materials*, *Solid State Communications*, and *Journal of Magnetism and Magnetic Materials*.

Contact: Josep Fontcuberta,
Institut de Ciència de Materials
de Barcelona (ICMAB-CSIC).
Campus de la Universitat
Autònoma de Barcelona, 08193 Bellaterra, Catalonia, Spain; e-
mail: fontcuberta@icmab.cat.



Materials Challenges for Next-Generation, High-Density Magnetic Recording: Media and Read Heads

Kazuhiro Hono, National Institute for Materials Science (NIMS), Tsukuba, Ibaraki, Japan

The hard-disk-drive industry is making continuous efforts to increase the areal density of magnetic recording. To realize an areal density of greater than 2 Tbit/in² in the future, both media and readers need technical breakthroughs. Since the bit size will be in the range of 20 nm, the magnetic grains in the recording media must be reduced to less than 6 nm, requiring the use of ferromagnetic materials with high magnetocrystalline anisotropy such as *L1₀* FePt.

The shield-to-shield spacing of read sensors must also be smaller than 20 nm with low device resistance (resistance-area product $RA \approx 0.5 \Omega \mu\text{m}^2$), which is very difficult to achieve using MgO-based tunneling magnetoresistance devices.

In this talk, we will address the materials challenges to the realization of an ideal media nanostructure using *L1₀* FePt for

heat-assisted magnetic recording (HAMR) media and narrow readers for > 2 Tbit/in² areal density.

Recently, significant progress has been made in current-perpendicular-to-plane giant magnetoresistive (CPP-GMR) devices, using highly spin-polarized Heusler alloy ferromagnetic layers and new spacer materials. The very high magnetoresistance ratios achieved in CPP-GMR are encouraging for future read head applications of CPP-GMR, or its laterally extended version, lateral spin valves.

The devices with high magnetoresistive output at low RA may open new applications in addition to disk read heads.

Kazuhiro Hono received the B.S. and M.S. degrees in materials science from Tohoku University in 1982 and 1984, respectively, and the Ph.D. degree in metals science and engineering from Penn State in 1988.

After working as a postdoctoral associate at Carnegie Mellon University, Prof. Hono became a research associate at the Institute for Materials Research, Tohoku University, in 1990. He moved to the National Research Institute for Metals (currently National Institute for Materials Science, NIMS) as a senior researcher in 1995, and is now a NIMS Fellow and the director of the Magnetic Materials Unit. He is also a professor in Materials Science and Engineering at the Graduate School of Pure and Applied Sciences, University of Tsukuba.

Prof. Hono's current research interest is materials science in magnetic and spintronics materials and their devices. He is also active in the development of high performance permanent magnets without critical elements.

Contact: Kazuhiro Hono, National Institute for Materials Science (NIMS), 1-2-1 Sengen, Tsukuba, Ibaraki 305-0047, Japan; e-mail: kazuhiro.hono@nims.go.jp.



Spin Dynamics in Inhomogeneously Magnetized Systems

Teruo Ono, Division of Materials Chemistry, Institute for Chemical Research,
Kyoto University, Gokasho Uji, Kyoto, Japan

Worldwide efforts are underway to create revolutionary and energy-efficient data-storage technologies such as magnetic random-access memory (MRAM). An understanding of spin dynamics in inhomogeneously magnetized systems is indispensable for further development of nanoscale magnetic memory.

This lecture provides a clear picture of inhomogeneously magnetized systems, such as magnetic nanowires with domain walls and disks with magnetic vortices, and presents not only technological developments and key achievements but also the unsolved puzzles and challenges that stimulate researchers in the field.

First, the basic concept of an inhomogeneously magnetized system is described by introducing a magnetic vortex structure in a magnetic disk. A magnetic domain wall in a magnetic nanowire is also provided as a typical example. The magnetic

field-driven dynamics of these inhomogeneously magnetized systems are described to illustrate their uniqueness.

Second, electric-current-induced dynamics of magnetic vortices and domain walls are described. One can flip the core magnetization in a magnetic vortex using electrical current excitation, and move a domain wall by current injection into a wire.

The next part focuses on the applications of current-induced magnetization dynamics in devices. The basic operations of two kinds of magnetic memories—magnetic vortex core memory and magnetic domain wall memory—are demonstrated.

