Science and Technology of Magnetic Oxides

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Science and Technology of Magnetic Oxides

Symposium held December 1–4, 1997, Boston, Massachusetts, U.S.A.

EDITORS:

Michael F. Hundley
Los Alamos National Laboratory
Los Alamos, New Mexico, U.S.A.

Janice H. Nickel
Hewlett-Packard Laboratories
Palo Alto, California, U.S.A.

Ramamoorthy Ramesh
University of Maryland
College Park, Maryland, U.S.A.

Yoshinori Tokura
University of Tokyo
Tokyo, Japan

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PREFACE

This proceedings volume contains papers presented at the "Metallic Magnetic Oxides" symposium (Symposium V) held in Boston, Massachusetts, December 1-4, 1997 as part of the 1997 MRS Fall Meeting. The considerable degree of interest in metallic magnetic oxides was demonstrated by the attendance at the symposium sessions as well as by the 82 papers presented during the four-day symposium.

Research into the science and technology of magnetic oxides has undergone a renaissance during the past seven years. In large measure this stems from the rediscovery of the colossal magnetoresistance associated with the ferromagnetic-order-induced, metal-insulator transition exhibited by the doped lanthanum manganites. These are not "new" materials. Indeed, pioneering work was carried out by Jonker, Van Santen, and Volger at the Dutch Phillips Research Laboratory in the 1950s. Research today is focused both on improving our understanding of the phenomena exhibited by these compounds and on developing technological applications that utilize their extremely magnetic-field-dependent conductivity near room temperature.

With the development of advanced oxide thin-film growth techniques in recent years it has become possible to produce novel materials with exciting electronic and magnetic properties which may be candidates for future device applications. One key class of these materials is the metallic magnetic oxides. This symposium focused on colossal magnetoresistance (CMR) materials, including manganites and cobalites. Transport and magnetic properties and their dependence on stress, growth conditions, stoichiometry, and elemental composition are now being explored quite extensively. These new and exciting results are driving an effort to explain the underlying physical mechanisms responsible for the remarkable electrical properties exhibited by these compounds. The large magnetic field required to obtain the CMR effect has been perceived as a technological roadblock for commercialization of this phenomenon. This has motivated research aimed both at reducing the intrinsic field dependence as well as at developing novel device structures that will reduce the magnetic field required to realize the CMR effect. Technologically useful devices utilizing these compounds will undoubtedly involve multilayer, spin-valve or tunneling-junction heterostructures. Extremely impressive low field effects have indeed been observed recently at low temperatures in CMR heterostructure devices. Due to the strong interplay between spin, charge, and lattice degrees of freedom in these compounds, the magnetic and transport properties of CMR systems are extremely stress dependent. As such, CMR heterostructures will most likely involve other metallic or insulating oxide materials. Hence, CMR device research must involve other metallic magnetic oxide systems as well. Other compounds of interest include half-metallic ferromagnets, yttrium garnet materials, ferrites, spinels, and vanadates. In addition to their consideration for magnetic recording applications, these systems are also under consideration for more generic magnetic sensing uses, microwave, bolometric, and other high-frequency applications.

The research on metallic magnetic oxides presented in this proceeding volume is composed of both device-related technology work and basic research studies focusing on the novel phenomena exhibited by these systems. Device-related research is presented that examines the fabrication and properties of CMR-based spin valves, tunnel junctions, and bolometers grown via MBE, pulsed-laser deposition, and sputtering techniques. Hybrid CMR/high-T_c devices are also discussed. These devices are characterized via magnetization, magnetotransport, and microstructural microscopy measurements. Extensive research is also presented that examines the underlying properties from which the CMR effect originates. Progress in elucidating the influence of strain on the magnetic and electronic properties of CMR compounds is reported from both experimental and theoretical viewpoints. Advances in our understanding of local structure effects are presented which clarify the nature of the charge transport process in CMR manganites below T_c. Optical and Raman spectroscopies, spin-dynamic measurements, results from isotope-effect experiments, magnetostriction, and thermal expansion measurements are also presented that extend our understanding of the way in which the spin, charge, and lattice act in unison to produce the novel properties that CMR materials exhibit.

The contents of this proceedings volume represent the latest research concerning the science and technology of magnetic oxides performed at academic, government, and industrial laboratories world wide.

Michael F. Hundley
Janice H. Nickel
Ramamoorthy Ramesh
Yoshinori Tokura

January 1998

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C.H. Booth	A.J. Millis
Alexander Bratkovsky	J.J. Neumeier
S-W. Cheong	M. Rajeswari
L.F. Cohen	Yuri Suzuki
David Emin	Hitoshi Tabata
J.B. Goodenough	T. Venkatesan
Tsuyoshi Kimura	X-D. Xiang
V. Kiryukhin	Gang Xiao

We also thank the session chairs for their assistance in orchestrating the sessions and the associated discussions. We extend our appreciation to all of the participants who took the time to prepare a manuscript for this proceeding volume. We are also grateful to those who promptly and thoroughly reviewed the proceedings manuscripts.

The symposium organizers wish to thank the following organizations for their generous financial support, which enabled us to present the "Metallic Magnetic Oxides" symposium:

Hewlett-Packard Corporation
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