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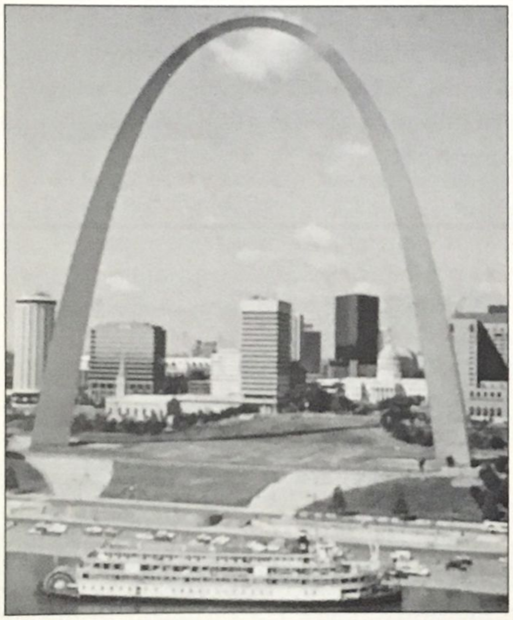
JODIE CHRISTNER, EDITOR



INTERMAG '92

By Marcel Muller, Conference Chair

INTERMAG 92 met April 13-16, 1992 at the Adam's Mark Hotel in Saint Louis, Missouri, steps away from the Gateway Arch, Eero Saarinen's famous monument of the nation's westward expansion. Over 850 engineers and scientists from around the world attended the conference. Student attendance was gratifyingly large.

The conference was preceded on Sunday, April 12 by an all-day executive seminar designed to offer an update on a wide range of matters magnetic to marketing and engineering management personnel from companies dependent upon current magnetics technology.

The program committee lead by co-chairs Robert Fontana (IBM, San Jose) and Barbara Shula (Hewlett-Packard, Palo Alto) organized a program of 31 invited and 474 contributed papers reporting on the latest research and development results in all branches of magnetics. More than half the papers originated overseas, in keeping with the international nature of the conference.

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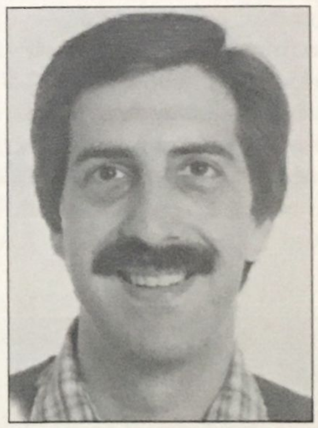
TECHNICAL COMMITTEES UPDATE

By Craig M. Perlov



Craig M. Perlov

We have recently been working on reviewing the composition and goals of the technical committees to better serve the Magnetics Society. So far we have added some new committees, deleted some old ones and identified specific tasks the committees will perform. Among the specific tasks are Newsletter articles from committee chairs summarizing the state of the art and future directions in their field. We should see two or three such articles in each edition of the Newsletter. This will allow for an increased awareness of the activities in all areas of magnetics research. These articles may be the most visible committee activity but not the only one. The committee chairs have composed 'expert lists' which are cross-sections of knowledgeable people in their areas of magnetics. This list will serve multiple functions. First as a tool for conference program committee chairs to use (at their discretion) for insuring that the program committee has the appropriate spectrum of expertise. Also the lists will be available to the editors of the Transactions as an aid for identifying reviewers. Another potential activity of the technical committee will be to help conference program committees review digests in those areas where only a handful of papers are submitted and there is no expertise

TECHNICAL COMMITTEES UPDATE *(Continued on page 2)*

TECHNICAL COMMITTEES UPDATE *(Continued from page 1)*

resident on the committee. (Magnetics in life sciences is a good example. Only about 10 papers in this area are usually submitted to a conference.) Finally, in those areas where appropriate, the technical committees will also be involved in standards support. These are the activities we have identified so far; new ideas are welcome.

TECHNICAL COMMITTEE CHAIRS

Department Chair	C.M. Perlov
Control and Power Processing	J.D. Harnden, Jr.
Electromagnetic Launch and Levitated Transportation Technology	H.H. Kolm
Heating by Induction and Magnetic Shielding	P.P. Biringer
High Frequency Properties of Magnetic Materials	C. Vittoria
Large Magnet Technology	P.G. Marston
Magnetic Imaging	J.N. Chapman
Magnetic Recording Media	D. Speliotis
Magnetic Recording Heads	K. Howard
Magnetic Separation	D.R. Kelland
Magnetics in Life Sciences	R.B. Frankel
Magnetometers and Measurements	R.M. Josephs
Magneto-Optics	M.R. Madison
Memories	N.T. Veillette
Micromagnetics and Field Computation	J.G. Zhu
Permanent Magnets	K. Strnat
Recording Systems	N.H. Yeh
Soft Magnetic Materials	R. Hasegawa
Superconductivity	R.B. Goldfarb

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The objective of the **IEEE Magnetics Society Newsletter** is to publicize activities, conferences, workshops and other information of interest to the Society membership and technical people in the general area of applied magnetics. Copy is solicited from the Magnetics Society membership, organizers of conferences, officers of the Society and local chapters and other individuals with relevant material. Send copy to Dr. Jodie A. Christner, Dept. 2H2, IBM Corporation, 3605 Hwy 52 North, Rochester, MN 55901-7829, Telephone: (507) 253-5513 FAX: (507) 253-4146.

NEW MAGNETICS SOCIETY 1992 FELLOWS

Four members of the IEEE were recently named Fellows for their work in magnetism. The new IEEE Fellows and the contributions leading to the awards are as follows.

Dr. Simon Foner, Francis Bitter National Magnet Laboratory, MIT, 170 Albany Street, Cambridge MA 02139, "For invention of the vibrating sample magnetometer, contributions to pulsed magnetic field technology, and the development of advanced superconducting systems."

Dr. A. Frank Mayadas, IBM T.J. Watson Research Center, Yorktown Heights, NY 10598, "For contributions to magnetic storage and thin film technology and systems."

Dr. Juan A. Rodriguez, Exabyte Corporation, 1745 38th Street, Boulder, CO, "For technical leadership in the development of computer data storage devices."

Prof. Susumu Uchiyama, Dept. of Electrical Engineering, Nagoya University, Furo-cho Chikusa-ku, Nagoya 464-01, Japan, "For contributions to the research and development of magneto-optical recording."

THE IEEE PRESS IS LOOKING FOR AUTHORS!!

At the Intermag Conference in St. Louis, a meeting was organized with Dudley Kay, Executive Editor of the IEEE press. Dudley presented the mission and goals of the press: to publish books of interest to IEEE Members and Societies, to bring professional image enhancement to the Institute through quality publications, and to create a financial surplus as a contribution to ongoing IEEE operations. He described the current operations and offerings from the IEEE press, and distributed brochures with information for prospective authors and editors to those who attended.

The IEEE press offers authors one of the most supportive and 'friendliest' writing environments in technical publishing. This includes very competitive royalty rates and contract terms (10-18%) with extensive manuscript development via reviews by experts. The scope of the publications can include advanced texts, handbooks, monographs, practical guides, or 'understanding' basic topics books. Magnetics Society members who have interest as prospective authors or reviewers are encouraged to contact Dudley at the IEEE press, 445 Hoes Lane, Piscataway, NJ 08855-1331 telephone 908 562 3969, FAX 908 981 8062, e-mail d.kay at ieee.org; or the Magnetics Society/IEEE press liaison R.F. Hoyt, IBM Almaden Research Center, 650 Harry Road, San Jose, CA 95120, telephone 408 927 2118, FAX 408 927 3204, e-mail, rfhoyt at ibm.almaden.com.

TECHNICAL COMMITTEE UPDATE: ELECTROMAGNETIC LAUNCH AND LEVITATED TRANSPORTATION TECHNOLOGY

By Henry H. Kolm, Chair

Henry H. Kolm

Electromagnetic Launch Technology

The DoD launched a coordinated research program in 1978 to develop electromagnetic launchers ranging from high-mass, low-velocity applications (aircraft catapults to torpedo tubes), through medium-mass, medium velocity devices (artillery to anti-armor guns) to low-mass, high velocity devices (smart pebbles for exo-atmospheric, SDI missions). The program was initially planned by Dr. Harry Fair (of ARDEC and DARPA) and Henry Kolm (of MIT and EML Research Inc., with a committee of about 9 experts from academia, industry and DoD. Research has been reported in a biennial "EML Symposium" since 1981, and published in Transactions on Magnetics.

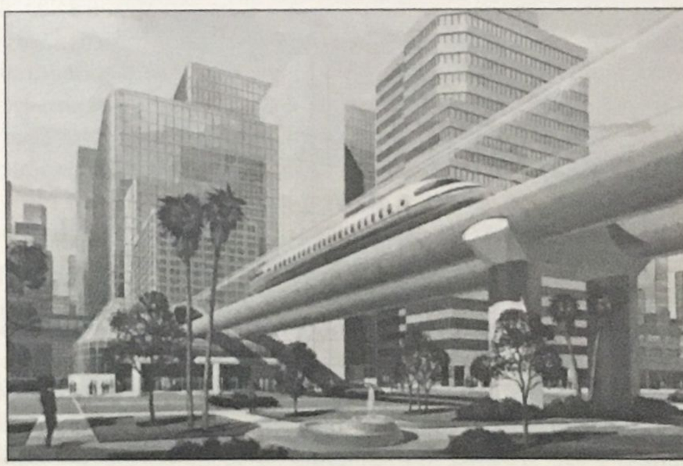
Two categories of launchers were pursued: railguns and coilguns [see IEEE Spectrum April 1982 for a review of basics]. Railguns are basically a single-turn motor compatible with homopolar generators which are also single-turn machines capable of supplying several mega-amperes of dc current at several dozen volts. They can launch small gram size projectiles to ten km/sec, do not extrapolate to larger size, and involve inherent problems and limitations. They are conceptually simple, however. A high school student can build one in a weekend with an auto battery and two lengths of copper tubing.

Coilguns are high-impedance, multi-turn synchronous motors, and considerably more complex. They require stationary and projectile coils and a mechanism for synchronous commutation. They are not suitable for small projectiles, but they do extrapolate very well to larger launch masses, even space vehicles.

The originally planned research program provided for a balanced division of effort between railguns and coilguns, but was abandoned in the early eighties, with less than one percent of funding devoted to coilguns. At first, all but one research team jumped on the railgun bandwagon, and later the SDI program assumed virtually all funding authority and excluded almost all tactical applications not applicable to exo-atmospheric missions.

The pursuit of railguns proved futile and expensive, and has resulted only in spectacular laboratory demonstrations based on the use of capacitors or explosive flux compressors. To this day there has not emerged a single practical railgun weapon system, strategic or tactical. After twenty-five years of overly optimistic prognostications, The DoD has understandably lost interest in EML technology.

Despite receiving less than one percent of the support, coilguns have resulted in the only practical applications ready for deployment: an electric aircraft catapult which is better, lighter and potentially less expensive than the steam catapults used on Nimitz class carriers, and a torpedo launcher superior to the hydro-pneumatic ones currently in use. Coilgun research has also resulted in some spin-off technologies: inductive energy storage components, including toroidal inductors and opening switches, and flywheel disk alternators applicable to a variety of pulsed-power devices and propulsion for ships and vehicles. The potentially most valuable contribution of coilgun research, however, is the "quenchgun," a superconducting launch engine which has been demonstrated to be capable in principle of launching multi-ton payloads to orbital velocities without the need for and penalties inherent in chemical rockets. An old dream of science fiction writers has come of age. Regrettably, the concept will have to wait for our space program to regain its ability to innovate.



The Magneplane

Magnetically Levitated Transportation

Magnetically levitated (maglev) transportation has been under development in Germany since 1922, but became practical only in the late sixties when superconducting magnets made large and stable clearance gaps possible, on the basis of motion-induced lift forces analogous to aerodynamic flight (lift generated at the expense of drag). Repulsive maglev has been named "repulsive" or "electrodynamic," to distinguish it from the 1922 technology, in which servo-controlled electromagnets cling to the underside of a steel rail, and

MAGNETICALLY LEVITATED TRANSPORTATION *(Continued on page 4)*

MAGNETICALLY LEVITATED TRANSPORTATION *(Continued from page 3)*

which has been named "attractive" or "electromagnetic". Attractive maglev typically operates at gaps of several millimeters, while repulse maglev can operate at gaps of several inches, and therefore require less stiff and accurate guideways.

Various repulsive maglev configurations were invented in the late sixties and early seventies. They were based on on-board superconducting coils interacting with aluminum coils or continuous sheets in the guideway (Guderjahn-Wipf, Powel-Danby, Kolm-Thornton). Towing tests were performed with support from the DOT (SRI, Ford). The first complete, practical, integrated levitation-propulson system was developed by a team comprising MIT, Raytheon and Avco, with support from Alcoa, 3-M, and eventually the National Science Foundation, under the RANN program. A fully operational 1/25 scale model system of the MIT Magneplane, as it was called, was built, and five generations of increasingly sophisticated vehicles were tested. In 1975 all government support was terminated by the OMB. German and Japanese teams continued development, taking over many crucial features of the Magneplane system, most notably its "smart" linear synchronous motor.

It is significant that both the German and the Japanese teams viewed maglev as nothing more than faster railroads, i.e., a batch flow system using multiple-vehicle "consists". Magneplane, by contrast, is a continuous flow system in which individual vehicles operate at 20-second headways and are able to deviate to off-line stations without slowing the flow of traffic. Vehicles are supported resiliently at 6 inch clearance, and are free to self-bank in turns, with airplane comfort. Because guideways carry only individual vehicles, the can be significantly lighter and less expensive to build and maintain than railroad type guideways. They need to carry only 1/20th the live load, and can be compatible with the curves, grades and overpass requirements of highways. Because of the large clearances possible with the Magneplane concept, guideways do not require high stiffness and accuracy of alignment or banking (superelevation), and are aesthetically more graceful. Less energy is needed than for railroads because individually targeted vehicles travel non-stop. This eliminates the need to accelerate passengers who did not want to stop at every station, and reduces the cruising speed required to match airline trip times. Individual Magneplanes can transport a continuous stream of 25,000 passengers/hour, and can provide non-stop service at high frequency along multi-station corridors. Magneplane can therefore compete with the automobile, not just the railroads or airlines. It can make high speed transportation accessible at virtually every major shopping mall, not requiring new mega-hubs. Magneplane has about five times the capacity of a railroad, and can operate at average speeds close to 300 mph.

