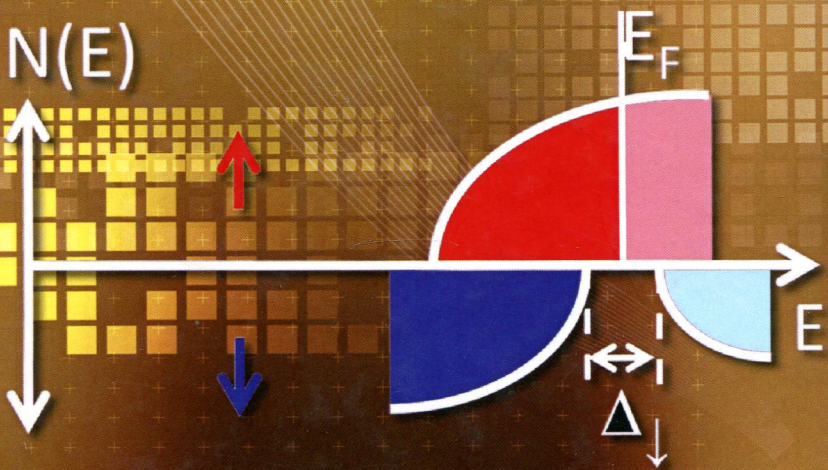


# Half-metallic Materials *and* Their Properties

C. Y. Fong  
J. E. Pask  
L. H. Yang

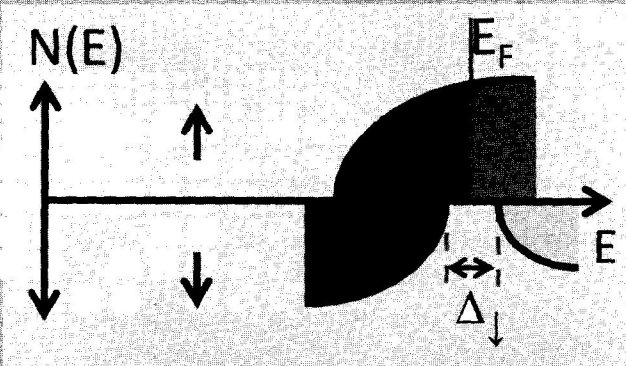


# Half-metallic Materials *and* Their Properties

C. Y. Fong (University of California, Davis, USA)

J. E. Pask (Lawrence Livermore National Laboratory, USA)

L. H. Yang (Lawrence Livermore National Laboratory, USA)



*Published by*

Imperial College Press  
57 Shelton Street  
Covent Garden  
London WC2H 9HE

*Distributed by*

World Scientific Publishing Co. Pte. Ltd.  
5 Toh Tuck Link, Singapore 596224  
*USA office:* 27 Warren Street, Suite 401-402, Hackensack, NJ 07601  
*UK office:* 57 Shelton Street, Covent Garden, London WC2H 9HE

**British Library Cataloguing-in-Publication Data**

A catalogue record for this book is available from the British Library.

**Materials for Engineering — Vol. 2**

**HALF-METALLIC MATERIALS AND THEIR PROPERTIES**

Copyright © 2013 by Imperial College Press

*All rights reserved. This book, or parts thereof, may not be reproduced in any form or by any means, electronic or mechanical, including photocopying, recording or any information storage and retrieval system now known or to be invented, without written permission from the Publisher.*

For photocopying of material in this volume, please pay a copying fee through the Copyright Clearance Center, Inc., 222 Rosewood Drive, Danvers, MA 01923, USA. In this case permission to photocopy is not required from the publisher.

ISBN 978-1-908977-12-0

Typeset by Stallion Press  
Email: [enquiries@stallionpress.com](mailto:enquiries@stallionpress.com)

Printed in Singapore by World Scientific Printers

# Contents

Preface	vii
Acknowledgments	ix
1. Introduction	1
1.1 Background	1
1.2 Classes of Half-metals	4
1.3 Half-metallic Devices	12
2. Methods of Studying Half-metals	15
2.1 Introduction	15
2.2 Molecular Beam Epitaxy (MBE)	16
2.3 Characterization of Samples	19
2.4 Methods of Determining Physical Properties	27
2.5 Theoretical Methods	56
3. Heusler Alloys	77
3.1 Introduction	77
3.2 Half-Heusler and Full-Heusler Alloys	78
3.3 Methods of Growing Heusler Alloys	79
3.4 Characterization of Heusler Alloys	87
3.5 Physical Properties of Bulk Heusler Alloys	89
3.6 Physical Properties of Heusler Alloys in Thin-film Form	107
4. Half-Metallic Oxides	141
4.1 Introduction	141
4.2 $\text{CrO}_2$	141
4.3 $\text{Fe}_3\text{O}_4$	159
4.4 $\text{La}_{1-x}(\text{Sr}, \text{Ca}, \text{Ba})_x\text{MnO}_3$	187
4.5 Magnetic Interactions in the Oxides	196

5. Half-metals with Simple Structures	205
5.1 Introduction . . . . .	205
5.2 Half-metals with Zincblende Structure . . . . .	206
5.3 Half-metallic Superlattices . . . . .	229
5.4 Quantum Dots . . . . .	235
5.5 Digital Ferromagnetic Heterostructures . . . . .	241
5.6 One-dimensional Half-metals . . . . .	257
Appendix A Anisotropic Magnetoresistance	263
Bibliography	265
Index	289