Magnetic Recording Materials: Present and Future

Ami Berkowitz, Guest Editor

For more than 40 years, magnetic recording has been the dominant technology for electronic data storage. During this time, the areal storage density on disks has risen to $>10^8$ bits/cm^2. On tapes the corresponding figure is 0.2×10^8 bits/cm^2. Thus each bit uses about a 1.0 μm^2 area. These bits are written and read at data rates that require head-disk relative speeds of tens of meters per second and head-tape relative speeds of several meters per second. All this is accomplished at head-disk spacings of ≈ 0.2 μm and with contact recording for tapes.

It is truly a wonder that the systems work as well as they do. In fact, for many features in magnetic recording systems it isn't certain *why* they work as well as they do. However, the demand for storage capacity is estimated to be increasing at about 40% per year. So it is natural to ask whether magnetic recording can maintain its present dominant position in the foreseeable future. The answer is—"Very likely, yes"—but this prediction is based on the assumption that a number of formidable fascinating problems will be solved in order to increase the areal bit density.

The five articles in this special issue present the state-of-the-art in those key areas of magnetic recording that involve materials science, and they define the problems involved in increasing storage density. James U. Lemke discusses the background and outlook for magnetic recording. Tomasz Jagielinski considers recording heads. The tribological issues of lubrication and overcoats are presented by A.M. Homola, C.M. Mate, and G.B. Street. Particulate media are covered by M.P. Sharrock, while thin film media are described by Jack H. Judy.

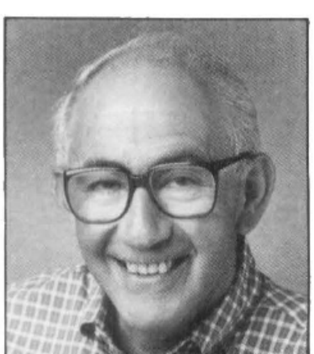
Future magnetic recording systems will utilize materials engineered on the nanometer scale.

In all of these areas, the dimensional unit of interest is rapidly becoming the nanometer. This is due in part, of course, to the shrinking dimensions of the various components of recording systems. Another reason is that the structural and magnetic properties of surfaces and interfaces are increasingly occupying the attention of investigators in magnetic recording. Every one of the present electron, photon, neutron, and tunneling surface characterization techniques are employed.

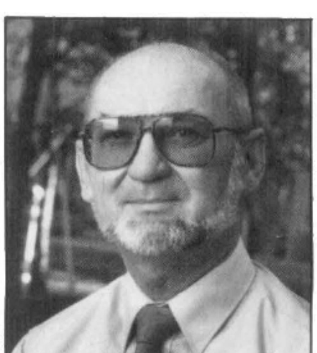
The object is more than understanding and controlling surface behavior. Magnetic recording systems of the future will utilize materials engineering in the true sense of the term—namely, manipulating surface and interfacial features to create magnetic properties that are simply not available in equilibrium systems. Particulate media have long benefited from this approach; the particles in videotapes are surface treated with cobalt to increase coercive force. Sputtered film media already rely on interactions with appropriate underlayers to achieve control of grain size and orientation. The dimensional considerations and interfacial interactions are perhaps most dramatically demonstrated by the thickness of the lubricant that protects disks rotating at tens of meters per second—namely, several nanometers. An indication of future trends is the strong current interest in artificial superlattices as potential head materials. Clearly, we are in an era of difficult but exciting challenges as we begin to explore the magnetic recording potential of "materials engineering" on the nanometer scale.

Acknowledgment

I would like to take this opportunity to acknowledge the contribution of Matthew Libera, Stevens Institute of Technology, for his role in helping to conceptualize this overview series on magnetic materials and in supporting the editorial staff. □