Interest in maglev was revived in 1982, when Governor Bob Graham of Florida, recognizing that I-95 would need 42 lanes each way by 2016, introduced legislation similar to the Land Grant Act of 1837. His Act proposed to grant an exclusive franchise for land use to a successful bidder willing to build a high speed railroad running from Miami via Orlando to Tampa, at no expense to the taxpayer. Of the initial 14 bidders, only 3 remained in 1988, when selection was to be made. Two offered European railroad technology and were disqualified by their inability to eliminate 300 grade crossings; the third bidder offered Magneplane technology capable of all-elevated construction, but was unable to raise the required capital.

As the Florida project died, it stimulated two other ventures. The German Transrapid company, unable to fit their 1922 railroad style technology into the Miami-Tampa corridor, succeeded in finding support for a 13-mile demonstration line from the Orlando airport to International Drive. There will be neither curves nor intermediate stations, and they will be subsidized by $100 M of federal money.

The second more promising fall-out from the ill-fated Florida project is that Senator Moynihan became very interested as the result of a field hearing in Florida before a committee on which he served. He hailed maglev as "the Maypole we need to dance around," and invited Kolm to help him write a "maglev bill": S-1704 of 1988. This bill provided $750M to develop the best possible US maglev system within six years, under management by NASA. Ultimately NASA was replaced by a triumvirate of DOT, COE (the Army Corps of Engineers), and the DOE, and the bill was incorporated into the ISTEA act signed in November 1991.

Within a month after signing this bill, President Bush undertook to kill the maglev development program. The OMB instructed the DOT not to request the maglev prototype funds appropriated for FY-93, although he authorized $1.25B for electrifying the AMTRAC line from New Haven to Boston. The earliest possible funding is therefore FY-94. This will cause the US to lose the four teams now working on maglev, and to miss the narrow window of opportunity for regaining US leadership in transportation.

Prior to passage of the ISEA bill, Senator Moynihan made available $9.6M of Senate study money in FY-91, which is supporting about 30 small BAA contracts dealing with pieces of maglev support technology, and four major "System Concept Definition Studies", to be completed in September 92, at a total cost of $8.2M. The four teams are:

> Grumman with Parsons Brinkerhoff and Intermagnetics General, etc, developing an improved version of the German Transrapid attraction system. It achieves a larger gap (2 inches insead of 3/8 inch) by using a superconducting bias coil on an iron yoke.
>
> Foster-Miller with Boeing, etc., developing an improved version of the Japanese repulsion system.
>
> Bechtel Corp with Hughes and G.M. and Draper Lab, developing a monorail type system.
>
> Magneplane International with MIT, Raytheon, Beech Aircrat, United Engineers, Bromwell & Carrier and Process Systems International, developing radically different technology based on the MIT Magneplane configuration of 1970.

A more detailed review of the various systems will be found in the "Trends in Science and Industry" article in the August 1992 issue of Scientific American.

INTERMAG '92 *(Continued from page 1)*

Technical areas prominently featured were magnetic information technology including magnetic recording heads, media, and systems, magneto-optic storage, and alternative storage technologies; permanent magnets, hard magnetic materials and fine particles; magnetic multilayers; soft magnetic materials and magnetic domains and domain walls; magnetic measurements and microscopy; sensors; superconductors; magnetic levitation and propulsion; microwave magnetics; theory and calculations. One afternoon and two evenings of invited symposia provided in-depth coverage of permanent magnet nitrogenation, giant magnetoresistance, and new developments in magnetometry. A technical exhibit displayed instruments, materials, services, and literature of interest to the magnetics community.

The plenary session was a noteworthy display of achievement of members of the magnetics community. IEEE Magnetics Society President Stanley Charap presented four new Fellow awards to Simon Foner, Frank Mayadas, Juan Rodriguez, and Susumu Uchiyama, the Magnetics Society Achievement award to Yochifumi Sakurai, and he announced that the Magnetics Society Information Storage Award would be presented to Claude Shannon. He then introduced IEEE President Merrill Buckley who presented three IEEE Field Awards: the Cledo Brunetti Award to David Thompson; the Morris E Leeds Award to H. Kumar Wickramasinghe; and the Morris N Liebman Memorial Award to Praveen Chaudhari, Jerome Cuomo, and Richard Gambino. Following the awards ceremony the large audience heard an address by William Almon, President of Conner Peripherals, on "The Magnetic Recording Industry" which described both the brilliant history and the bright prospects of this sturdy technology.

An evening reception was held in the newly opened St. Louis Science Center. Conference participants and guests strolled among the exhibits, talking shop, enjoying food and drink, and "zapping" the traffic passing below with radar guns from a bridge built over the Interstate Highway.

Executive Seminar

By Clark Johnson

This year's Executive Seminar was not as well attended as last year's. Part of this was no doubt due to the economy and our raising the admission fee to $600. In fact, we only had one walk-in and two attendees that were not affiliated with exhibitors.

In addition to the mailing list established at the first Executive Seminar held in 1991, we sent out approximately 6,000 letters to the IDEMA mailing list. I do not believe that we had any attendees resulting from that effort.

The seminars themselves covered a number of areas of magnetism, with a fairly strong emphasis on magnetic recording. The recording talks included an overview of control theory in rigid disk systems by Dr. Michael Sidman of Digital Equipment; the current state of affairs in helical-scan data recording systems by Juan Rodriquez the founder of Exabyte; microtribology of magnetic storage devices (becoming increasingly important as we continue toward ever lower flying heights) by Prof. Bharat Bhushan of Ohio State University; and a tutorial on partial response recording by Dr. James Lemke of Recording Physics.

The two non-recording presentations were on advances in micro-magnetic measurements by Dr. Pantelis Alexopolous of the IBM Almaden Research Center and on ultra-soft magnetic materials by Dr. Carl Smith of Allied-Signal Co.

All of the talks were well-presented and the authors succeeded in addressing their respective subjects in a sufficiently general way so as not to lose listeners unfamiliar with the field. The Executive Seminar was probably considered worth the money by the attendees.

Recommendations for future years:

1. Lower the admission fee to $300;
2. Purge our mailing list (especially important since the next seminar will not be until 1994);
3. Direct personal letters to the CEO's, CFO's and marketing types of our own magnetics industry companies (tying the Exec. Seminar to exhibitors is OK, but in large companies there is little if any coupling to the attendees who we want to attract).

Session AA: Magnetic Recording Heads — Inductive Thin Film and Laminated

By Mason L. Williams

Klaassen and Van Peppen presented equivalent circuits for noise sources in film heads and evaluated relative contributions to the noise spectrum. Lin *et al.* found that noise after write was associated with spike domains near the back gap closure. Sahami and Lee reported a study of plated permalloy composition variation with trackwidth and topography; they showed composition control is possible in 5 micron trackwidth heads. Das and Torabi demonstrated pole domain configurations improved by negative magnetostriction and a high uniform stress resulting from anchoring the end of the poletip with a bulb. Tong *et al.* found domain configurations in film heads depend not only on magnetostriction and as deposited stress, but also that the overcoat process was critical and wafer slicing produces little effect. Takano *et al.* used e-beam tomography to map dynamic fields of heads as a function of frequency. Kawakami *et al.* showed a correlation between write relaxation noise and the number of ripples in curves of inductance as a function

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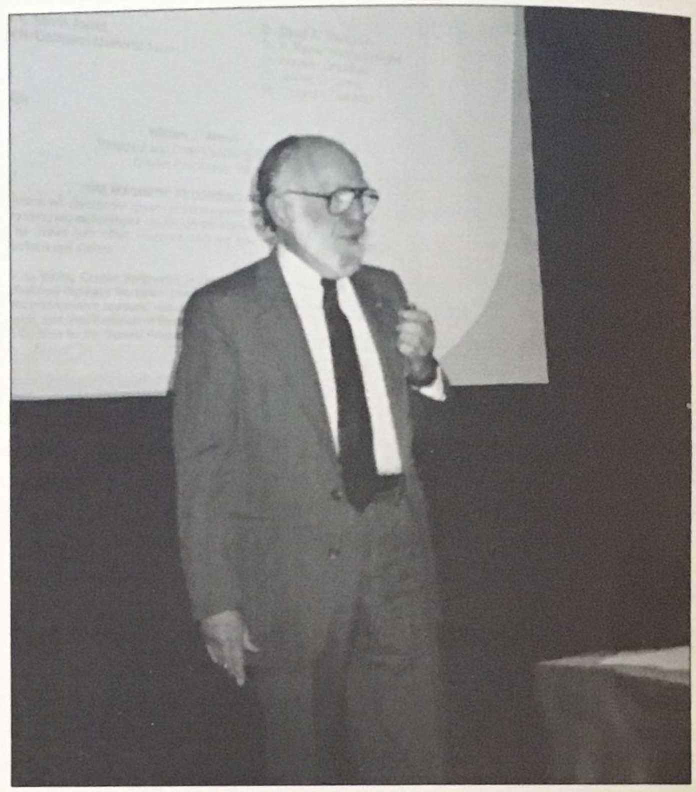
of current. Wang *et al.* showed laminated FeAlN/SiO_2 films stable against annealing cycles and having corrosion resistance similar to that of permalloy. Yoshimizu *et al.* described a film head containing no organic materials; *e.g.*, TiO_2 was used to insulate the coil. Mitsuoka *et al.* showed reduced noise and large fields for multilayer laminated heads. Ishiwata *et al.* reported a high performance laminated Sendust video head using $CaTiO_3$-NiO substrates. Lazzari *et al.* reported results of drive evaluation of silicon planar heads, including the absence of popcorn noise.



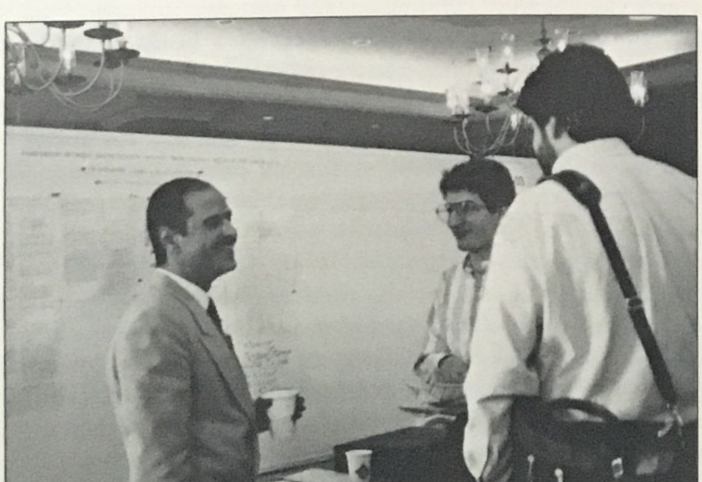
Session AD: Magnetic Sensors

By Don Krahn

This session, Magnetic Sensors (not recording), is part of an effort to further emphasize this important area of magnetics. It is hoped that more and more of the people working in magnetic sensor areas will attend future INTERMAG conferences. This was a very full session with 13 papers presented and very good attendance (average attendance of about 80 persons). The wide ranging scope of the magnetic sensor field was strongly evidenced in the presentations of the session.

The session began with D. Duret presenting a paper on an electron spin resonance magnetometer designed to measure vector components of a local field (e.g. the Earth's field). A differencing technique is used in conjunction with an alternating magnetic polarizing field to measure the component of the field along the axis of the polarizing coil. The second paper, presented by Y. Kanamaru, described a level and two axis attitude sensor using the changing inductance in a set of three coils as a function of the amount of magnetic fluid acting as a core within each coil. E. Hristoforou then presented a mechanical position and force sensor based on reentrant flux reversal. Using the propagation time of propagating domain walls it was shown that sub-micron sensitivity could be achieved.

Paper AD-04, presented by Seung-Ki Lee, described a magnetotransistor using a separated drift field. This demonstrated that emitter injection modulation can be used as the dominant mechanism of a magnetotransistor. C. Blache then described a series of new permanent magnet structures which would provide high magnetic field gradients for use as part of a position sensor. The sixth paper of the session describing an inductive absolute angular position sensor was presented by V. Lemarquand. Several variations were described using a yoked inductive pickup to measure the inductance change due to rotors with varying cross-sections acting to close the magnetic circuit.



K. Ishikawa presented paper AD-07 on a new torque sensor designed for automotive, robotic, and industrial applications. This sensor used a NiFeCr layer patterned onto the shaft and a coil assembly for magnetization and detection. I. Garshelis presented another torque sensor as paper AD-08 wherein a cylindrical ring of magnetostrictive material is press fit onto a shaft. With no torque on the shaft the magnetization is cylindrical, but when torque is applied the magnetization rotates providing a magnetic field which can be detected with, for example, a Hall sensor. A third torque sensor was presented by a colleague of the authors, Yoon-Bah Kim. Cobalt based amorphous ribbons were attached to the shaft and a differencing scheme were used to measure the shaft torque.

Paper AD-10 was presented by H. Wakiwaka. This paper presented an Acoustic Vibration Element using Giant magnetostriction material (AVEG) as an acoustic transducer. T. Meydan presented a load cell sensor design using an amorphous ribbon as the transducer element as paper AD-11. A novel directionally-conductive, optically transparent sheet material was presented by T. Tiefel. This material may have applications for touch screen and/or a writing stylus pad. Paper AD-13, presented by D. Ng, described the effect of biaxial stress on magnetoacoustic emission from nickel. This has potential application in the monitoring of defects and stress. Paper AD-14 was withdrawn prior to the session.

Session AP: Superconductors — Materials, Devices, Theory and Applications

By William Wilber

This was the only session devoted to superconductivity and, as the title suggests, the contributed papers addressed a broad range of topics. However, the presentations can be categorized into three areas: material fabrication, devices, and phenomena. The only report on material preparation was from the University of Colorado and collaborators on the spray pyrolysis of the high-T_c superconductor (HTSC) Tl-Ba-Ca-Cu-oxide. After annealing at 895 C, X-ray analysis of the films showed an approximately equal mixture of the 2212 and 2223 phases for 3 micron thick films grown on alumina. The critical current for these films was 1500 A/cm^2 at 76 K in zero magnetic field.

