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978-1-107-41349-8 - Materials Research Society Symposium Proceedings: Volume 494:  
Science and Technology of Magnetic Oxides

Editors: Michael F. Hundley, Janice H. Nickel, Ramamoorthy Ramesh and Yoshinori Tokura  
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**MATERIALS RESEARCH SOCIETY  
SYMPOSIUM PROCEEDINGS VOLUME 494**

# Science and Technology of Magnetic Oxides

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

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**Materials Research Society**  
Warrendale, Pennsylvania

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Cambridge, New York, Melbourne, Madrid, Cape Town,  
Singapore, São Paulo, Delhi, Mexico City

Cambridge University Press

32 Avenue of the Americas, New York NY 10013-2473, USA

Published in the United States of America by Cambridge University Press, New York

[www.cambridge.org](http://www.cambridge.org)

Information on this title: [www.cambridge.org/9781107413498](http://www.cambridge.org/9781107413498)

Materials Research Society

506 Keystone Drive, Warrendale, PA 15086

<http://www.mrs.org>

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First published 1998

First paperback edition 2013

Single article reprints from this publication are available through  
University Microfilms Inc., 300 North Zeeb Road, Ann Arbor, MI 48106

CODEN: MRSPDH

ISBN 978-1-107-41349-8 Paperback

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Frontmatter[More information](#)

## CONTENTS

Preface .....	xi
Acknowledgment .....	xiii
Materials Research Society Symposium Proceedings .....	xiv

**PART I: MATERIALS PROCESSING OF METALLIC MAGNETIC OXIDES**

<b>Dry and Wet Etch Processes for NiMnSb, LaCaMnO<sub>3</sub>, and Related Materials</b> .....	<b>3</b>
<i>J. Hong, J.J. Wang, E.S. Lambers, J.A. Caballero, J.R. Childress, S.J. Pearton, K.H. Dahmen, S. von Molnar, F.J. Cadieu, and F. Sharifi</i>	
<b>Epitaxial Growth Mechanism and Physical Properties of Ultrathin Films of La<sub>0.6</sub>Sr<sub>0.4</sub>MnO<sub>3</sub></b> .....	<b>9</b>
<i>Yoshinori Konishi, Masahiro Kasai, Masashi Kawasaki, and Yoshinori Tokura</i>	
<b>Thin-Film Growth and Magnetotransport Study of (La,Sr)MnO<sub>3</sub></b> .....	<b>15</b>
<i>Takashi Manako, Takeshi Obata, Yuichi Shimakawa, and Yoshimi Kubo</i>	
<b>Crystallinity and Magnetoresistance in Calcium-Doped Lanthanum Manganites</b> .....	<b>21</b>
<i>E.S. Gillman and K.H. Dahmen</i>	
<b>Microstructural Aspects of Nanocrystalline LiZn Ferrites Densified With Chemically-Derived Additives</b> .....	<b>27</b>
<i>Yong S. Cho, Vernon L. Burdick, Vasantha R.W. Amarakoon, Elijah Underhill, and Leo Brissette</i>	

**PART II: CHARACTERIZATION OF METALLIC MAGNETIC OXIDES**

<b>Lattice Deformation and Magnetic Properties in Epitaxial Thin Films of Sr<sub>1-x</sub>Ba<sub>x</sub>RuO<sub>3</sub></b> .....	<b>35</b>
<i>Noburu Fukushima, Kenya Sano, Tatsuo Shimizu, Kazuhide Abe, and Shuichi Komatsu</i>	
<b>*Magnetic Anisotropy and Lattice Distortions in the Doped Perovskite Manganites</b> .....	<b>41</b>
<i>Y. Suzuki, H.Y. Hwang, S-W. Cheong, R.B. van Dover, A. Asamitsu, and Y. Tokura</i>	
<b>Evidence for a Jahn-Teller Distortion in the CMR Layered Manganite La<sub>1.4</sub>Sr<sub>1.6</sub>Mn<sub>2</sub>O<sub>7</sub></b> .....	<b>53</b>
<i>Despina Louca, G.H. Kwei, and J.F. Mitchell</i>	

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Frontmatter

[More information](#)

