Design Of Microfabricated Inductors Power Electronics

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Applications to Storage and Microelectromechanical Systems (MEMS)
Micro-fabricated Racetrack Inductors with Thin-film Magnetic Cores for On-chip Power Conversion
Design and Implementation of Fully-Integrated Inductive DC-DC Converters in Standard CMOS
Design, Test, and Microfabrication of MEMS and MOEMS
2000 IEEE 31ú Comhdháil Bhliantúil Na Saineolaithe Ar Leictreonaic Chumhachta : Imeachtaí Na Comhdhála
A Structured Design Approach
Advanced Magnetic Materials
(Microelectromechanical Systems) Toroidal Magnetics for Integrated Power Electronics
Low-Power CMOS Design
Proceedings
Micromachining and Microfabrication Process Technology
Fundamentals of Microfabrication
Analysis, Design, and Measurement
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Proceedings 1999 International Symposium on Microelectronics
Proceedings of the Fourth International Symposium on Magnetic Materials, Processes, and Devices
Power Electronics Handbook
Proceedings of the International Symposium

LOWERY ZAYNE

IWIPP The Electrochemical Society
The accelerating trend to miniaturize electronic systems and devices is placing large demands on the components responsible for delivering electrical power to these systems. Most power conversion circuits require magnetic components (inductors and transformers) in order to operate at high efficiencies; these components, however, have not yet been widely miniaturized and integrated with electronic components that are fabricated in a CMOS process and are most often realized as discrete off-chip components. Improved on-chip inductors are therefore required to realize a monolithic Power Supply On-Chip (PwrSoC) for electronic systems where size and efficiency are of critical importance. This thesis presents design, modeling, optimization, and micro-fabrication techniques for building chip-scale racetrack power inductors with thin-film magnetic cores. Our inductors are designed for high-power-density and high efficiency dc-dc converters which transfer 25 W of power at frequencies between 5 and 30 MHz. The dc-dc converter is designed to serve as a high-input-voltage solid-state lighting driver. Magnetic components on silicon substrates with sputtered Co-Zr-O magnetic cores are optimized using a series of models that characterize each inductor loss mechanism. The optimized designs were fabricated and tested at small-signal levels and in the high-frequency power converter. The converter achieves an 89% conversion efficiency at 5 MHz with an inductor power density of 1 W/mm2 of substrate area. Small-signal

measurements of the inductors are compared with modeled predictions to validate the design optimization approach. Fabricated components achieve inductance values of 1.2 [mu]H and peak quality factors of 15.1 at 8.3 MHz.

Applications to Storage and Microelectromechanical Systems (MEMS) John Wiley & Sons

Power Management Integrated Circuits and Technologies delivers a modern treatise on mixed-signal integrated circuit design for power management. Comprised of chapters authored by leading researchers from industry and academia, this definitive text: Describes circuit- and architectural-level innovations that meet advanced power and speed capabilities Explores hybrid inductive-capacitive converters for wide-range dynamic voltage scaling Presents innovative control techniques for single inductor dual output (SIDO) and single inductor multiple output (SIMO) converters Discusses cutting-edge design techniques including switching converters for analog/RF loads Compares the use of GaAs pHEMTs to CMOS devices for efficient high-frequency switching converters Thus, Power Management Integrated Circuits and Technologies provides comprehensive, state-of-the-art coverage of this exciting and emerging field of engineering.

Micro-fabricated Racetrack Inductors with Thin-film Magnetic Cores for On-chip Power Conversion John Wiley & Sons

This book reports on recent progress in emerging technologies, modern characterization methods, theory and applications of advanced magnetic materials. It covers broad spectrum of topics: technology and characterization of rapidly quenched nanowires for information technology; fabrication and properties of hexagonal ferrite films for microwave communication; surface reconstruction of magnetite for spintronics; synthesis of multiferroic composites for novel biomedical applications, optimization of electroplated inductors for microelectronic devices; theory of magnetism of Fe-Al alloys; and two advanced analytical approaches for modeling of magnetic materials using Everett integral and the inverse problem approach. This book is addressed to a diverse group of readers with general background in physics or materials science, but it can also benefit specialists in the field of magnetic materials.