The device papers included a description of a HTSC memory module presented by Nagoya University. One advantage of this device is that the frequency of operation can exceed 10 MHz. A paper from Northeastern U. offered an analytical description of a HTSC coplanar resonator. Their analysis provides, for example, a means to deduce the London penetration depth from the measured device characteristics; they calculated a 0 K penetration depth of 0.179 μ m for a Y-Ba-Cu-oxide HTSC resonator. The Tokyo Inst. of Tech. presented their analysis of the power loss in an air-core superconducting transformer. They developed an equivalent circuit for estimating the loss, and show that their model compares favorably to an experimental transformer.

Several papers addressed experimental observations of superconducting phenomena. A group from Donesk Physico Tech. Inst. and Royal Inst. of Tech. studied the magnetic susceptibility versus temperature of the Bi-based HTSC as a function of applied dc current and magnetic field. Their results show a suppression of both the intra- and intergranular susceptibility with increasing current. The same group authored a second paper that describes magnetization measurements of the Bi HTSC carrying an alternating current. Northeastern Univ. presented their observations of macroscopic quantum effects in Y-based HTSC rings that incorporate a weak link. The rings were inductively driven and the output voltage, isolated by a transformer, exhibited steps corresponding to quantum changes in the capacitance of the weak link.

Two papers in this session discussed calculations of superconducting phenomena. The Northeastern group collaborated with NRL for one paper in which an upper limit was calculated for the critical current density of Y-based HTSC films. Based upon the free energy of vortex rings nucleated within the thin film, they calculated a maximum J_c of 1.3×10^9 A/cm.^{2} The second paper in this category was from Honeywell Systems and Research Center, and discussed the calculation of hysteretic magnetic levitation forces for type II superconductors. The derived hysteresis loops showed a dependence on field gradient and critical current density, as well as applied field and sample size.

Session BB: Permanent Magnets by Nitrogenation — Present and Future

By S. G. Sankar, Advanced Materials Corporation and Carnegie Mellon University

Several rare earth intermetallics absorb significant amounts of nitrogen under mild reaction conditions. Recent work by a number of researchers around the world has shown that some of these nitrides have a potential for fabrication into technologically useful permanent magnets with respectable remanence, coercivity and energy product. This Symposium was organized to review the current state-of-the-art in this rapidly developing field. Six talks were delivered at the Symposium.

The first talk was presented by W.E. Wallace from the Advanced Materials Corporation, Pittsburgh. He pointed out that only three intermetallics, $SmCo_5$, Sm_2Co_{17}-type and $Nd_2Fe_{14}B$ have been used to fabricate commercially significant permanent magnets with energy products exceeding 25 MGOe. Research effort, until very recently, was focussed mainly on substitutional modifications. Recent work with the nitrides, however, involves the incorporation of nitrogen into the interstitial sites. $Sm_2Fe_{17}N_x$ and $NdFe_{11}TiN_x$ appear to show promise for magnet fabrication. Conventional powder metallurgical techniques using these nitrides are unsuitable for magnet fabrication due to the decomposition of nitrogen at high temperatures. Wallace pointed out some preliminary work reported on the fabrication of zinc bonded magnets which yield energy products of -10 MGOe.

The second talk by W.B. Yelon (U. Missouri, Columbia) dealt with the advantages of employing neutron diffraction techniques to determine the structure of the nitrides, the bond lengths and the location of nitrogen atoms in the lattice. He presented results obtained on $Nd_2Fe_{17}N_x$, $Y_2Fe_{17}N_x$, $YFe_{10}V_2N_x$ and $NdFe_{10}Mo_2N_x$. His results point to an interesting trend in the variation of the bond lengths and the nature of magnetic interactions. Yelon also pointed out the problems in obtaining high quality specimens with homogeneous composition and low strain.

S. S. Jaswal (U. Nebraska, Lincoln) presented an interesting survey of the electronic structure of the nitrides based on self-

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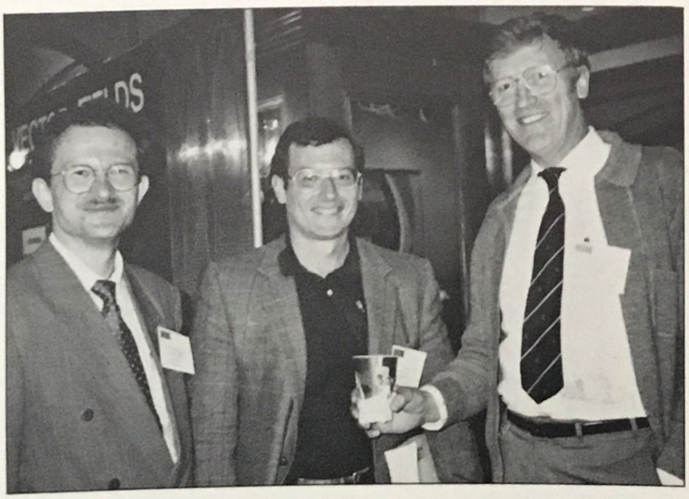
consistent, spin-polarized band structure calculations. The magnetization results before and after nitrogenation in Y_2Fe_{17} have been shown to be in very good agreement. Further, Jaswal pointed out that the spin fluctuation theory of Mohn and Wohlfarth correctly predicts the (near) doubling of the Curie temperature upon nitrogenation as observed experimentally.

T. Iriyama (Asahi Chemical Industries, Japan) summarized the careful work undertaken by his group in which they examined $Sm_2Fe_{17}N_x$ ($0<X<6$). He pointed out that the saturation magnetization and anisotropy field show maxima when x -3.0 ($4\pi M_s = 15.7$ kG and $H_A = 260$ kOe). They have also fabricated anisotropic powder magnets with an energy product of nearly 21 MGOe for $x = 3.0$. He concluded his talk by pointing out the favorable nature of $Sm_2Fe_{17}N_x$ to fabricate bonded magnets.

J. Wecker (Siemens AG Research Laboratories, Germany) described the variation of intrinsic magnetic properties of Sm_2Fe_{17} with nitrogen content, substitution of iron by cobalt and that of samarium with neodymium. He also discussed the basic principles of magnetic hardening by nonequilibrium techniques such as mechanical alloying and melt spinning. His group successfully fabricated isotropic magnetic materials with $Sm_2Fe_{17}N_x$.

J.M.D. Coey (Trinity College, Dublin) discussed the nature of gas phase interstitial modification of Sm_2Fe_{17} and evaluated the diffusion coefficient and activation energy. In a very careful analysis of the results, his group estimated the diffusion constant to be 1.02 mm^2/s and $E_a = 133$ kJ/mole. Using these values, they calculated the nitrogen concentration profiles and nitrogenation curves. He also pointed out that only particles with $x > 2$ in $Sm_2Fe_{17}Nx$ can be expected to yield any appreciable coercivity.

Interesting discussions were held after each talk and the general consensus was that this field is in its infancy. Scientifically important and technologically valuable results should emerge in the near future.



Session BC: Novel Memories — "VBL, Bubble, Magnetic RAM, and others"

By Romney R. Katti, JPL

Session BC on novel magnetic devices was concentrated on devices using garnet materials, such as vertical Bloch line (VBL) and bubble devices, and magnetic random access memories.

Paper BC-01 was an invited paper, given by Dr. Matsutera from NEC Corporation, on the performance of a prototype 300-bit VBL memory. Useful operating margins were obtained in 5 micron-stripe width garnet material for the major line, read/write gates, and VBL bit propagation.

Paper BC-02, given by Dr. Stadler from the Jet Propulsion Laboratory discussed the use of partial grooving in 2 micron-stripe width garnet films to stabilize stripe domains in a VBL memory. Favorable comparisons between simulated and experimental bias field margins were obtained, and magnetostrictive effects were determined to be less significant than magnetostatic effects in determining bias field stability.

Paper BC-03 was presented by Mr. Patterson of Boston University. This work showed the results, from a two-dimensional simulation of the Landau-Lifshitz-Gilbert equation on a Connection Machine, of the simulated dynamics of horizontal Bloch line (HBL) generation and propagation in a domain wall in 2 micron-stripe width garnet material. Simulation results indicate that HBL formation is suppressed the most under conditions of high bias fields and uniform field profiles with respect to film thickness.

Paper BC-04, given by Dr. Bagneres of Boston University, calculated in three dimensions the dynamics of gyrotropic VBL motion in a domain wall. The simulations predict that wall velocity and VBL velocity increase with applied field, but at a rate such that the ratio of VBL velocity to wall velocity decreases with applied field. For low drive field levels, the wall velocity predicted by the simulation is in agreement with that calculated using an analytical rigid wall model.

Paper BC-05, presented by Prof. Nyenhuis from Purdue University, used a rotating gradient experiment to observe the behavior of bubbles when many VBLs are added to a bubble but not so many VBLs are added so that the bubble becomes hard. Plots of bubble velocity were made vs. the product of bubble radius and radial drive field to deduce bubbles states and state changes through winding numbers and dimensionless momenta/VBL numbers. Because certain state changes were not explicable simply by counting generated unwinding VBL pairs, it was concluded that Bloch points were playing a role in many of the state changes.

Paper BC-06 was presented by Dr. Anatoly. In this paper, three-laser high speed sampling microscope photography was used to image interactions and collisions between VBLs. This technique allowed observing combinations of VBL-VBL interactions which showed unaffected, partially affected, and annihilated VBLs after the collision process. Such observations indicate that while VBLs can be treated topologically as solitons, the interactions experienced by the VBLs is observed to be more general than that predicted by classical soliton theory.

Paper BC-10 was presented by Dr. Pohm, and was on the subject of magnetoresistive (MR) random access memories. A new mode was demonstrated for a special cell element in which an MR element with an active area of 0.7 micron by 3.0 micron produced signal levels of +/− 1.2 mV. In this new mode, information is stored in the direction of edge magnetization, and the body of the element becomes the sensor.

Paper BC-11, presented by Dr. Pohm, provided simulation results on an improved differential sensing method in which the total analog circuitry time delay is as small as 9.8 ns, indicating that read sense times for an appropriately sized cell can be in the 10 ns to 20 ns range. Simulation results were obtained for a three-segment folded memory cell that used an area of 264 square microns.

Session BR: Magnetic Measurements — New and Improved Techniques

By Craig A. Grimes

A strong theme in this years Magnetic Measurements Session was remote, non-intrusive determination of magnetic properties. Two papers presented by M. Devine and D. Jiles concerned the construction and application of an insitu BH-Looper called a magnescope. The magnescope was used to determine the magnetic surface properties of various steels, which could be correlated to creep damage in the metal. R. Rabinovici et al. demonstrated a compact, portable 50/60 Hz magnetic field measurement system. A tuned, filtered resonant circuit allows them to inexpensively measure field strengths from 20-3,000 nTs. A. Khanlou et al. presented an insitu, on-line method for measuring the magnetic properties of grain oriented steel; a coil wound in the plane of the steel sheet is used to excite flux measured by a Hall probe.

At the high end of the frequency spectrum, M. Amano et al. presented results on their strip-line technique for measuring the high frequency complex permeability of thin films. The magnetic specimen is treated as an impedance load between coaxial drive and receive ports. By measuring the S-parameters of the load, the permeability is determined at frequencies up to 3 GHz. A high frequency, coplanar FMR technique was presented by P. Dorsey, C. Vittoria, and M. Wittenauer. They determined the resonance frequency and linewidth of a planar sample placed upon a strip-line designed cavity. The strip-line design is seen to be just as accurate as other techniques, and much easier to use.

At the low end of the frequency spectrum, M. Dababneh et al. presented a comparison between magnetization values obtained using the VSM, Squid, or Faraday Balance. They were found to be in pretty good agreement for small sample sizes. T. Nakata et al. presented an iterative, numerical method for determining the magnetization curve of a ring specimen with greater accuracy. A. Bogliette et al. detailed their new power supply for high-field, ring specimen measurements. By connecting the emf into a feed-back loop they were able to eliminate the high frequency harmonics commonly found when driving high voltage-current loads.

B. Frost and H. Lichte showed results of their electron holography system for several magnetic specimens. Their system is an interesting one in that phase distributions of the holographic images describe quite accurately the magnetic flux propagation. And finally, T. Kawabe and J. Judy combined under and over-focused Lorentz TEM images to obtain much clearer images of magnetic recording transitions.

Session DA: Optical Storage — Materials, Recording Process and System

By Chien-Jung Lin

One invited and eight contributed papers were presented in session DA.

Kaneko of Sony gave an invited overview on Direct Overwriting (DOW) and Magnetically induced Super Resolution (MSR) using exchange-coupled multilayers, made of RE-TM layers with various compositions, Curie temperatures and anisotropy constants. An overwritable 5.25″ trilayer disk with twice the capacity of the current ISO disk was achieved by combining zoning recording with high linear density of 0.8 μm/bit and narrow track pitch of 1.4 μm. More than 10^6 times overwriting cyclability was reported. MSR used in Front Aperture Detection (FAD), Rear Aperture Detection (RAD) with single mask, and RAD with double masks were described. Greatest resolving power was obtained by RAD with double masks, with cutoff spatial frequency expanded to more than twice of conventional detection, leading to a high density of 0.3 μm/bit. Overwriting by magnetic field modulation was reported on an MSR disk by using a floating magnetic head with a slightly lower CNR than laser modulation.