<b>Mn K-Edge X-ray-Absorption-Spectroscopy (XAS) Studies of <math>\text{La}_{1-x}\text{Sr}_x\text{MnO}_3</math></b> .....	<b>59</b>
<i>S.M. Mini, J.F. Mitchell, D.G. Hinks, Ahmet Alatas, D. Rosenmann, C.W. Kimball, and P.A. Montano</i>	
<b>*X-ray-Induced Insulator-Metal Transitions in CMR Manganites</b> .....	<b>65</b>
<i>V. Kiryukhin, D. Casa, B. Keimer, J.P. Hill, A. Vigliante, Y. Tomioka, and Y. Tokura</i>	
<b>Resonant X-ray Fluorescence Spectroscopy at the V L-Edges of Vanadium Oxides</b> .....	<b>77</b>
<i>L.C. Duda, C.B. Stagarescu, J.E. Downes, K.E. Smith, and G. Dräger</i>	
<b>Phase Diagram and Anisotropic Transport Properties of <math>\text{Nd}_{1-x}\text{Sr}_x\text{MnO}_3</math> Crystals</b> .....	<b>83</b>
<i>H. Kuwahara, T. Okuda, Y. Tomioka, T. Kimura, A. Asamitsu, and Y. Tokura</i>	
<b>Stoichiometry and Magnetic Properties of Iron Oxide Films</b> .....	<b>89</b>
<i>D.V. Dimitrov, G.C. Hadjipanayis, V. Papaefthymiou, and A. Simopoulos</i>	
<b>Paramagnetic Susceptibility of the CMR Compound <math>\text{La}_{1-x}\text{Ca}_x\text{MnO}_3</math></b> .....	<b>95</b>
<i>D.H. Goodwin, J.J. Neumeier, A.H. Lacerda, and M.S. Torikachvili</i>	
<b>Effect of Domain Structure on the Magnetoresistance of Epitaxial Thin Films of Ferromagnetic Metallic Oxide <math>\text{SrRuO}_3</math></b> .....	<b>101</b>
<i>R.A. Rao, D.B. Kacedon, and C.B. Eom</i>	
<b>The Local Atomic Structure of <math>\text{La}_{1-x}\text{Sr}_x\text{CoO}_3</math>: Effects Induced by the Spin-State and Nonmetal to Metal Transitions</b> .....	<b>107</b>
<i>Despina Louca, J.L. Sarrao, and G.H. Kwei</i>	
<b>Analysis of Cation Valences and Oxygen Vacancies in Magnetoresistive Oxides by Electron Energy-Loss Spectroscopy</b> .....	<b>113</b>
<i>Z.L. Wang, J.S. Yin, Y. Berta, and J. Zhang</i>	
<b>Negative Magnetoresistance in <math>(\text{Bi,Pb})_2\text{Sr}_3\text{Co}_2\text{O}_9</math> Layered Cobalt Oxides</b> .....	<b>119</b>
<i>I. Tsukada, T. Yamamoto, M. Takagi, T. Tsubone, and K. Uchinokura</i>	
<b>Surface Morphology and Lattice Misfit in YIG and <math>\text{La:YIG}</math> Films Grown by LPE Method on GGG Substrate</b> .....	<b>125</b>
<i>Duk-Yong Choi and Su-jin Chung</i>	

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Frontmatter

[More information](#)

**Magnetotransport in Thin Films of  $\text{La}_{n-nx}\text{Ca}_{1+nx}\text{Mn}_n\text{O}_{3n+1}$   
( $n = 2, 3, \text{ and } \infty$ )** ..... 131  
*H. Asano, J. Hayakawa, and M. Matsui*

**Micromorphology, Microstructure and Magnetic Properties  
of Sputtered Garnet Multilayers** ..... 137  
*R. Marcelli, G. Padeletti, N. Gambacorti, M.G. Simeone,  
and D. Fiorani*

**Improvement of Thermal Stability of Metal/Oxide  
Interface for Electronic Devices** ..... 143  
*Yo Ichikawa, Masayoshi Hiramoto, Nozomu Matsukawa, Kenji Iijima,  
and Masatoshi Kitagawa*

**Room-Temperature Magnetoresistive Response in CMR  
Perovskite Manganite Thin Films** ..... 149  
*Michael A. Todd, Charles Seegel, and Thomas H. Baum*

### **PART III: METALLIC MAGNETIC OXIDE THEORY AND DEVICES**

**The Magnetic Susceptibility in Ultrathin Films of Magnetic  
Materials** ..... 157  
*Kamakhya P. Ghatak, P.K. Bose, and Gautam Majumder*