Design and Implementation of Fully-Integrated Inductive DC-DC Converters in Standard CMOS Electrochemical Society

Recent catastrophic blackouts have exposed major vulnerabilities in the existing generation, transmission, and distribution systems of transformers widely used for energy transfer, measurement, protection, and signal coupling. As a result, the reliability of the entire power system is now uncertain, and many blame severe underinvestment, aging technology, and a conservative approach to innovation. Composed of contributions from noted industry experts around the world, Transformers: Analysis, Design, and Measurement offers invaluable information to help designers and users overcome these and other challenges associated with the design, construction, application, and analysis of transformers. This book is divided into three sections to address contemporary economic, design, diagnostic, and maintenance aspects associated with power, instrument, and high-frequency transformers. Topics covered include:

Design considerations Capability to withstand short circuits Insulation problems Stray losses, screening, and local excessive heating hazard Shell type and superconducting transformers Links between design and maintenance Component-related diagnostics and reliability Economics of life-cycle cost, design review, and risk-management methods Parameter measurement and prediction This book is an essential tool for understanding and implementing solutions that will ensure improvements in the development, maintenance, and life-cycle management of optimized transformers. This will lead to enhanced safety and reliability and lower costs for the electrical supply. Illustrating the need for close cooperation between users and manufacturers of transformers, this book outlines ways to achieve many crucial power objectives. Among these, the authors focus on the growing demand for transformer miniaturization, increased transmitted power density, and use of advanced materials to meet the requirements of power materials running under higher operational frequencies. Suggesting ways to redirect resources and exploit new technologies—such as computational modeling software—this book presents relatively inexpensive, simple, ready-to-implement strategies to advance transformers, improve power system integrity, reduce environmental impact, and much more.

Design, Test, and Microfabrication of MEMS and MOEMS John Wiley & Sons

A sequel to Power Electronics Technology and Applications, this text is targeted specifically towards the needs of practicing design engineers. The focus is to provide the practicing engineer with up-to-date technology and emerging applications.

2000 IEEE 31ú Comhdháil Bhliantúil Na Saineolaithe Ar Leictreonaic Chumhachta : Imeachtaí Na Comhdhála CRC Press

This compendium reports fundamental science and engineering advances of the US Army Research Labratory (ARL) within the area of Energy and Power technologies. Although, in general, ARL's Materials Research encompasses a broad range of materials technologies (e.g.: Photonics, Electronics, Biological and Bio-inspired Materials, Structural Materials, High Strain and Ballistic Materials, and Manufacturing Science), this publication specifically addresses selected energy and power material related work at ARL. While this work includes electrochemical energy storage (batteries and capacitors) and electrochemical energy conversion (fuel cells, photoelectrochemistry, and photochemistry), special emphasis is given on electrochemical energy storage: • Micro Electro-Mechanical Systems (MEMS): Power density, efficiency, and robustness of motors, generators, and actuators while also reducing their life cycle costs. • Energy Storage: Electrical and electrochemical energy storage devices to decrease device size, weight, and cost as well as increase their capabilities in extreme temperatures and operating conditions. • Power Control and Distribution: Tactical, deployable power systems using conventional fuels, alternative fuels, and energy harvested from renewable/ambient sources. • Power Generation/Energy Conversion: Smart energy networks for platforms, forward operating bases, and facilities using modeling and simulation tools as well as new, greater capability and efficiency components. • Thermal Transport and

