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# The Physics of Multifunctional Materials

*Concepts, Materials, Applications*

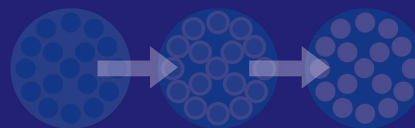
**Martin Gurka, Dr. rer. nat.**

*Institute for Composite Materials, Kaiserslautern, Germany*

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The  
**PHYSICS of  
MULTIFUNCTIONAL  
MATERIALS**

*Concepts, Materials, Applications*



**Martin Gurka**

- Applies foundational physics and materials science concepts to piezoceramics, shape memory alloys, and switchable fluids
- Uses basic scientific measurements to address manufacturing, processing, and modeling
- Includes information on multifunctional materials' applications for actuators and sensors

This book uses basic mechanical, thermodynamic, material science, and electrical concepts from well-known physics to explain the properties and performance of multifunctional materials. With familiar theory and a focus on phase transitions, the text offers a simple, elegant introduction to the design and operation of devices that incorporate piezoceramics, shape memory alloys, electrorheological and magnetorheological fluids. The physics equations and graphical data in this volume form a novel approach to characterizing and assessing smart materials.

#### From the Preface

"The scope of this book is to explain the physics and materials science underlying multifunctional materials and composites made thereof. The text identifies and elaborates the fundamental principles of ferroelectricity, elastic phase transformation, and energy transfer mechanisms that form the common basis for understanding the functionality, application potential, and limitations of a smart materials system. "While these principles are independent of specific kinds of materials or particular applications, they are explained in the context of a representative material and application. That is, the principles apply to whole groups of materials and can be used to differentiate between them. The present book endeavors to cover the basic physics pertaining to multifunctional materials: from mechanics, electrodynamics, thermodynamics, and condensed matter physics, either as a short summary or as applied to selected examples from the large group of multifunctional materials. Familiar physics principles are thus used as a guide to the nature and design of these materials.

"The book concentrates on three different types of multifunctional materials: piezoceramics, shape-memory alloys, and switchable fluids (electrorheological and magnetorheological fluids). These materials are the best-known commercially available multifunctional materials with the most applications. More interesting in the context of this book is the fact that although the aforementioned examples are all made from very different materials, namely, ceramics, metals, and fluids, respectively, their multifunctionality is based on the same underlying principle—a structural phase transition induced by an external field, either an electrical, magnetic, or thermal field. This is one reason why multifunctional polymeric materials are not discussed. In most cases, polymer multifunctionality relies on mechanisms besides phase transition."

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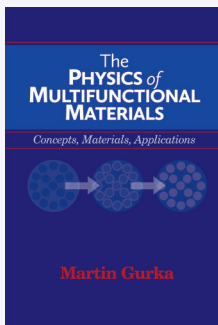
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## Table of Contents



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### Preface

#### 1. Introduction

#### 2. Multifunctional Materials or Smart Materials Versus Normal Materials

- General Definition of Multifunctional Materials from a Physical Aspect • Passive Multifunctional Materials • Active Multifunctional Materials • Smart and Very Smart Materials • Multifunctional Materials in Complex Systems or Applications • Economic Aspects of Multifunctional Materials

#### 3. Basic Physics and Materials Science

- Basic Mechanics • Force • Work • Energy • Power • Elasticity, Stiffness and Strength • Plastic Deformation • Oscillations • The Influence of Damping • Different Forms of Energy • Forced Oscillations • Impedance Matching and Work Performed by an Oscillating Object • Diffusion and Heat Transfer • Steady State Heat Conduction • Transient Temperature Gradient • Thermal Relaxation Time • Diffusion • Phase Transitions

#### 4. Classification of Multifunctional Materials

- Performance Index of a Multifunctional Material • Single Stroke Performance • Performance at Cyclic Operation • Performance Data of Various Materials

#### 5. Ferroelectrics—Piezoelectric Materials

- Perovskite Structure and Spontaneous Polarization • Ferroelectric Hysteresis • Piezoelectric Tensor • Dielectric Permittivity, Elastic Constant • Sensor- and Actuator-Equation • Electrostriction • Dynamic Behavior of Piezoelectric Elements • Coupling Factors and Efficiency • Frequency Coefficient • Pyroelectric Behavior • Compensation of the Temperature Dependency • Nonlinear Behavior of Ferroelectric Materials • Piezoelectric Materials • Piezoelectric Crystals • Piezoelectric Ceramics • Piezoelectric Polymers • Piezoelectric Composite Materials

#### 6. Shape Memory Alloys

- Structural Thermo-elastic Phase Transition in Shape Memory Alloys • Dependency Between Microstructure and

- Elastic Behavior of SMA • Discontinuous Change of Physical Properties—Martensitic Phase Transition • Shape Memory Alloys and Entropy • Different Approaches to Describe the Shape-Memory Effect • Phenomenological Description of the Shape-Memory Effects • Kinematic Description of a SMA Device • Physically Based Motivated Microscopic Material Model for SMA • Quantitative Models for Shape Memory Alloys • Thermal Properties of SMA Actuators • Materials and Important Properties

#### 7. Magnetorheological and Electrorheological Fluids

- Viscoelastic Properties and Basic Rheology • Newtonian Fluids and Viscosity • Viscoelasticity • Thixotropic and Rheopectic Fluids • Some Rheological Models • Flow-curve Model According to Bingham • Flow-curve Model According to Herschel/Bulkley • Flow-curve Model According to Casson • Understanding the Microscopic Structure of ERF and MRF • ER- and MR-effect Explained by the Interaction of Induced Dipoles • Ferromagnetic Polarization • Dielectric Polarization • Applications—Switchable Fluid Acting as a Valve • Shear-mode Operation of a Switchable Fluid • Flow-mode Operation of a Switchable Fluid • Minimum Required Fluid Volume for a Given Application • Dynamic Response • Geometric Considerations • Energy Density in a Switchable Fluid • Response Time • Sedimentation and Re-dispersing • Selected Properties of Switchable Fluids

#### 8. Applications—Multifunctional Materials as Actuators and Sensors

- General Considerations • SMA Wire-actuators for Active Hybrid Composites • Combination of SMA and Fiber-reinforced Polymers • Load Transfer Between SMA and Composite Materials • Qualitative Description of an SMA Bimorph • Example of a First Application: Active Vortex Generators for an Airplane • Piezo Electric Elements (PXE) as Actuators and Sensors • Quasistatic versus Resonant Operation of a PX Element • Axial and Transversal Piezo Actuators—Quasistatic Actuation • Axial and Transversal Transducers as Sensors for Quasistatic Operation • Transversal Transducers Used as Bending Elements • Operation in Resonance Mode—Acoustic Transducers

References • Index

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