Weller et al., of IBM Almaden described an abrupt saturation of the coercivity with increasing period at $N = 13$ for Co/Pt multilayers. This behavior was interpreted in terms of nm scale defects. Zeper et al., of Philips Research reported comparative MO recording performance of GdTbFe and Co/Pt multilayers at wavelengths of 820, 647, and 458 nm. They reported that at 820 and 647 nm, CNR of GdTbFe disks was 2-3 dB higher, whereas at 458 nm Co/Pt multilayers offered 3 dB more CNR. Shieh of IBM Yorktown showed transient temperature measurements of MO films during thermomagnetic writing, derived from a time-resolved Kerr microscope reported previously, with 5 ns temporal and 0.3 μm spatial resolutions. Curie diameter versus time was shown for a particular writing experiment, and thermal modeling was used for comparison. Nakaki et al., of Mitsubishi Electric reported jitter and CNR improvements at increased linear density and track density for LM DOW recording on pentalayer exchange-coupled MO media. This was achieved by combining the previously reported "self-sharpening" effect of boundary erasure with a multi-pulse writing method. Saito et al., of Nikon and Hewlett-Packard reported LM DOW PWM recording at high linear density of 0.54 μm/bit. They used pattern-dependent write compensation and a third writing power level P_{LB} ($< P_H, P_L$) at the end of P_H pulses on improved disks with GdFeCo readout layer. They achieved 1 GB/side capacity on a 5.25″ DOW-MO disk. Thomson et al., of North Wales and Keele Universities, in conjunction with Hewlett-Packard, discussed the optical and magnetic measurements of time dependence effects in MO recording films. Analysis of the time dependence data revealed the activation volumes for magnetization reversal. The minimum bit size was estimated from the activation volume. Torazawa et al., of Sanyo Electric discussed characterization of GdDy/FeCo multilayers with periods ranging from 1.5 to

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50 Å. They reported optimal recording performance at a period of about 3 Å.

Session DB: Tribology I

By F. E. Talke

The seminar was chaired by Prof. Talke from CMRR and started with a presentation by K. Schultz of IBM, Rochester on the effect of sputter conditions on the tribology of thin film disks. The next paper (H. Lee, et al.) from Conner discussed the longtime durability of disks using chemically bonded lubricants, followed by studies of the effect of humidity on friction (H. Tian et al., Hoya Electronics) and the durability of zirconia overcoats (K. S. Ganapathi et al., CMRR). Instrumentation aspects of the head/disk interface were the subject of the next five papers, with contributions in the area of capacitance probe techniques, load/unload, and measurement of interface temperatures during contacts between slider and disk. The last three papers in the session dealt with flexible media tribology, starting with a paper by M. Wahl (CMRR) on the measurement of head/flexible disk spacing using monochromatic interferometry, followed by a paper on wear simulation of the head/tape interface (C. Lacey and F. E. Talke, CMRR), and ending with a paper on an optimization study of head contours for helical scan recorders (T. Megawa, Mabushita).

The session was very well attended, and good comments on the papers and presentations were heard after the conclusion of the session, which finished right on time.

Session DD: Hysteresis Calculations

By Gordon Hughes, Seagate Technology

Twelve papers were given, covering hysteretic material modelling.

Aid et al. presented a finite element calculation for thin film head soft materials. The method maintains constant M vector magnitude and separates out the scalar potential representing the external demag field energy. Spontaneous domain patterns arose that checked classical cases.

Bertotti introduced rate-dependent element switching fields as a Preisach generalization suitable for ac sinusoidal applied fields.

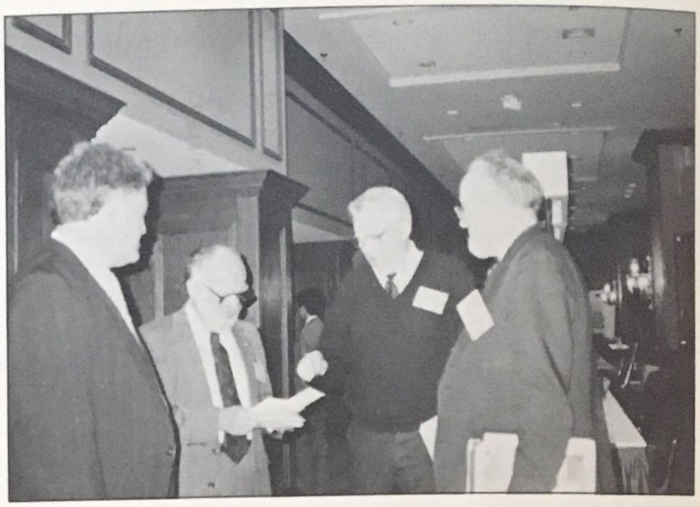
Jiles discussed a Preisach model for the MH constitutive relationship in a self consistent model, enforcing minor loop closure by a "working fraction" concept. Cartesian magnetization representation naturally permitted domain wall movement.

Mayergoyz and Adly presented a numerical implementation of the feedback Preisach model, arising from demag fields proportional to local magnetization.

Vajda and Della Torre generalized Preisach elements to include both reversible and irreversible components, to model more realistic material loops.

Inoue et al. modelled eddy currents in MIG writing heads, finding that the conductive sendust magnetization is significantly altered by the currents, but that the media magnetization and playback response change only slightly.

Kvarsnjo found significant eddy current effects in a stress dependent Preisach model, applied to the highly magnetoresistive material Terfenol-D.



Session DP: Magnetic Recording Heads — Ferrite, MIG, and Others

By N. H. Yeh

Ten papers were presented in this poster session. DP01 and DP02 are dealing with dual-sided MIG head recording on thin film disks with coercivity as high as 2150 Oe. The superior performance of MIG head on these disks is primarily due to its high saturation moment, lack of head saturation, and excellent overwrite. DP03 describes a low temperature (<350°C) MIG head fabrication process which employs CoZrMoPd amorphous film to control the diffusion at the interface and reduces the secondary gap ripple down to less than 0.3 dB. The next four papers investigate the instability or the so called "wiggles" in MIG heads. Kerr microscope and magnetic force microscope were used in some of these studies to examine the domain wall and the head field near the gap. Good correlation has been obtained between the domain observation and the recording performance. Those heads with "wiggles" show a remanent state with significant fringing field and domain walls which change irreproducibly with repeatedly applied current cycles. The head defect and unfavorable crystalline orientation may induce domain wall nucleation site after write and produce instability during the subsequent readback. DP08 gives the analytic modeling result of an asymmetric ring head with saturation taken into consideration. The last two papers describe an innovative recording scheme using a 400 track fixed matrix head for record and a Kerr head for playback. Experimental data of SNR, eye pattern, and bit error are presented to demonstrate the feasibility of this concept.

Session DR: Particulate Media — Characterization and Analysis

By M. R. Parker

Eight poster papers were presented in this session. Only one of these, by Pouillard et al., University of Savoie, France, dealt with particulate films - co-sputtered granular films of AgFe of relatively high coercivity - which this writer anticipates will be one of the hotter topics at future Intermag meetings. The only other relatively novel system described was that of Templeton et al., Simon Fraser University, Canada, a chemical precipitation technique for ultafine Fe particles. In one of a series of papers on this topic, the preparation technique is outlined. Essentially, the Fe particles are formed by H- reduction of lepidocrocite, the size of the particles being limited by exfoliations of MoS_2.

The remaining six papers of the session involved more familiar systems and the usual mix of techniques - time decay, remanence and transverse susceptibility. High-coercivity CrO_2 received some attention from Ensling et al., University of Mainz, Germany who used Mössbauer techniques for investigation of the valence state of Fe dopant in these materials. Sollis et al., (Preston, Bochum and Keele) modeled anomalies of the transverse susceptibility maximum around H_K due, in part, to texturing. CrO_2 also received attention from El-Hilo et al. (Bangor, Jena, Keele, Ludwigshaven) who measured thermal fluctuation fields from magnetic viscosity measurements in the usual way, this time, however, with both particle volume distributions and anisotropy distributions accounted for. The three final papers focused on remanence measurements. Bissell et al. (Preston, Keele) related remanence to dc noise in metal evaporated tapes. Papers by Kato and Susumi (Hitachi) and He et al. (Alabama), by different methods, modeled interaction fields in particulate media. Common to both approaches, however, is the idea of a simple proportionality between interaction field and sample magnetization.

Session FA: Magnetic Recording Systems — Modeling and Analysis

By Tom Howell

This session was chaired by Kiran Chopra of Storage Technology Corporation. Neal Bertram of UCSD started the session with an invited paper on nonlinearities and pulse asymmetry in tape recording. He showed that nonlinear transition shifts vary as a function of depth into the media, and that imaging and demagnetizing fields must be taken into account to model these effects accurately. Nan Yeh of Ampex followed with another paper on nonlinear effects in tape recording. He showed how transition broadening or sharpening can be recognized by their effects on echo pulses in the computed dipulse response. He explained how to correct for pulse broadening by introducing record current overshoots. Rick Barndt of UCSD spoke on nonlinear effects in thin film disk media. Percolation causes partial erasure of transitions when the spacing gets below a critical value. He proposed a finite state model which accounts for partial erasure by transitions on either side or both sides of a given transition. These effects can eliminate the advantage of signal processing systems using $d=0$ codes over systems with $d=1$ codes for densities higher than .5 bits per a, where a is the transition parameter. Ken Johnson of IBM spoke on the effect of spacing on media noise. Spacing was adjusted from 95 to 223 nm by changing the thickness of a Cr overcoat layer on the disks. Noise was measured with an MR head, and the results were in agreement with theoretical calculations. The ratio of isolated pulse amplitude to media noise improved by 6-10 dB as the spacing was reduced. Ron Indeck of Washington University presented a method of measuring transverse correlation lengths in thin film media. Correlations between on track and off track readback signals from DC erased media drop linearly as the off track distance increases. With a high frequency signal recorded both on and off track, the drop in correlation is similar, but with much smaller slope. A characteristic length of the magnetic structure of the disk can be determined from these measurements. Mr. Tagawa of Tohoku University compared readback signals computed using reciprocity with those computed by a finite element simulation model. Since the head and the media interact magnetically, a question arises about which field distribution to use for the head sensitivity function in a reciprocity calculation. The best results are obtained using the field of the head with the recording layer removed from the two layer medium. Jimmy Zhu of Minnesota presented modeling studies of side writing. He showed a calculated Lorentz micrograph of a written track! The written track from a 1.5 micron head was ⅓ wider than the head. The side reading on unoriented media was less than on oriented media due to flux closure by the transverse component of magnetization. The noise on oriented media was much more strongly concentrated at the transitions and track edges than the noise on unoriented media. Jim Su of IBM studied side reading experimentally. He showed that the yoke of a thin film head can read isolated pulses from 25-30 microns away. This kind of interference is more troublesome for thin film and MIG heads than for shielded MR heads. Reducing throat height and flying height can increase the on track signal while keeping side reading about the same. Joost Mortelmans of IBM presented a new mathematical model for track misregistration distributions. They measured position error signals in an operating disk drive, and fit the observed distribution with a series expansion whose terms are products of Gaussian probability density functions and Hermite polynomials. The Gaussian fit well near the center of the distribution, but was a poor fit in the tails. The series expansion with sixteen terms fit well over the whole range studied. Robert Weinstein of Storage Technology presented a study of track density constraints for MR heads. Some of the most important factors to be considered are separation between read and write elements, alignment of the elements, mechanical misalignments and servo performance, and off track capability. It was shown that in order to reach track densities much above 4000 tpi the head must be moved between write and read operations. Joe Poss of IBM presented a paper on thermal asperity compensation for MR heads. Thermal asperities produce large, slowly decaying spikes adding to the readback signal. These were compensated by holding the timing and gain control signals and by halving the sensitivity of the A/D converter to create more headroom. These measures were applied as error recovery procedures after failure of the initial attempts to read a record with a thermal asperity.

Session FB: Multilayers II — Giant MR and Magneto-Optical

By Dieter Weller

Session FB06 consisted of 9 papers, 4 on MR, 4 on MO materials and an overview on thin film and multilayer characterization.

B. Tanner discussed the various, impressive aspects of x-ray reflectometry in obtaining structural information such

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as individual layer thicknesses, interface roughness, interface abruptness, surface flatness. The technique appears to be a powerful, non-destructive multilayer characterization tool. It is best suited for systems with large differences in scattering factors like Co/Au. Other examples discussed were Cr/Fe and Cu/Ni, which were grown with different methods and under different deposition conditions.

The papers on giant MR concentrated on the Co/Cu, Fe/Cu and CoFe/Cu systems. It is worth mentioning that the substitution of Co with about 10% Fe can considerably increase the room temperature MR effect. Y. Saito reported a ~25% increase and pointed to a strong dependence on the interface conditions in his ion beam sputtered multilayers.

The section on magneto-optic materials contained mixed topics. T. Suzuki discussed the coercivity mechanism in Co/Pt multilayers in conjunction with domain wall pinning. He reported that varying the substrate condition, e.g. by using different types of buffer layers and initial etching procedures dramatically influenced both the microstructure and coercivity. While this was known before, Suzuki derived in a quantitative model the size of defects (non-magnetic inclusions) responsible for pinning. This can be as small as 4A in multilayers with rectangular magnetization loops.

F.J.A. den Broeder presented for the first time data on the just recently reported Co/Ni multilayers. These structures showed unexpected sizeable perpendicular magnetic anisotropy, 100% remanence, decent coercivities and larger Kerr effects than Co/Pt or Co/Pd, and therefore range among the prospective candidates for magneto-optic recording materials. Den Broeder discussed in detail effects of different buffer layers on anisotropy and coercivity. Despite the high magnetization and a Curie temperature of $T_C \approx 680°C$, which must be considered a drawback for these materials, den Broeder was able to demonstrate thermomagnetic writing capability and showed viewgraphs of bits written with laser powers up to 130mW!

The session was concluded with presentations on FeCo/Pd multilayers (magnetics and magneto-optics) by S.-C. Shin and a discussion of remanence curves and interaction plots in Tb/Fe multilayers by T. Thomson.

Session FP: Hard Magnetic Materials

By Richard T. Obermyer

The hard magnetics materials poster session dealt with a wide variety of topics: microstructure characterization, intrinsic magnetic properties, preparation and fabrication techniques, nitrogenation, thin films and neutron diffraction.

Posters FP-01, 03 and 04 focused on the 1:12 type systems. The presentation of FP-01 was a detailed constitutional study in the Fe-rich corner of the Sm-Fe-Ti where $Sm(Fe,Ti)_{12}$ was found to be in equilibrium with α-Fe, Fe_2Ti, and $Sm(Fe,Ti)_9$ between 1000 - 800 °C. FP-03 investigated texturing in sputtered Sm-Fe-Ti,V films with and without nitrogenation. Nitrogenation results in up to a 7% volume change and the conversion of the magnetization from normal to the film plane to an in plane system. In paper FP-04 neutron diffraction was used to show the 8i positional preference of a fourth element(Nd) substitution in the ternary $Y(Fe,Ti)_{12}$.