Control: Heat and higher power density systems, advanced components, system modeling, and adaptive or hybrid-cycle technologies. Keywords: Electrochemical Energy Storage, Batteries, Capacitors, Electrochemical Energy Conversion, Fuel Cells, Photoelectrochemistry, Photochemistry, High Voltage Electrolytes, Li-ion Batteries, Li-ion Chemistry, Lithium–Sulphur Batteries, Nuclear Metastables, Pyroelectric Energy Conversion, Charged Quantum Dots, High-Efficiency Photovoltaics, IR Sensing, GaN Power Schottky Diodes, Threshold-Voltage Instability, Reliability Testing, SiC MOSFETs, Power Electronics Packaging, High Voltage 4H-SiC GTOs, Silicon Carbide, Avalanche Breakdown Diode, SiC PiN Diodes, Thyristor Protection, Compact DC-DC Battery Chargers

A Structured Design Approach John Wiley & Sons

This book offers a comprehensive review of the state-of-the-art in innovative Beyond-CMOS nanodevices for developing novel functionalities, logic and memories dedicated to researchers, engineers and students. It particularly focuses on the interest of nanostructures and nanodevices (nanowires, small slope switches, 2D layers, nanostructured materials, etc.) for advanced More than Moore (RF-nanosensors-energy harvesters, on-chip electronic cooling, etc.) and Beyond-CMOS logic and memories applications.

Advanced Magnetic Materials CRC Press

CMOS DC-DC Converters aims to provide a comprehensive dissertation on the matter of monolithic inductive Direct-Current to Direct-Current (DC-DC) converters. For this purpose seven chapters are defined which will allow the designer to gain specific knowledge on the design and implementation of monolithic inductive DC-DC converters, starting from the very basics.

(Microelectromechanical Systems) Toroidal Magnetics for Integrated Power Electronics Springer Nature

This collection of important papers provides a comprehensive overview of low-power system design, from component technologies and circuits to architecture, system design, and CAD techniques. LOW POWER CMOS DESIGN summarizes the key low-power contributions through papers written by experts in this evolving field.

Low-Power CMOS Design Design and Optimisation of Micro-fabricated Inductors for High-frequency Power ConvertersTrends in the miniaturisation of electronic products, especially in the portable products area, has sparked considerable interest in the miniaturisation of the energy processing electronics i.e. the power conversion circuits such as the switched mode power supply (SMPS). Unlike digital electronics which have benefited from miniaturisation and integration in microelectronics, power conversion electronics have not significantly reduced in size. This is directly due to the fact that power conversion requires energy storage components such as inductors and capacitors. The value of the inductors and capacitors required can be reduced if the switching frequency of the power converter is increased. In order to miniaturise the power converter, the switching frequency must be increased so that passive components can be miniaturised and integrated. Traditionally the inductive components have been difficult to integrate on chip. This work