The lecture describes not only the current understanding about inhomogeneously magnetized systems, but also unexpected features that have emerged. It concludes with prospects for future developments.

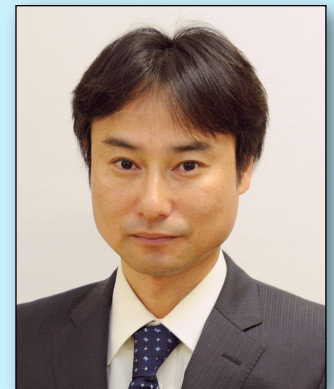
Teruo Ono received the B.S., M.S., and D.Sc. degrees from Kyoto University in 1991, 1993, and 1996, respectively. After a one-year stay as a postdoctoral associate at Kyoto University, he moved to Keio University where he became an assistant professor.

In 2000, Prof. Ono moved to Osaka University where he became a lecturer and an associate professor. Since 2004, he has been working at Kyoto University, where he is now a professor. He has published over 280 technical articles in peer-reviewed journals, including book chapters and review articles, and has given more than 90 invited presentations at international conferences.

Prof. Ono served as conference co-chair of the 8th International Symposium on Metallic Multilayers (MML) in

2013, and on the program committees of various international conferences on magnetism and spintronics. He is a member of the IEEE Magnetics Society and is an editor of the Japanese Journal of Applied Physics.

Contact: Teruo Ono, Division of Materials Chemistry, Institute for Chemical Research, Kyoto University, Gokasho Uji, Kyoto 611-0011, Japan; e-mail: ono@scl.kyoto-u.ac.jp



Compumag 2015

By Jan Sykulski, Compumag 2015 Editorial Board Chair

The 20th Compumag conference recently took place at McGill University, Montreal, Canada during June 28 - July 2, 2015. Prof. David Lowther of the Computational Electromagnetics Laboratory and his team prepared a fantastic venue and very enjoyable programme, with opportunities for networking and scientific discussions. The event was attended by over 400 delegates from 32 countries. The topics covered ranged from optimization and design of electromagnetic devices to multi-physics and numerical modeling as well as the more traditional analysis of static, quasistatic and transient fields.

Compumag is the oldest meeting devoted to the computation of electromagnetic fields with the first event organised in Oxford in 1976. Since then the conference has been hosted at sites around the world every two years, including 2013 in Budapest, Hungary. In 2017 the event will be held in Korea and in 2019 in France.

The conference is overseen by the International Compumag Society (<http://www.compumag.org/jsite/>), which is now a Sister Society to the IEEE Magnetics Society. The conference is technically co-sponsored by the IEEE and selected extended papers regularly published in *IEEE Transactions on Magnetics*; a special post-Montreal issue will appear in March 2016.

Details about the conference may be found on its web page (<http://www.compumag2015.com>), including a gallery of photos taken during the event itself. Around 650 abstracts were originally submitted to the conference, 425 short (two-page) papers accepted for presentation, and between 200 and 250 are expected to be published in extended form in the *IEEE Transactions on Magnetics*.



2016 IEEE Magnetics Society Summer School

By Chih-Huang Lai, Education Committee Chair

The 9th IEEE Magnetics Society Summer School will be held at Tohoku University, Sendai, Japan during July 10-16, 2016. The School will consist of lectures by international experts and will include poster presentations by participating students. The program will cover both fundamentals and advanced topics in magnetics. Financial support will be awarded to approximately 85 students from around the world. Awardees will be provided free accommodation for the duration of the school and will be reimbursed for most of their travel cost.

The summer school is open to current M.S. and Ph.D. students who are members of the IEEE Magnetics Society (at the time of attendance) and have not attended previous summer schools.

For more information about the school and applications, please visit <http://summerschool.ieemagnetics.org>.

The student application deadline is November 30, 2015.

SCTE 2016

By Juan Bartolomé, Conference Chair and Fernando Bartolomé, Conference Co-Chair

The 20th International Conference on Solid Compounds of Transition Elements (SCTE 2016) will take place at the University of Zaragoza in Spain, during April 11-15, 2016.

SCTE provides a forum for discussion on fundamental and applied research in the areas of the solid-state chemistry, physics and materials science of compounds containing d- and f-elements. On this occasion, SCTE will celebrate its twentieth edition, after previous meetings from Paris (1965) to Genoa (2014).