Rani et al. (FP-02) presented structural and magnetic evidence for the formation of two element Sm_2Fe_{17} sputtered films with very large anisotropy (>90 kOe) and large room temperature coercivities (>14 kOe). This is in contrast to bulk sample synthesis which typically requires a small amount of a third element such as Ti to stabilize this phase.

Computer stress simulations were used by K. Iwasaki et al. (FP-09) to suggest a preform shape in order to fabricate trapezoidal shaped rapid quenched, die upset Nd-Fe-B magnets. The experimental results showed that it was possible to achieve good quality magnets with high energy product (> 320 kJ/m³) by employing this new method. A collaborative effort by GM and Daido Steel researchers (FP-10) reported some interesting results for Nd-Dy-Ce-Fe-Co-B anisotropic magnets. When Co content was varied up to 11% substantial improvements were made in the temperature coefficients α and β as well as the irreversible flux losses as compared to the base alloy.

A microstructure characterization of $Sm_xFe_{73}Zr_{27-x}$ melt spun hard magnetic systems was presented by B. Simion and G. Thomas (FP-07). Using transmission electron microscopy they were able to identify three extra phases (Fe_3Zr, Fe_7Sm and ZrO_2 cubic) in the low Sm content, low coercivity samples. In contrast, the high Sm content, high coercivity samples did not contain these phases.

Paper FP-05 reported the composition dependence of the Curie temperature and magnetization of $GdFe_7Si_x$ and $ErFe_7Si_x$ ($0<x<2.5$) ribbons. X-ray analysis showed the samples to be of the $CaCu_5$ type structure. Spin reorientation phenomenon was observed for $ErFe_7Si_{1.0}$. Lin et al. (FP-06) presented crystallographic and magnetic results on $Sm_2Fe_{17-x}Si_x$ ($x = 0 - 2.5$). The Curie temperature increased with increasing Si content while lattice parameters decreased. All samples studied had the easy magnetization direction perpendicular to the c axis. A large anomalous thermal expansion was observed below T_c for $Sm_2Fe_{15}Si_2$ and is thought to indicate that Si atoms do not preferentially occupy the dumbbell site.

Paper FP-12 (M.Q. Huang et al.) investigated the possibility of degrading the cubic symmetry of $La_2(Co_{1-x}Fe_x)_{13}$ by nitrogenation. Although the samples absorbed substantial amounts of nitrogen and the unit volume increased by 9%, the nitrogenation of $La(Co,Fe)_{13}$ did not degrade the cubic symmetry, however the magnetic properties were degraded.

Efforts to modify the structural, morphological and magnetic properties of Dy_3Al_2 were presented by FP-11. Hot pressing of $Dy_{3-x}R_xAl_2$ (R = Gd and Tb) alloys produced preferential crystallographic alignment in all alloys and reasonably good energy products (~36 MGOe) and coercivities (~9.5 kOe) in some alloys at 10 K.

Papers FP-15 and FP-16 dealt with hard ferrite materials. FP-15 presented a new manufacturing method to produce Sr-Zn W-type hexagonal ferrite magnets. It was found that addition of SrO_2 after a semi-sintering treatment was very effective in stabilizing the W-type crystal structure in a wide temperature range. In the case of FP-16 a novel compound ($5BaO \cdot 4Fe_2O_3$) was synthesized by using excess $Ba(OH)_2$ during autoclaving. The crystal structure and magnetic properties were quite different from any known compounds in the $BaO\text{-}Fe_2O_3$ system.

0. A. Pringle et al. (FP-13) described the properties of novel iron carbide films of the Fe_7C_3 type formed in a glow discharge. The films exhibited columnar growth perpendicular to the substrate surface with the iron magnetic moments aligned normal to the plane of the film and coercivities of the order of a few hundred Oersteds.

N. Qui and J.E. Wittig (FP-14) presented a systematic study of melt spun Pt-Co-B ternary alloys using a variety of techniques. Various heat treatments were used in order to establish a correlation between the development of coercivity and the evolution of the microstructure.

Session FC: Bulk Soft Magnetic Materials

By Joseph Bularzik

The presentations provided a good overview of current work in many areas. They can be divided into several categories.

Amorphous Ribbons (1) Remnance and coercivity of Co-rich amorphous wires were measured after annealing to relieve tensile and torsional stress, and explained by structural relaxation and magnetic anisotropy. (2) Annealing Co-rich ribbons in a small field can result in asymmetric hysteresis loops. The asymmetric loops are due to surface effects. (3) Thinning Fe-based ribbons can produce low core losses. Starting with thicker ribbons and thinning on the roll side reduces the losses. (4) Ultrathin (3μm) Fe-based ribbons have been developed; the composition is determined by considering fluidity and electrical resistivity.

3% Si-Fe GO (110)[001] Ribbons (5) Recovery from residual stresses from coiling were measured by recovery of domain walls (SEM measurements) and magnetic properties (B_8 and h_c) after annealing above 8000°C. (6) A thin (15 - 5μm) low core loss ribbon was developed for high frequency applications after stress relief annealing.

Models (8) Loss separation experiments on 3% NO Si steel at various frequencies and inductions were modeled by a statistical loss theory. The hysteresis and excess losses follow a power loss dependence. (9) Another loss model was presented based on a dynamic generalization of the Preisach hysteresis model. (12) Magnetization of 3% GO Si steel was calculated using a model based on texture misorientation, magnetic anisotropy and magnetostatic interaction between grains, leading to a vector relation between induction and applied field.

Magnetic Properties of GO and NO Electrical Steels (7) One experiment varies the pause time at the highest magnetic induction while keeping the magnetization time constant. Loss per cycle increased with pause time; attributed to several magnetic relaxation phenomena and magnetic reversal. (13) Magnetic losses of rotational induction were compared with sinusoidal induction along the L and T directions. This superposition principle only worked at very low inductions. (14) Rotational power losses were measured for NO 6.5% Si steel and compared to Si steels and non-Si steels. The experimental procedure was very clearly explained. A difference in rotational loss was noticed when the rotation direction was reversed, this phenomena needs to be explored and explained further.

Fe-Ni-Cr (11) Permeability of the Fe-Ni-Cr system was examined. 36%Ni-12%Cr results in the highest initial permeability and 38%Ni-12%Cr results in the highest maximum permeability. To optimize the permeability, O must be below 25ppm and S below 10ppm.

Session GA: Magnetic Recording Systems — Coding and Detection

By Kiran Chopra

Session GA, Magnetic Recording Systems: Channels and Coding, was chaired by Tom Howell of Quantum Corporation. The session opened with an invited paper on the Evolution of Signal Processing and Coding presented by Hemant Thapar of IBM. This paper overviewed recent developments in recording channels, in particular the use of Karabed-Seigel Matched Spectral Null Codes to achieve an additional 3 db coding gain over the baseline PRML channel. This was followed by a paper on practical considerations of MSN codes by Lyle Fredrickson of IBM. He discussed the elimination of quasi-catastrophic sequences in the Karabed-Siegel MSN code and showed simulation results confirming the 3 db gain over PRML. Hamid Shafiee from the University of Minnesota described a low-complexity Viterbi decoding method employing "ambiguity zones." He shows how a PR system of the form $(1\text{-}D)(1\text{+}D)^2$ can be decoded with fewer metric computations and

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retained paths than required by the Viterbi algorithm. Simulation results show that this technique (VA-AZD) produces less than 0.1 db degradation in SNR. Weinig Zeng another student from Minnesota discussed a modified Viterbi algorithm suitable for a jitter dominant channel. His simulation results indicate a factor of 4 to 10 improvement in error rates. William Ryan of Ampex Corporation presented a paper comparing the performance of Kelly Knudsen's Viterbi soft decision metric with that of a dropout detector used as an erasure flagger. He shows that the simpler dropout detector, which flags all bytes with more than 12 db signal loss, outperforms the Viterbi erasure flagger in environments where the decoded performance is burst limited and burst errors are the results of signal level drops. Mr. Shimpuku of Sony Corporation described a new maximum likelihood detection system for digital audio tape recorder. An 8/11 DC free code is used with Class 1 partial response and a waveform matching terminal code detector to provide better margin than a conventional Viterbi decoder. This decoder when applied to a DAT recorder achieved 419 Mb/sq. in. recording density and 22.2 Mbps. data transfer rate using ME tape. Mr. Menyennett of Johannesburg University presented a paper describing a new run length limited code for binary asymmetric channels. This four parameter (α, β, γ, δ) code allows for different run length constraints on the 0's and 1's to maximize recording density in write-once optical data storage where mark and non-mark sizes may differ. The next paper presented by Mr. Ling of U.W. Cardiff U.K. dealt with a two frequency coherent phase recording technique for encoding data on magnetic stripe cards. The stripe is read by an unbiased magneto-resistive head and provides accurate data detection over a wide range of swipe speeds. R. Kati of the Jet Propulsion Laboratory described how the degradation of one of the space flight recorders on the Magella spacecraft was analyzed via remote instrumentation diagnostics. After an extensive review of the data error patterns it was concluded that the failure was due to malfunction in the write circuits. Mr. Jackson from the Southwest Polytechnic in Plymouth U.K. discussed a compensation for head-tape misregistration in multitrack tape systems. It involves starting from an uncorrupted edge track and working iteratively across the width of the tape to generate the compensation factors. Kurt Hallmasek of UCLA Berkeley described an experimental sector servo system which was implemented on a D2 video recorder and significantly reduced tracking errors. The system involves the use of 12 evenly spaced track registration marks to provide tracking error signals. A periodic error profile is developed from five of these TRM's and then canceled by a feed forward compensator. The final paper in this session was presented by Yamaguchi of Hitachi. This paper described a robust variable structure digital control system employing optimal control theory to estimate initial values for the servo compensator as it switches modes from seeking to settling. Experimental results from 3.5 inch drive with 326 μ sampling rate showed minimal variation in settling transient characteristics.

Session GP: Soft Magnetic Devices

By Carl H. Smith

Session GP contained a collection of papers describing devices which emphasize the concerns of the future — miniaturization, low losses and low noise. Several posters utilized the opportunities offered by a poster session to display actual devices as well as pictures of them and computer output of FEM calculations. A total of 12 of the 14 scheduled posters were presented.

Paper GP-02 by Sasada and Haradu of Kyushu University compared shielding properties of amorphous ribbon shields while excited by a low-intensity, 100 Hz "shaking" field applied by mesh or toroidal coils. The shielding factor and noise spectrum were better for the mesh coil.

Five papers on motor followed the paper on shielding. In search of reduced losses due to more uniform fields in the air gap in motors, Kaga, Anazawa, and Tajima of Akita University investigated the effect of ferrite wedges inserted between teeth in the stator of a capacitor motor in GP-03. A theoretical treatment of the prediction of stator losses in brushless dc motors by FEM calculations was given by Atallah, Zhu, and Howe of the University of Sheffield in GP-04. Several FEM calculations of field distributions were shown in colored figures. Paper GP-05 by Sakamoto, Natsusaka, and Murakami of Hachinohe Institute of Technology demonstrated a method of reducing acoustic motor noise by eliminating teeth and using a parametric motor configuration. Minimization of weight rather than losses was the subject of paper GP-06 by Osawa, Wada, Ebihara, and Yokoi of the Institute for Posts and Telecommunications Policy and Karita of Shinko Electric Company. A linear induction motor was designed and built using a 50% cobalt-iron core and aluminum windings to achieve a significant weight savings at some penalty in electrical losses. Paper GP-07 by Vranish and Naik of Goddard Space Flight Center and Restorff and Teter of NSWC described a motor based on magnetostrictive Terfenol-D rods. This high torque, low speed motor uses cams and rollers to achieve rotary motion from linear magnetostrictive motion.

The sole transducer in the session was an hydrophone made from a transverse-annealed metallic glass scroll. Paper GP-08 by Wynne, Gibbs, and Pace of the University of Bath described the device which achieved a magnetomechanical coupling factor of 0.68 in an actual device.

The final five papers concerned miniature devices for circuits operating at megahertz and even gigahertz frequencies. Paper GP-09 by Sakai from Chiba University described a combination inductor and capacitor using thin ferrite toroids as both dielectrics for a multi layer capacitor and as core material for an inductor. Kobayashi, Ishibashi, Shirakawa, and Toriu of The Amorphous Devices Lab.; Matsuki of Tohoku University; and Murakami of Hachinohe Institute of Technology continued their work on cloth devices using amorphous wires in paper GP-10. Characteristics up to 10 MHz were reported for inductors and transformers made from cloth woven from multi-strand bundles of amorphous wires and multi-strand conductors. Thin film techniques were used for the last three papers. Paper GP-11 by Yamaguchi, Arakawa, Ohzeki, Hayashi, and Arai of Tohoku

University reported characteristics up to one GHz of a spiral, thin-film inductor in which the magnetic layers formed a closed circuit surrounding the conducting layer. Another thin-film device for use in the GHz range was the pinhole device described in paper GP-12 by Tsujimoto, Wada, and Shirae of Osaka University. By applying a control current through a hole in a thin-film, amorphous CoNbZr film which had been deposited in a stripline configuration, the output signal could be modulated. Both the transmission and reflection coefficients were affected. The need for thin film of various materials on various substrates motivated paper GP-13 on plating ferrite films from aqueous solutions by laser enhancements by Itoh, Hori, Abe, and Tamaudra of Tokyo Institute of Technology. Both plating techniques and magnetic properties were reported for ferrite films up to 5 μm thick. By using laser illuminations, maskless patterns were deposited by slowly moving the substrate.

Session GQ: Permanent Magnetic Devices

By H. A. Leupold

The poster session on Permanent Magnet Devices featured twelve papers of which nine were concerned with motors (GQ-1 to GQ-9), one with a passive di/dt limiter (GQ-12) and two (GQ-10 and GQ-11) with the provision of permanent magnet field sources for special purposes. The majority of the motor papers described linear types especially with regard to measurement, computer modeling, and improvement of their magnetic field sources. Of particular interest is an ingenious method for vibration reduction in electrical machinery described by G. Jang and D. Lieu in paper GQ-2. Vibration reduction is effected by shaping the magnets so that both the number of vibrational frequency components and their amplitude are significantly reduced. Papers GQ-10 and GQ-11 discussed respectively permanent magnets for light weight XUV Image Sensors and for the production of tapered magnetic fields in the Tesla range.