**\*Polaron Formation and Motion in Magnetic Solids** ..... 163  
*David Emin*

**Calculated Transport and Magnetic Properties of Some  
Perovskite Metallic Oxides  $\text{AMO}_3$**  ..... 175  
*G. Santi and T. Jarlborg*

**Experimental Determination of the Key Energy Scales  
in the Colossal Magnetoresistive Manganites** ..... 181  
*D.S. Dessau, T. Saitoh, C-H. Park, Z-X. Shen, Y. Moritomo, and  
Y. Tokura*

**\*Spin Tunneling in Conducting Oxides** ..... 187  
*Alexander Bratkovsky*

**\*Formation of Ferromagnetic/Ferroelectric Superlattices  
by a Laser MBE and Their Electric and Magnetic Properties** ..... 201  
*Hitoshi Tabata, Kenji Ueda, and Tomoji Kawai*

**Low-Energy  $k$ -Dependent Electronic Structure of the  
Layered Magnetoresistive Oxide  $\text{La}_{1.2}\text{Sr}_{1.8}\text{Mn}_2\text{O}_7$**  ..... 213  
*T. Saitoh, D.S. Dessau, C-H. Park, Z-X. Shen, P. Villeda,  
N. Hamada, Y. Moritomo, and Y. Tokura*

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Frontmatter[More information](#)**PART IV: METALLIC MAGNETIC OXIDE DEVICES AND MULTILAYERS**

<b>*Sub-200 Oe Giant Magnetoresistance in Manganite Tunnel Junctions</b> .....	221
<i>Gang Xiao, A. Gupta, X.W. Li, G.Q. Gong, and J.Z. Sun</i>	
<b>Low-Field Colossal Magnetoresistance in Manganite Tunnel Junctions</b> .....	231
<i>J. Nassar, M. Viret, M. Drouet, J.P. Contour, C. Fermon, and A. Fert</i>	
<b>Observation of Large Low-Field Magnetoresistance in Ramp-Edge Tunneling Junctions Based on Doped Manganite Ferromagnetic Electrodes and a SrTiO<sub>3</sub> Insulator</b> .....	237
<i>C. Kwon, Q.X. Jia, Y. Fan, M.F. Hundley, D.W. Reagor, M.E. Hawley, and D.E. Peterson</i>	
<b>Fabrication of La<sub>0.7</sub>Sr<sub>0.3</sub>MnO<sub>3</sub>/La<sub>0.5</sub>Sr<sub>0.5</sub>CoO<sub>3</sub>/La<sub>0.7</sub>Sr<sub>0.3</sub>MnO<sub>3</sub> Heterostructures for Spin-Valve Applications</b> .....	243
<i>M.C. Robson, S.B. Ogale, R. Godfrey, T. Venkatesan, M. Johnson, and R. Ramesh</i>	
<b>Fabrication of High-Temperature Superconductor-Colossal Magnetoresistor Spin Injection Devices</b> .....	249
<i>J. Kim, R.M. Stroud, R.C.Y. Auyeung, C.R. Eddy, D. Koller, M.S. Osofsky, R.J. Soulen, Jr., J.S. Horwitz, and D.B. Chrisey</i>	

**PART V: PHYSICAL PROPERTIES OF METALLIC MAGNETIC OXIDES**

<b>In-Plane Grain Boundary Effects on the Transport Properties of La<sub>0.7</sub>Sr<sub>0.3</sub>MnO<sub>3-δ</sub> Thin Films</b> .....	257
<i>J.Y. Gu, S.B. Ogale, K. Ghosh, T. Venkatesan, R. Ramesh, V. Radmilovic, U. Dahmen, G. Thomas, and T.W. Noh</i>	
<b>Observation of Growth-Related Magnetic Structures in La<sub>0.67</sub>Sr<sub>0.33</sub>MnO<sub>3</sub></b> .....	263
<i>M.E. Hawley, G.W. Brown, and C. Kwon</i>	
<b>The Effect of Elastic Strain on the Electrical and Magnetic Properties of Epitaxial Ferromagnetic SrRuO<sub>3</sub> Thin Films</b> .....	269
<i>Q. Gan, R.A. Rao, J.L. Garrett, Mark Lee, and C.B. Eom</i>	
<b>*Effects of Localized Holes on Charge Transport, Local Structure, and Spin Dynamics in the Metallic State of CMR La<sub>1-x</sub>Ca<sub>x</sub>MnO<sub>3</sub></b> .....	275
<i>R.H. Heffner, M.F. Hundley, and C.H. Booth</i>	
<b>The Effect of Radiation-Induced Disorder on La<sub>0.7</sub>Ca<sub>0.3</sub>MnO<sub>3-δ</sub></b> .....	287
<i>R.M. Stroud, V.M. Browning, J.M. Byers, D.B. Chrisey, W.W. Fuller-Mora, K.S. Grabowski, J.S. Horwitz, J. Kim, D.L. Knies, and M.S. Osofsky</i>	