Topics covered include:

- Processes and syntheses, crystal chemistry;
- Phase transitions, equilibria, and thermodynamics;
- Magnetic, electrical and optical properties;
- Theory, “ab initio” methods, electronic structure;
- Physical and chemical properties at the nanometer scale: nanoparticles, films, interfaces; and
- Synchrotron radiation and neutron scattering research.

Materials:

- Intermetallic compounds;
- Strongly correlated electron systems and topological quantum matter;
- Multiferroics and multifunctional materials;
- Magnetocalorics and materials for energy storage;
- Molecular solids: molecular magnetism, MOFs, spin crossover;
- Novel superconducting materials; and
- Disordered and frustrated materials.

Important dates:

- November 1, 2015: Abstract submission and registration period starts;
- January 18, 2016: Abstract submission deadline;
- February 21, 2016: Early-bird registration deadline; and
- May 15, 2016: Manuscript submission deadline.

For more information please visit scte2016.unizar.es.

New Senior Members

The following members of the IEEE Magnetics Society were recently elevated to the grade of Senior Member.

July 2015: Manfred Albrecht and Giovanni Angiulli.

August 2015: Claudio Carretero, Frederic Lafon and Mark Stiles.

September 2015: Heath Hofmann.

October 2015: Afusat Dirisu, Benjamin Pulido, and Rakesh Srivastava.

For further information, visit the IEEE Web site at:

www.ieee.org/membership_services/membership/grade_elevation.html

Call for Editors and Editorial Board Members

By Ron Goldfarb, Publications Committee Chair

As we approach the new year, we would like to solicit expressions of interest from Magnetics Society members who might like to serve on the editorial boards or as editors of our journals: *IEEE Transactions on Magnetics*, *IEEE Magnetics Letters*, and *IEEE Journal on Exploratory Solid-State Computational Devices and Circuits* (which the Magnetics Society co-sponsors). Appointments will depend on experience and journal needs in different technical areas.

Most of our editors manage the reviews for submitted articles. We would also be interested in technical editors who have a broad knowledge of magnetics, English grammar and usage, and SI units, and an ability to edit titles and abstracts to effectively capture main points.

Please contact me at r.goldfarb@ieee.org.

Conference Calendar

December 14-18, 2015 International Conf. on Nanoscience, Nanotechnology & Nanobiotechnology
Brasilia, Brazil
<http://www.3nano.net>

January 11-15, 2016 Joint MMM-INTERMAG Conference
San Diego, California, USA
<http://www.magnetism.org>

January 21-22, 2016 Magnetism 2016
Jacksonville, FL, USA
<http://www.magnetismmagazine.com/conferences/>

April 11-15, 2016 20th Conference on Solid Compounds of Transition Elements SCTE 2016
Zaragoza, Spain
<http://scte2016.unizar.es>

June 5-8, 2016 IEEE International Conference on Microwave Magnetism 2016
Tuscaloosa, AL, USA
<http://icmm2016.ua.edu>

To list your conference in the Newsletter Conference Calendar, please contact the Editor

Young Professionals' Event

During the Joint MMM-INTERMAG Conference in San Diego, California, USA, an event for young professionals will be held on January 14, 2016, 6:00-7:30 PM at the Hilton Bayfront Hotel.

In addition to networking opportunities, presentations including "Mistakes to Avoid in

Writing Professional Research Papers" (Ron Goldfarb) and "Young Professionals' Food Sources, Predators and Corner of Career Jungle" (Alex King) will be made.

for more information, contact
nlebedim@ameslab.gov.

About the Newsletter

The purpose of the IEEE Magnetics Society Newsletter is to publicize activities, conferences, workshops and other information of interest to the Society's members and other technical people in the general area of applied magnetism. Manuscripts are solicited from Magnetics Society members, conference organizers, Society Officers & other volunteers, local chapters, and other individuals with relevant material.

The Newsletter is published in January, April, July and October electronically on the Magnetics Society webpage at www.ieeemagnetics.org. Submission deadlines are January 1, April 1, July 1, and October 1 respectively.

Please send articles, letters & other contributions to the Newsletter Editor:

Gareth Hatch
Technology Metals Research, LLC
180 S. Western Ave #150
Carpentersville, IL 60110 USA

Email: g.p.hatch@ieee.org

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