Session JA: Thin Film Media — New Materials and Processes

By Jack H. Judy

An invited paper (JA-01) "Roadmap for 10 Gigabit/in^2 Media: Challenges" by E. Murdock, R. Simmons, and R. Davidson, Hewlett-Packard, predicted that revolutionary improvements in existing thin film media will be required to support an areal density of 10 Gigabit/in^2, perhaps as profound as the change from particulate to thin film media. It was assumed that such a ultra-high areal storage density achieved at a track density of 25 Ktpi and linear density of 400 Kbpi with an uncorrected error rate of 10^{-4} will require a 150 nm thick media with a grain size of 8-10 nm in diameter, coercivity of 3000 Oe., Mrδ of 0.6 memu/cm^2, transition jitter of 2 nm, and a head-media separation of 28 nm to store 900 MBytes on a 1″ diameter disk. It was also suggested that an optimum perpendicular, longitudinal, or intermediate recording mode and sputtered quaternary cobalt alloys, barium ferrite, granular Fe/SiO_2, superlattices or other laminated thin film media, new or modified deposition and growth processes, and advances in recording modeling and characterization techniques will be required for success. C. Paik et al. (JA-02), ULVAC, showed that an addition of 10 at.% B in CoCr(10%)Pt(10%)/Cr media increased the coercivity to 3200 Oe and reduced the medium noise significantly by increasing magnetic anisotropy or pinning domain walls. The Pt content can be reduced to less than half by adding B to obtain the same coercivity. B. Lal et al. (JA-03), HMT Technology, showed that the disadvantages of low SNR at the ID and low OW at the OD associated with zone bit recording can be overcome by using a composite target with CoCrTa at the ID and CoCrTaPt at the OD. X.G. Ye and J.G. Zhu (JA-04), University of Minnesota, presented computer simulations of magnetization processes and di-bit recording on bicrystal thin film media using a Connection Machine CM-2. The results indicated that bicrystal films have potential for high-density narrow-track recording. M. Mirzamaani et al. (JA-06), IBM, presented a new technique for fabricating thin film disk media with controlled surface roughness by evaporating a low melting point metal (Ga) as a transient underlayer on a non-wetting substrate to form isolated spherical features which increase coercivity, decrease noise, and improve tribological performance. T. Reith et al. (JA-07), IBM, showed that substrate texture has a significant effect (x10^{-7}) on the 100 KBPI soft error rate of identically-processed CoPtCr/Cr longitudinal thin film media. H. Tsai et al. (JA-08), HMT Technology, showed that sputtered Ni_3P sublayers decreased the coercivity of CoNiCr films on NiP substrates and increased the coercivity on Canasite glass ceramic substrates, and for both substrates enhanced the SNR which correlated with the decrease of S* for NiP but was independent of S* for Canasite indicating that factors other than magnetic coupling of grains may be important for Canasite. Y. Deng et al. (JA-O9), Carnegie Mellon University, showed that high coercivity (1200 Oe.) can be obtained in CoNiCr films sputtered on Cr-coated Si and glass at room temperature by improving grain isolation with DC substrate bias. K. Johnson et al. (JA-10), IBM, showed that the noise of CoPtCr/Cr thin film media maximizes at 250 Å thick Cr and then decreases for thinner Cr down to 25 Å. TEM microstructural analysis showed that the reduction in medium noise with very thin Cr may be related to elemental segregation resulting from random growth of misoriented grains which decouple the grains and decreases the noise. T. Shimizu et al. (JA-11), IBM Japan, showed that high-coercivity (2000 Oe.) and low-noise CoPtCr media can be

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obtained without using a Cr underlayer by co-sputtering with SiO_2. G. Rauch et al. (JA-12), DEC, showed by dark-field TEM that lower noise electroplated CoNiP thin film media is due to formation of smaller clusters of grains. N. Matsushita et al. (JA-13), Tokyo Institute of Technology, showed that Co ferrite films deposited on ZnO underlayers by facing target sputtering exhibit (111) orientations with large perpendicular and in-plane coercivities suitable for isotropic ultra-high-density magnetic recording.

Session JQ: Magneto-Optical II (not storage); Materials, Applications, and Theory

By Terry McDaniel, ADSTAR/IBM

Iwata, et al., of IBM Almaden (JQ-01) studied FeCo/Pt multilayers (ML's) to seek an improved material relative to Co/Pt and Fe/Pt. A 50-50 CoFe layer was used throughout, with the thicknesses of the ML components being varied to search for the best magnetic properties. Unfortunately, the Kerr loops showed very low remanence and coercivity. Enhanced MO response in the blue was observed.

Deeter and Williams of NIST Boulder (JQ-02) described a characterization technique for garnet crystals using photo-elastic modulator data. The degree of sample depolarization could be observed through the Faraday effect, and was pronounced near the multidomain, demagnetized state.

Hirano, et al., of TOPPAN Printing and Tokyo Institute of Technology (JQ-03) performed a material characterization of Ca-doped Bi-YIG films to identify a processing window for a material with improved MO properties in the visible part of the spectrum.

Ostorero and Escorne of CNRS in France (JQ-04) presented information on the Verdet constant and susceptibility of EuGaG single crystals. Better device performance and basic material studies were goals of this research.

Contreras, et al., of University of Ovieda (JQ-05) showed inverse susceptibility versus applied field to study surface magnetic and MO properties of NiY.

JQ-08 by Savchuk, et al., of USSR Academy of Sciences showed temperature dependence of Faraday rotation in the dilute magnetic semiconductor CdTe(Fe) and CdTe(Mn).

JQ-12 was an added paper (formerly DA-II). Rusakov, et al., of Moscow State University described Mössbauer spectroscopy and MO studies of amorphous films of Tb(x)Fe(1-x). They focused on mechanisms responsible for declination of the Fe magnetic moment away from the film normal in the nominally perpendicular anisotropic material.

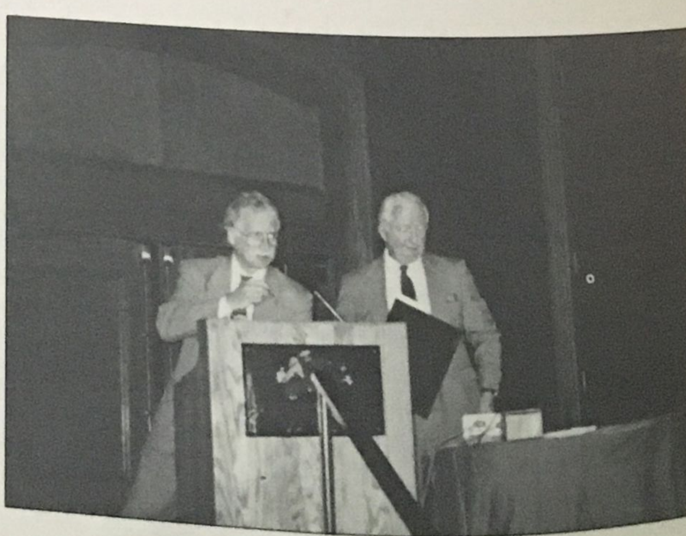
Papers JQ-06 and JQ-09 were withdrawn. Papers JQ-07, JQ-10, and JQ-11 were not presented.

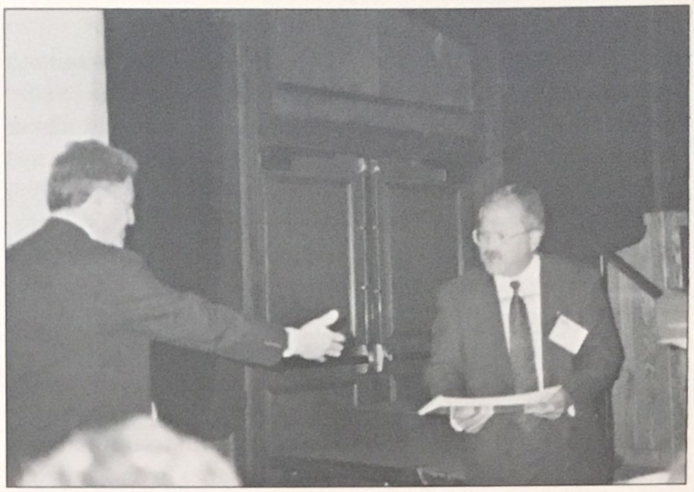
IEEE AWARDS PRESENTED AT INTERMAG '92

by John Nyenhuis

IEEE President Merrill W. Buckley, Jr. presented three prestigious awards at the Plenary Session of Intermag '92 on April 14, 1992 in St. Louis Missouri.

David A. Thompson received the 1992 IEEE Cledo Brunetti Award with citation "For pioneering work in miniature magnetic devices for data storage, including the invention, design and development of thin film and magnetoresistive recording heads". Dr. Thompson received the B.S., M.S., and Ph.D. degrees in Electrical Engineering from the Carnegie Institute of Technology, Pittsburgh, Pennsylvania, in 1962, 1963, and 1966, respectively. At the completion of his degree requirements in September 1965, he became an Assistant Professor of Electrical Engineering at CIT, now Carnegie-Mellon University. His research activities there were primarily in the fields of magnetic thin film phenomena and microwaves. From 1968 to 1987, Dr. Thompson worked for the IBM Thomas J. Watson Research Center, Yorktown Heights, New York. In 1985, he was named director of the Compact Storage Laboratory, a joint program between IBM Research and a product division. He moved to San Jose in 1987 to assume additional responsibilities as Director of the Magnetic Recording Institute, a similar program. The joint programs merged to become the Advanced Magnetic Recording Laboratory in 1991. Dr. Thompson is co-inventor of the magnetoresistive sensor used in all magnetic bubble memories. However, the main thrust of his work has been with heads and sensors used for magnetic recording for data storage. In the early 1980's, Dr. Thompson and Dr. L. Romakiw designed the first efficient and manufacturable thin film recording head for hard disk drives. Dr. Thompson also holds the patent on the shielded magnetoresistive head, which is playing an increasingly important role in advanced tape and disk storage. In recognition of these and other activities, he was named an IBM Fellow in 1980. Dr. Thompson has been active in the IEEE Magnetics Society for 25 years, and has served in many capacities in the Society and its affiliated conferences. He is currently Vice President of the Magnetics Society. He is Fellow of the IEEE, and a member of the National Academy of Engineering.





The 1992 IEEE Morris E. Leeds Award was presented to **H. Kumar Wickramasinghe.** The citation reads "For contributions to electrical techniques for nanometer-scale measurement of magnetic, optical, electrostatic and thermal properties of surfaces". Dr. Wickramasinghe obtained the B.Sc.(Eng.) and Ph.D. degrees in Electrical Engineering from the University of London in 1970 and 1974, respectively. His thesis work was in the Physical Electronics area, specializing in high frequency acoustic holography in solids. After working as a researcher at University College, London and at Stanford University, he joined the faculty of Electrical Engineering at University College, London in 1978, and gained tenure in 1982. Together with his students, he pioneered the work on acoustic microscopy in gases and ultra-sensitive laser differential phase microscopy techniques. In 1984, he moved to IBM T.J. Watson Research Center, New York, to start a group in Non-Destructive Evaluation. There he started the activity in scanning probe microscopy, which has led to techniques for measuring magnetic, thermal, electrostatic and optical properties of surfaces on the nanometer scale. Dr. Wickramasinghe is currently Manager of Physical Measurements at the IBM T.J. Watson Research Center where he has responsibility for developing and transferring key measurement technology to the manufacturing divisions. He has authored over 100 scientific papers, edited books in the field of scanning microscopy, and is a member of editorial boards of various journals and book series in nanotechnology. He holds several patents in the area of optics, acoustics, photoacoustics, STM and related techniques. Dr. Wickramasinghe is a Fellow of the IEEE, the American Physical Society and the Royal Microscopical Society.

The IEEE Morris N. Liebmann Memorial Award was given to three IBM researchers, **Praveen Chaudhari, Jerome J. Cuomo,** and **Richard J. Gambino.** The citation reads "For the discovery of amorphous magnetic films used in magneto-optic data storage systems."

Dr. Chaudhari received the B.S. degree from the Indian Institute of Technology, Kharagpur, India in 1961, and the M.S. and Ph.D. degrees from the Massachusetts Institute of Technology in 1963 and 1966, respectively. He joined the IBM Corporation in 1966 and over the years carried out his personal research, while holding various management responsibilities in science and science related to technologies such as optical storage, magnetic bubbles, and the Josephson program. He was appointed director in 1981 and Vice President, Science in 1982. In 1989, he became a member of the Corporate Technical Committee in Armonk and in 1990 he returned to the Research Division as a Research Staff Member. Dr. Chaudhari has worked on the structure and properties of amorphous solids, mechanical properties of thin films, defects in solids, quantum transport in disordered systems, superconductivity, and on magnetic monopole and neutrino mass experiments. He has published over 100 technical papers, edited two books and holds over a dozen patents. He is a member of the National Academy of Engineering, a Fellow of the American Physical Society and a member of the American Institute of Mining, Metallurgical and Petroleum Engineers. Dr. Chaudhari has received a number of IBM awards and is also the first recipient of the Leadership Award (1986) of the Metallurgical Society of AIME for his contributions to advancing the science and technology of electronic materials. He was executive secretary of President Reagan's Advisory Council on Superconductivity in 1988.