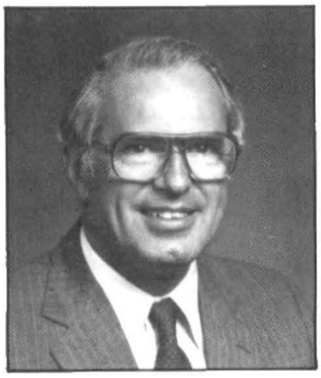
Ami Berkowitz



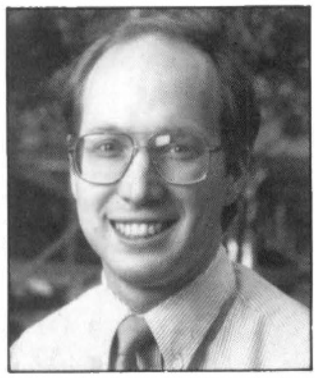
Andrew M. Homola

Tomasz M. Jagielinski

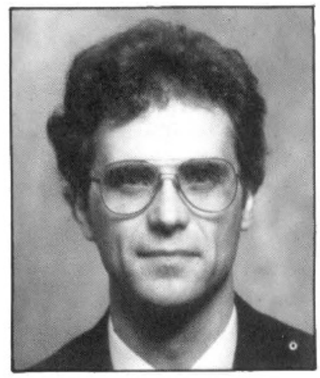
Jack R. Judy



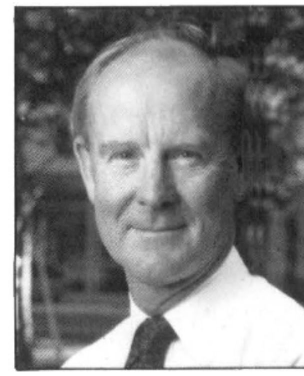
James U. Lemke



C. Mathew Mate



Michael P. Sharrock



G. Bryan Street

Ami Berkowitz, Guest Editor for this issue of the *MRS Bulletin,* is a professor in the Physics Department and the Center for Magnetic Recording Research at the University of California, San Diego. He received his PhD in physics from the University of Pennsylvania and was previously associated with Franklin Institute Research Laboratories, the IBM Research Center at Yorktown Heights, the IBM Components Division in Burlington, Vermont, and the General Electric Research and Development Center. His research has primarily involved crystalline and amorphous magnetic alloys and compounds in bulk, film, and fine particle form. His present activities include investigations of magnetic structure and behavior at surfaces and interfaces, magnetization relaxation in particles and films, and the analysis of ultrafine particles of various systems prepared by the spark erosion technique.

Andrew M. Homola is a research staff member in the Storage Systems and Technology Department at the IBM Almaden Research Laboratory, San Jose, California. He joined IBM in 1978 after receiving a PhD degree in colloid and surface chemistry from McGill University, Montreal, Canada, in 1974. For the academic years 1974-1978, he was a research fellow at the University of Melbourne, Australia. Homola's current research interests include dynamic properties of molecularly thin liquid films and interfacial forces in polymer systems.

Tomasz M. Jagielinski is the manager of the Magnetic Heads Research Laboratory, Mass Memory Division, Eastman Kodak Company, San Diego, California. He received his MS, Dipl. Eng. and PhD (with honors) in solid state electronics from the Warsaw Institute of Technology, Poland. His principal research interests are in magnetic and elastic properties of crystalline and amorphous alloys. Since joining Eastman Kodak Research Laboratories, he has been responsible for the research and development of magnetic materials for thin film heads. He has authored or co-authored over 70 technical papers in the magnetic materials field.

Jack R. Judy is professor of electrical engineering and director of the Center for Micromagnetics and Information Technologies (MINT) at the University of Minnesota in Minneapolis. He received his PhD in electrical engineering in 1965 from the University of Minnesota and subsequently was involved in studies of magneto-optical thin films and magnetic recording at IBM. His research interests include micromagnetics, magneto-optics, and magnetic thin films for magnetic recording heads and media.

James U. Lemke is president of Recording Physics, Inc. and adjunct professor at the University of California, San Diego. A former fellow of Eastman Kodak Research Laboratories, he is co-founder of the Center for Magnetic Recording Research at the University of California, San Diego. He is the author of numerous papers in the field of magnetic recording theory and practice, and also holds many patents in the field. Lemke is a member of the National Academy of Engineering, IEEE Magnetic Society, American Physical Society, AAPT, and STLE.

C. Mathew Mate has worked at IBM's Almaden Research Center, San Jose, California since 1986. He has concentrated on the development of atomic force microscopy for atomic-scale investigations of the tribology of the head-disk interface. He received a BS in engineering (1981) and PhD in physics (1986) from the University of California at Berkeley. His PhD thesis research, supervised by Prof. G.A. Somorjai, involved studying how organic molecules interact with metal surfaces under ultrahigh vacuum conditions.

Michael P. Sharrock is a senior researcher in the Memory Technologies Group of 3M Company, St. Paul, Minnesota. Since 1979 he has worked at 3M in the areas of magnetic materials and magnetic recording. His major current research interests include the time-dependent magnetic behavior of small particles (especially with reference to high-density recording), the magnetic characteristics of barium ferrite, the effects of cobalt ions in iron oxides, and the recording properties of particulate media. He has published numerous papers in these areas and in Mössbauer spectroscopy. He received a PhD in physics from the University of Illinois (Urbana) in 1973 and has held positions as a research fellow at the University of Pennsylvania and as a faculty member in the Physics Department of Gustavus Adolphus College.

G. Bryan Street received his PhD in applied science from Leeds University in 1962 and has worked in the IBM Research Laboratory, San Jose, California since 1964. Currently, he is manager of advanced recording technology at the IBM Almaden Research Center. He has more than 110 publications to his credit and holds six patents.

Articles begin on p. 31.