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Frontmatter

[More information](#)

<b>*Volume-Based Considerations for the Metal-Insulator Transition of CMR Oxides</b> .....	293
<i>J.J. Neumeier, A.L. Cornelius, M.F. Hundley, K. Andres, and K.J. McClellan</i>	
<b>Raman Investigation of the Layered Manganese Perovskite <math>\text{La}_{1.2}\text{Sr}_{1.8}\text{Mn}_2\text{O}_7</math></b> .....	305
<i>D.B. Romero, V.B. Podobedov, A. Weber, J.P. Rice, J.F. Mitchell, R.P. Sharma, and H.D. Drew</i>	
<b>High-Frequency Magneto-electrodynamics of <math>\text{La}_{1-x}\text{Sr}_x\text{MnO}_3</math> Single Crystals</b> .....	311
<i>H. Srikanth, B. Revcolevschi, S. Sridhar, L. Pinsard, and A. Revcolevschi</i>	
<b>Magnetic and Electronic Transport Properties of Single-Crystal <math>\text{La}_{0.64}\text{Pb}_{0.36}\text{MnO}_3</math></b> .....	317
<i>Jihui Yang, Siqing Hu, Citrad Uher, P.D. Han, and D.A. Payne</i>	
<b>Effects of Chromium Ion Implantation on the Magneto-transport Properties of <math>\text{La}_{0.7}\text{Ca}_{0.3}\text{MnO}_3</math> Thin Films</b> .....	323
<i>P.S.I.P.N. de Silva, N. Maide, A.K.M.A. Hossain, L.F. Cohen, K.A. Thomas, R. Chater, J.D. MacManus-Driscoll, T.J. Tate, N.D. Mathur, M.G. Blamire, and J.E. Evetts</i>	
<b>Evaluation of Raman Scattering in <math>\text{La}_{1-x}\text{M}_x\text{MnO}_3</math> Single Crystals Due to Structural and Magnetic Transitions</b> .....	329
<i>V.B. Podobedov, A. Weber, D.B. Romero, J.P. Rice, and H.D. Drew</i>	
<b>*Pressure and Isotope Effects in the Manganese Oxide Perovskites</b> .....	335
<i>J.B. Goodenough and J-S. Zhou</i>	
<b>*Magnetotransport Properties in Layered Manganite Crystals</b> .....	347
<i>T. Kimura, Y. Tomioka, T. Okuda, H. Kuwahara, A. Asamitsu, and Y. Tokura</i>	
<b>Author Index</b> .....	357
<b>Subject Index</b> .....	359

\*Invited Paper

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Frontmatter[More information](#)

## 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.

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Frontmatter

[More information](#)

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

Cambridge University Press

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## ACKNOWLEDGMENTS

The organizers wish to thank all those who participated in the 1997 MRS symposium "Metallic Magnetic Oxides". We would especially like to thank the invited speakers for their presentations; each added significantly to the symposium, and, as a whole, the invited talks formed the foundation for a very successful symposium. The invited speakers include:

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  
Joint Research Center for Atom Technology  
Lake Shore Cryotronics, Inc.  
Los Alamos National Laboratory

Our thanks go to the Materials Research Society, its staff, and the 1997 MRS Fall Meeting chairs, for a highly successful meeting. We also gratefully acknowledge the assistance of Pamela Rockage at Los Alamos, as well as the MRS publications staff, in assembling these proceedings.

Cambridge University Press

978-1-107-41349-8 - Materials Research Society Symposium Proceedings: Volume 494:  
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