Dr. Cuomo obtained the B.S. degree in Physical Chemistry in 1960 from St. John's University, and a Ph.D. in Physics in 1979 from Odense University in Denmark. Dr. Cuomo joined IBM Research Division as a Research Staff Member,

INTERMAG '92 AWARDS *(Continued on page 18)*

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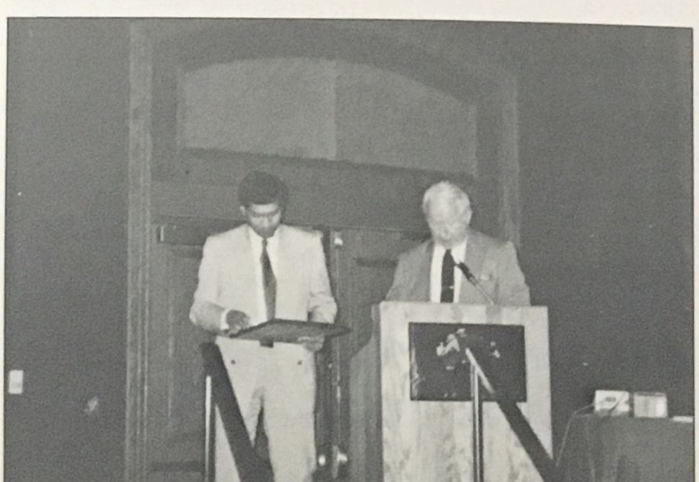
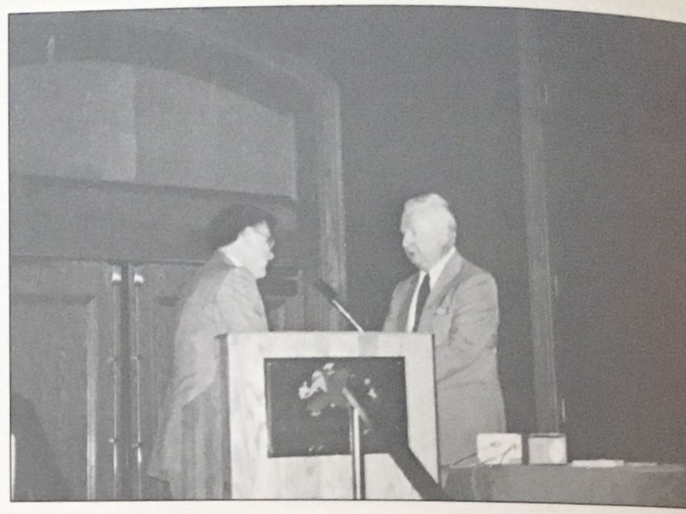
where from 1963 to 1983, he developed a Materials Processing Service Laboratory. He has made important contributions to the development of lanthanum-boron electron emitters and silicon nitride dielectric layers. He has pioneered work in selective chemical vapor deposition, dendritic solar thermal absorbers, sputtered amorphous silicon, amorphous magnetic materials with uniaxial anisotropy for bubble domain and magneto-optic applications, and ion beam modification and synthesis of materials. He invented and produced single crystal Josephson tunneling junctions out of Nb and NbN. The work of Dr. Cuomo and his group remains a cornerstone in the development of ion beam technology. From 1983 to the present, he has managed the Materials Laboratories Advanced Materials Processing area with research projects in enhanced plasma processes, laser deposition and cathodic arc processes. Dr. Cuomo is an active member of the American Vacuum Society and also a member of the Materials Research Society. He is co-editor of three books, and author or co-author of 8 book chapters and 165 refereed journal articles. He is an inventor or co-inventor of 70 issued or pending patents, which gives him the distinction of the highest patent level in the history of IBM Corporation.

Richard J. Gambino earned the B.A. degree in chemistry from the University of Connecticut in 1957 and the M.S. in inorganic chemistry from the Polytechnic Institute of New York in 1976. Prior to joining IBM's Research Division in 1961, he was a scientist at U.S. Army electronics laboratory, Ft. Monmouth, NJ and a metallurgist at United Aircraft in Middletown, CT. As a research staff member at the IBM Thomas J. Watson Research Center, Mr. Gambino conducted research on the magnetic properties of rare earth alloys and intermetallic compounds, and on thin film materials for magnetic bubble devices and magneto-optic storage applications. He is one of the discovers of perpendicular magnetic anisotropy in rare earth-transition metal amorphous alloy films. This work resulted in a key patent in magneto-optic storage media, one of 16 patents Mr. Gambino holds on materials and devices. In 1976, he showed that amorphous alloys of gadolinium have spin glass properties because of their disordered structure. Returning to magneto-optics in the 1980's, Mr. Gambino showed that the light rare earths have much larger mag-





neto-optic effects than the heavy rare earths at shorter wavelengths, an advantage for high density storage. His work on perpendicular anisotropy amorphous alloys was recognized with an IR100 award by Industrial Research and by an IBM Corporate Award. He also received an IBM Outstanding Technical Achievement Award for his work on epitaxial films of high temperature superconductors. Mr. Gambino is a member of the IEEE and the IEEE Magnetics Society, the Materials Research Society, the American Vacuum Society, and Sigma Xi. He was a Guest Editor of a special issue of the Materials Research Society Bulletin devoted to materials for optical storage.

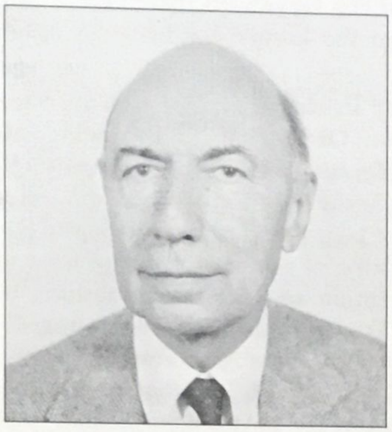
SAKURAI AND SHANNON RECEIVE MAGNETICS SOCIETY AWARDS

Two prestigious Magnetics Society awards were presented at Intermag '92 in St. Louis. The Society Achievement Award was presented to Dr. Y. Sakurai, President of Setsunan University, Osaka, Japan. Additional information on this award and on Dr. Sakurai will be given in the next issue of the Newsletter. The Information Storage Award was given to Dr. Claude E. Shannon, emeritus Professor at Massachusetts Institute of Technology. The April issue of the Magnetics Society Issue described Dr. Shannon's career contributions.

ISEM5-SAPPORO

The fifth International Symposium on Simulation and Design of Applied Electromagnetic Systems will be held in Sapporo, Japan on January 26-30, 1993. These conferences stimulate the exchange of innovative ideas in the simulation and design of applied electromagnetic systems. Topics of interest include: magnetic bearings, microactuators, piezoelectric actuators, linear motors, magnetic bearings, magnetic levitation, electromagnetic propulsion, MHD generators, biological systems, magnetic fluids and superconductivity as well as advanced computer simulation and intelligent computer aided design. The deadline for abstracts is September 30, 1992. Contact H. Igarashi, Secretariat, Department of Electrical Engineering, Hokkaido University, Kita 13, Nishi 8, Kita-ku, Sapporo 060, Japan.

FRITZ FRIEDLAENDER AWARDED HONORARY DOCTORATE



Dr. Fritz J. Friedlaender

Fritz J. Friedlaender, a professor of Electrical Engineering at Purdue University, has been granted an honorary doctorate degree from the Ruhr University in Bochum, Germany. The ceremony honoring Prof. Friedlaender took place Feb. 3, 1992. He is only the second scientist to receive an honorary doctorate in electrical engineering from the Ruhr University in the 27 years since its establishment.

Prof. Friedlaender won the Humboldt Award for scientific accomplishment in 1972, and in connection with this award he was guest professor at the Ruhr University in 1972-73. This marked the beginning of two decades of close ties between Prof. Friedlaender and the Ruhr University. He has also held visiting professorships at the Universities of Stuttgart and Regensburg, and in 1981 he initiated a study-abroad program that brings students from Ruhr University to Purdue University for a year. He was also visiting professor at Nagoya University in 1980 and was Meyerhoff Visiting Professor at the Weizmann Institute of Science in Israel during the first half of 1990. He has collaborated on research with scientists from many countries.

In earning the honorary doctorate, Prof. Friedlaender was cited for his professional and technical achievements and his leadership in international collaboration.

Prof. Friedlaender was born in Freiburg im Breisgau, Germany. He and his family left Germany in the 1930's because of religious persecution. He received the B.S., M.S., and Ph.D. degrees from the Carnegie Institute of Technology (now Carnegie Mellon University) and he was an Assistant Professor at Columbia University in 1954 before coming to Purdue in 1955.

Among Prof. Friedlaender's previous honors are the 1984 Centennial Medal from the IEEE and the 1986 Magnetics Society Achievement Award. He is a Fellow of the IEEE and has held numerous positions in the Magnetics Society. He has attended every INTERMAG and its predecessor conferences since the first one in Syracuse, NY in 1956. He has held numerous positions in the organization of the Intermag conferences, including General US Chairman of INTERMAG '75 in London. He has been a member of the IEEE Magnetics Society since its founding and has held numerous positions therein, including the presidency. He has been a member of ADCOM since its founding. Prof. Friedlaender has been active in magnetism his entire professional career, especially magnetization processes, magnetic separation, and magnetic domain dynamics. He is author or co-author of more than 160 journal and conference articles and he has delivered more than 70 invited lectures. In addition, he is co-holder of two patents for magnetic separation methods.

NOMINATIONS FOR EVENING TUTORIAL AT INTERMAG '93

The IEEE Magnetics Society Education Committee is soliciting nominations for speakers and suggestions for topics for the evening tutorial to be held at the upcoming INTERMAG in Stockholm, Sweden. Please send your ideas by Nov. 30 to:

Prof. Ronald Indeck
Department of Electrical
Engineering
Washington University
St. Louis, MO 63130-4899

Tel: (314) 935-4767
FAX: (314) 935-4842
email: rsi@ee.wustl.edu

LETTER TO THE EDITOR

Dear Editor:

I have obtained permission to publish 100 copies of *Ferromagnetism* by Richard M. Bozorth to be made available to colleagues working in magnetics, and have done so. This is a classic reference, and I believe the best reference on bulk magnetic materials in existence. It has been out of print many years, and second hand copies are very hard to find. The books which I have are high-quality photo copies and are hard bound in durable, sewn covers. Considerable care was taken to mask out defects caused by use, and some existing in the original printing. The book is about 1000 pages, and the copies are somewhat thicker than the original book.

Your readers can have one of these books by sending me a check for $100.00 to this address:

James M. Daughton
5805 Amy Drive
Edina, MN 55436

I will send them a copy by return mail while quantities last. For information call me at (612) 550-0913.

James M. Daughton
Magnetics Society Member

IEEE PUBLICATIONS PRODUCTS COUNCIL MEETING

By Chester L. Smith, Division IV Representative
Thursday 16 July 1992

Attendance: While there were more than a dozen people in and out during the day there were only four with vote. Beside the Chairman, Dr. Smits, Computing [Div V], and Electromagnetics and Radiation, [Div IV], were represented. Vehicular Technology, [Div IX], was represented by Dr. Jan Brown. She was wearing two hats, Div. IX which has a vote, and also Chair of the Book Broker Committee which does not. All in all it was a good meeting and we were a very approving group.

Non-Member Pricing: Most of the day was taken up with the issue of how the IEEE should price its publications to non-members. A study has been completed that demonstrated that the IEEE Technical Publications are priced not only well below similar commercial publications but also below those of other professional or technical organizations. The pricing strategy can be summed up by this: "Prices should maximize income for the IEEE, but still remain below the 'market' ". The IEEE Charter describes the Institute, among other things, as "not for profit," however, it is "not for loss" either. A staff member reported that libraries, our principle non-member customers, do not subscribe on the basis of price, but rather on the basis of their internal staff requirements.

The All Publications Package (AAP) price was raised by some 18% for 1992. This was driven by some substantial increases in published material by several Societies. 1993 price changes will be closer to 12 or 13%. Some information on the anticipated price increases of the "competition" indicate that theirs will be 20 to 30% shading to the high side. As usual IEEE's APP will remain a "bargain" for libraries and other non-member users.

Member prices for IEEE publications are set by the sponsoring Societies within guidelines set by the Technical Activities Board (TAB). Exceptions are reviewed by this Council with a recommendation furnished to TAB.

The Applications Book Series [New Venture]: The plan is for the Councils to invite the appropriate Societies to sponsor a series of "Workshops" on applications of electrotechnology. Applications papers would be solicited from qualified authors. The proceedings would then be edited and issued in book form. The authors and editors are to receive a royalty for this work. An initial set of five books has been suggested. The topics have not been selected nor has the royalty formula been settled.

Motivation for this venture arises in response to the somewhat piratical, but perhaps legal, practice of some commercial publishers. These organizations have been known to send representatives to IEEE Symposia and other meetings to sign up presenters as authors if their material appears to be marketable. Perhaps there is nothing overtly illegal in this so long as they do not directly use the IEEE material, it is certainly annoying and may, indeed, be impacting IEEE revenues. If it can be proven that IEEE is being financially damaged then the lawyers might see it differently.

OOP/POP Pricing: The Open Order Plan (OOP) and the Publications Order Plan (POP) pricing structure will be somewhat different next year. Two major changes in the pipeline are (1) the old formula based on the square root of the number of pages used to reimburse the Societies will be scrapped in favor of one that uses the least squares linear regression formula and (2) the publishing of extra large issues of the Transactions will be discouraged. If a publication is deemed excessive in terms of page count by the Periodicals Council (TAB PC) that issue will be assigned a lower page count for purposes of Society reimbursement.

CD ROMs: The University Microfilms, Inc (UMI) CD ROM is "out." This product is said to contain all Journals, Transactions, Technical Letters and Magazines of both the IEEE and IEE as well as a number of Conference Records of "major" (?) conferences from 1988 on. The price set by UMI is totally out of sight for the individual and many of the non-member libraries as well. The technical material on the CD ROM is copyrighted by the institutes (IEEE & IEE), but the licenses to use UMI's software with it costs $28,000 per CD ROM. APP subscribers get a "break," they can get the license for "only" $21,000! The comment was made that "we need Public Domain Software to get around these 'obscene' licensing fees." UMI has an exclusive marketing agreement with IEEE & IEE good for world-wide sales of the CD ROMs until at least the end of 1995. It will be interesting to see how this problem will be resolved sometime during the next millennium.

TAB Reorganization: The Council system has been in effect for about three years now, so it is time to reorganize. The TAB Councils will be retained with some cosmetic changes in their titles. The Divisional Representatives will be scrapped and a system of *ad hoc* Committee Chairs replacing them. These Committees can be created and dismissed as varying projects or needs come and go. The Chairs would report to the Council Chair and thence to TAB. Council Chairs are *ex officio* voting members of TAB.

Next Meeting: The exact date of the next TAB Products Council is still open, but the leading contenders are Thursday or Friday, 5th or 6th of November. The time would be the usual 10 AM to 4 PM, and the place, the IEEE Service Center in Piscataway.

If anyone wants all of the details they are welcome to copies of the official minutes. All they have to do is call Cindy Jablonowski (908-981-0600) or write to IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08855-1331 and ask.

BOOK REVIEW:

Noise in Digital Magnetic Recording
Anoldussen and Nunnelley, Editors.
World Scientific Publishing Co., March 1992.

Reviewed by Gordon F. Hughes, Seagate Technology

Noise in thin film recording media poses an increasingly difficult obstacle to rigid disc drive areal density improvement, particularly in small format drives where low playback signal levels make noise jitter a dominant cause of data recovery errors.

This timely and welcome book discusses disc media noise, from its underlying physics to practical engineering techniques for noise measurement and analysis. Thin film media forms the main theme, although particulate media is included. The bibliography references are notably thorough and complete.

First, the historical development of thin film media is presented, from electroless cobalt plated discs in the early 1960's to the magnetron disc sputtering technology nearly ubiquitous today. Cobalt alloys in current use are reviewed. Then discussed are media microstructure and its relationships to coercivity, squareness and noise; and micromagnetic noise concepts for guidance in media development. Experimental and theoretical media noise physics are reviewed (presently scattered throughout the magnetic recording literature), leading to the basic film media noise concepts generally accepted today: 1. the noise arises in the bit transitions so that noise power rises linearly with bit density, 2. there can be a supralinear noise increase at high bit density, 3. the noise is statistically nonstationary, requiring careful measurement and interpretation techniques, and 4. the primary phenomenon is transition jitter rather than systematic shifts. Techniques are presented for noise measurements by spectrum analyzer, time interval analyzer, and phase margin analyzer and mathematics are developed for noise analysis and separation into write and read contributions. Experimental methods are reviewed for imaging the media micromagnetic structures that underlie noise (zig-zag transitions, vortices, track edge noise); along with micromagnetic math models for theoretically calculating them.

Although this book has some of the uneven exposition characteristic of multi-author books, I fully recommend it as an important addition to the bookshelves of digital recording workers.

MAGNETICS SOCIETY SCHOLARSHIP PROGRAM

We are pleased to announce the 1994 competition of the Magnetics Society Scholarship Program. This program has been established for the children of Magnetics Society members through the annual nationwide scholarship competition conducted by the National Merit Scholarship Corporation. The National Merit Scholarship Corporation (NMSC) is an idependent, nonprofit organization whose major purposes are: (1) to identify and honor exceptionally talented high school students and to aid as many as possible in obtaining a college education, and (2) to enable business enterprises and other organizations to contribute more readily and effectively to the support of higher education through scholarship grants.

One Magnetics Society Scholarship will be awarded in the Spring of 1994 to a student who will complete high school requirements and who will enter a regionally accredited U.S. college in 1994 to pursue courses of study leading to one of the traditional baccalaureate degrees.

The Magnetics Society winner will be chosen through the facilities of NMSC from among children of Magnetics Society members who meet the competition requirements established by NMSC. The winner will be chosen on the basis of test scores, academic record, leadership, and significant extracurricular accomplishments.

The Magnetics Society Scholarship will be a renewable award covering up to four years of full-time study or until baccalaureate degree requirements are completed, whichever occurs first. The amount of the stipend accompanying the scholarship will be related to the individual winner's financial situation and the costs of attending the college of the winner's choice. The maximum amount that may be awarded to a winner is $4,000.00 per year; the minimum will be $1,000.00 per year.

Descriptive material and entry blanks for the Magnetics Society Scholarship may be obtained by writing to the Magnetics Society Scholarship Program Director listed below. Interested children of members should arrange to take the PSAT exam in October of this year if they are high school juniors.

Completed entry blanks must be returned to the Program Director by January 31, 1993.

Dr. Bernard R. Cooper
Magnetics Society Scholarship Program Director
℅ Department of Physics
West Virginia University
Morgantown, WV 26506

THE APPLIED COMPUTATIONAL ELECTROMAGNETICS SOCIETY

by Reinaldo Perez
Jet Propulsion Laboratory, California Institute of Technology

ABSTRACT

This article describes a relatively new and unique professional society, the Applied Computational Electromagnetics Society (ACES). The primary focus of ACES is on computational techniques, electromagnetics modeling software, and applications. This article describes the ACES annual symposia, publications, code user groups, benchmark problem solution workshops, short courses, software demonstrations, and other activities which serve the professional community.

INTRODUCTION AND BACKGROUND

During the past several years, computer modeling and numerical methods have matured as problem-solving tools in the real-world electromagnetics applications. However, even in the mid 1980's, the information exchange among practitioners and users had not kept pace. As a result many practitioners were forced to "reinvent" the wheel to solve the same computational problem. Consequently, the need arose for an application forum, of sufficient scope to include all modeling techniques and commonly-used codes. There was further consensus that both a regular meeting (with published proceedings) and an additional publication were appropriate. To these ends, ACES was organized in 1986. Now chartered and incorporated as a non-profit organization, ACES is an international, interdisciplinary professional society. The interdisciplinary scope is pivotal to maintaining a cross-pollination among various high-frequency and low-frequency applications.

GENERAL SCOPE OF ACES ACTIVITIES

Although the following list is not exhaustive, ACES activities and symposia or journal papers generally relate to at least one of these areas: 1) validation of codes and techniques (via internal checks and via comparison with experimental, computational data), 2) performance analysis of codes and techniques (involving identification of numerical accuracy or other limitations, solution convergence, numerical and physical modeling error, parameter tradeoffs, ease-of-use, and run times), 3) computational studies of basic physics (using code, algorithm, or computational techniques to provide improved physical insight), 4) new computational techniques or new applications for existing computational techniques or codes, 5) "tricks of the trade" in selecting and applying codes and techniques, 6) new codes, algorithms, code enhancements, and code fixes, 7) hardware issues (analysis of capabilities and limitations in meeting various types of electromagnetics computational requirements with vector and parallel computational techniques being of special interest).

Techniques of interest include frequency-, time-, and spectral domain techniques, integral and differential equation techniques, asymptotic methods, moment methods, finite differences and finite element techniques, model expansions, perturbation methods, transmission line methods, boundary value methods, and hybrid methods.

CODE USER GROUPS

To provide needed links between developers and users of electromagnetics modeling codes and techniques, ACES is forming several code user groups. The following benefits to code developers and to code users are envisioned: 1) distribution of developer communications, including bug reports, 2) collection and evaluation of user feedback (comments, bug report verifications, and work arounds), with subsequent forwarding to the developer, 3) periodic survey of users, to determine the major actual applications of the code, and 4) assistance to inexperienced code users via publications of tutorials, user guidelines, and typical solved problems, and also by increased access to experienced users.

BENCHMARK PROBLEM SOLUTION WORKSHOPS

An essential validation task is the testing of the codes and computational models against benchmark problems which themselves require careful selection. ACES publishes collections of benchmark problems and convenes international workshops at which problems solutions are presented. Whenever possible, ACES sponsors these workshops jointly with other groups. Several of the previous workshops were sponsored jointly with TEAM (Testing Electromagnetics Analysis Methods). A parallel effort is the development of performance standards for codes and computational techniques.

THE ACES NEWSLETTER

Several types of articles or columns appear in the ACES Newsletter, including: 1) modeling information (writeups, guidelines, and tutorials), 2) code information, 3) computer graphics showing EM fields and currents, 4) special features, 5) other articles of interest to ACES members, 6) a cumulative bibliography of measured EM data (to support code validation efforts), 7) correspondence, and 8) news.

THE ACES JOURNAL

The ACES Journal, administered by an international editorial board presently representing 11 nations, is a refereed publication devoted to the exchange of information in the computational electromagnetics, to the advancement of the state-of-art. A unique feature of the ACES Journal is the publication of unsuccessful efforts in applied computational electromagnetics (assuming that a reasonable expectation of success is reflected).

OTHER ACES ACTIVITIES AND SERVICES

ACES maintains a small software library and there are tentative plans for additional activity in artificial intelligence/expert systems and in computational electromagnetics education. A code performance data base is evolving out of the various ACES activities. A primary objective of this data base is to baseline the capabilities and limitations of the various codes for different applications, so as to provide the best user guidelines. The data base provides informal peer-review mechanisms for codes and computational techniques.

For more information, contact Dr. Richard W. Adler, Naval Post-Graduate School, Code EC/AB, Monterey, CA 93943.

MAGNETICS SOCIETY CHAPTERS

Chairman: Dr. H.S. Gill
IBM Corporation
G08/142
5600 Cottle Road
San Jose, CA 95193
Bus: 408/256-2308

1. **Santa Clara Valley**
   Dr. Roger Hoyt
   IBM Research Division
   Almaden Research Center
   Mail Stop: K61/802
   650 Harry Road, San Jose, CA 95120
   Bus: 408/927-2118
   Meeting day and time: 3rd Tuesday, 8:00 P.M.

2. **San Diego**
   Prof. Frank Talke
   CMRR
   R-001, UCSD
   La Jolla, CA 90093
   Bus: 619/534-3646
   Meeting day and time: 3rd Thursday, 7:00 P.M.

3. **Pittsburgh**
   Prof. Mike McHenry
   Carnegie Mellon University
   Schenly Park
   Pittsburgh, PA 15213
   Bus: 412/268-2703
   Meeting day and time: 2nd Thursday, 7:00 P.M.

4. **Twin Cities**
   Pat Ryan
   Seagate Technology
   Bloomington, MN
   Bus: 612/844-7530
   Meeting day and time: No fixed day, 7:30 P.M.

5. **U.K.**
   Prof. David Melville
   Lancashire Polytehnic
   Preston PR1 2TQ
   U.K.
   melville_d@p4.lancsp.ac.uk
   Bus: (44)772-26-2840

6. **Boston**
   John Judge
   John Judge and Associate, Inc.
   11 Magrath Road
   Durham, NH 03824
   Bus: 603/868-1644
   Meeting day and time: No fixed day, 6:00 P.M.

7. **Los Angeles**
   Peter Caloyeras
   4053 Redwood Ave.
   Los Angeles, CA 90066
   Bus: 310/827-2100
   Meeting day and time: 3rd Wednesday, 8:00 P.M.

8. **Philadelphia**
   Prof. Bryen E. Lorenz
   School of Engineering
   Dept. of EE
   Widener Univ., Chester, PA 19013
   Bus: 215/499-4040

9. **Washington, D.C.**
   Prof. M.P. Horvath
   EECS Dept.
   George Washington Univ.
   Washington, DC 20052
   Bus: 202/994-5516

10. **West Lafayette, IN**
    Herbert Pietsch
    7740 N. 100 W.
    West Lafayette, IN 47906

11. **Tokyo**
    Yo Sakai
    4-22-4 Tsuganodai
    Chiba-shi 260 Japan
    Bus: 81-472-521111

12. **Houston**
    Jeffery T. Williams
    Univ. of Houston
    Dept. of Electrical Eng.
    4800 Calhoun Road
    Houston, TX 77004
    Bus: 713-749-2782

13. **Denver**
    Dr. Subrata Dey
    Storage Technology Corp.
    2270 South 88th St.
    Ms 8110
    Louisville, CO 80028
    Bus: 303/673-6494

14. **Milwaukee**
    Roy Vanderheiden
    W204 N8348
    Lannon Road
    Menomonee Falls, WI 53051
    Bus: 414/357-0339

CONFERENCE CALENDAR

SEPTEMBER 2-4, 1992	**International Conference on Magnetic Recording Media (MRM).** Perugia, Italy. ADRIA CONGREX; Piazzale Indipendenza, 3; 47037 Rimini (Italy). Tlx: 550312, TEL: (39)(541) 56404, FAX: (39)(541) 56460.
SEPTEMBER 7-10, 1992	**First International Symposium on Barium Ferrite and Advanced Magnetic Recording.** Kalamata, Greece. Dennis Speliotis, Advanced Development Corporation, 8 Ray Avenue, Burlington, MA 01803. TEL: 617-229-8800, FAX: 617-229-0112.
SEPTEMBER 29-OCTOBER 2, 1992	**The 6th International Conference on Ferrites.** Tokyo, Japan. M. Naoe, Dept. of Physical Electronics, Tokyo Institute of Technology, 2-12-1,0-okayama, Meguro-Ku, Tokyo 152, JAPAN. TEL: 81-3-3726-1111 ext. 2575, FAX: 81-3-3729-1399.
NOVEMBER 2-5, 1992	**ASM Symposium on Hard and Soft Magnetic Materials with Applications.** Chicago, IL. K. S. Narasimhan 609-829-2220 or J. Salsgiver 412-226-6268.
DECEMBER 1-4, 1992	**Conference on Magnetism and Magnetic Materials.** Houston, Texas. Ms. Diane Suiters, Courtesy Associates, 655 15th St. NW, Suite 300, Washington, DC 20005, TEL: 202-639-5088, FAX: 202-347-6109.
DECEMBER 6-9, 1992	**Special Session at GLOBECOM on Signal Processing and Coding for Recording Channels.** Michael W. Marcellin, Department of Electrical and Computer Engineering, The Univ. of Arizona, Tucson, AZ 85721. TEL: 602-621-6190, FAX: 602-621-8076. marcellin@ece.arizona.edu.
JANUARY 26-30, 1993	**ISEM5-International Symposium on Simulation and Design of Applied Electromagnetic Systems.** Sapporo, Japan. H. Igarashi, Secretariat, Department of Electrical Engineering, Hokkaido University, Kita 13, Nishi 8, Kita-ku, Sapporo 060, Japan. Details in this issue.
APRIL 13-16, 1993	**International Magnetics Conference (INTERMAG).** Stockholm, Sweden. INTERMAG '93, % Congrex (USA), Inc., 7315 Wisconsin Avenue, Suite 606W, Bethesda, MD 20814 USA. TEL: 301- 469-3355, FAX: 301-469-3360.
AUGUST 23-28, 1993	**European Magnetic Materials and Applications (EMMA).** Kosice, Czecho-Slovakia. P. Sovak, Dept. of Exp. Physics, Faculty of Sciences, nam.Febr.vitazstva 9, 041 54 Kosice, Czecho-Slovakia. TEL: xx42-95-21128.