focused on the design and fabrication of integrated inductors-on-silicon for very high frequency power conversion (20 {u2013} 100 MHz). Initially an analytical model for micro-inductors which was developed in previous work was used to design inductors for operation up to 20 MHz. The designs selected for fabrication had a footprint area between 5 {u2013} 9 mm2 and a predicted device efficiency of 90% and above. These models were validated by finite element analysis before fabrication. The fabricated prototypes displayed a low loss of inductance to 20 MHz and current handling ability to 0.5 A. The micro-inductors were then interfaced with a high frequency dc-dc converter (20 {u2013} 100 MHz) developed by NXP Semiconductor, and achieved an inductor efficiency of 93% at 20 MHz. The maximum converter efficiency with the micro-inductor was measured to be 78.5%, which to date is highest quoted inductor-on-silicon device efficiency in a converter application at 20 MHz. Circuit equivalent lumped-element models of the micro-inductor for use in circuit simulation software were also developed. This equivalent circuit model includes elements such as capacitance, which are not accounted for in the previously developed analytical model. The initial micro-inductor devices performance was found to be comparable to commercial chip inductors for inductor efficiency when used in a converter. However, if the micro-inductor technology is to compete as a viable alternative to commercial devices, it needed to reduce its footprint area dramatically. This was achieved by using an optimisation software engine to find the inductor designs with maximum efficiency for a given footprint area. The footprint of these optimised devices ranged from 0.5 {u2013} 2.5 mm2 for a range of inductances to 200 nH. A range of optimised devices were fabricated and the measured optimised devices displayed a low loss of inductance to tens of MHz and good current handling capability. However, measured dc resistance was found to be substantially higher than design, due to issues in the fabrication process. The fabricated inductors also highlighted the trade-offs that are introduced in micro-inductor performance vs. footprint area. This design trade-off was also reflected in micro-inductor performance in a converter. An optimised 2.5 mm2 area device was tested in a dc-dc converter at 20 MHz, which resulted in a slightly lower peak micro-inductor efficiency of 90.5% than the previous larger devices. The fabricated optimised micro-inductors achieve an inductance density (inductance per unit area) ranging from 66 - 110 nH/mm2 and display current handling ability of 500mA for the 2.5 mm2, 250mA for the 1.3 mm2 and 150mA for the 0.5 mm2 area device. For inductors aimed at power conversion applications, this work shows a significant improvement to what is reported in literature - in high frequency operation to tens of MHz, inductance density and current handling.Micro-fabricated Racetrack Inductors with Thin-film Magnetic Cores for On-chip Power ConversionThe accelerating trend to miniaturize electronic systems and devices is placing large demands on the components responsible for delivering electrical power to these systems. Most power conversion circuits require magnetic components (inductors and transformers) in order to operate at high efficiencies; these components, however, have not yet been widely miniaturized and

integrated with electronic components that are fabricated in a CMOS process and are most often realized as discrete off-chip components. Improved on-chip inductors are therefore required to realize a monolithic Power Supply On-Chip (PwrSoC) for electronic systems where size and efficiency are of critical importance. This thesis presents design, modeling, optimization, and micro-fabrication techniques for building chip-scale racetrack power inductors with thin-film magnetic cores. Our inductors are designed for high-power-density and high efficiency dc-dc converters which transfer 25 W of power at frequencies between 5 and 30 MHz. The dc-dc converter is designed to serve as a high-input-voltage solid-state lighting driver. Magnetic components on silicon substrates with sputtered Co-Zr-O magnetic cores are optimized using a series of models that characterize each inductor loss mechanism. The optimized designs were fabricated and tested at small-signal levels and in the high-frequency power converter. The converter achieves an 89% conversion efficiency at 5 MHz with an inductor power density of 1 W/mm2 of substrate area. Small-signal measurements of the inductors are compared with modeled predictions to validate the design optimization approach. Fabricated components achieve inductance values of 1.2 [mu]H and peak quality factors of 15.1 at 8.3 MHz.Inductors and Transformers for Power Electronics

Written by well-known experts in the field, this first systematic overview of multiferroic heterostructures summarizes the latest developments, first presenting the fundamental mechanisms, including multiferroic materials synthesis, structures and mechanisms, before going on to look at device applications. The resulting text offers insight and understanding for scientists and students new to this area.

Woodhead Publishing

This book provides a comprehensive, single-source on resonant switched-capacitor converters. It is written in the style of a handbook, with systematic guidelines, and includes implementation examples. The authors explore integrated hybrid resonant DCDC converters in order to achieve highly compact, energy efficient and cost-effective power management solutions in the growing fields of wearables and internet-of-things applications. They provide an introduction into hybrid converters as a new and promising converter class, which merges capacitive and inductive conversion concepts into one. Coverage ranges from fundamentals to implementation details, including topics such as power stage design, gate drive schemes, different control mechanisms for resonant operation and integrated passives. Introduces a new, multi-ratio resonant converter architecture, which enables lower switching frequencies and better passive component utilization; Discusses circuit block design for high efficiency of the power stage; Explores implementation details and concepts for integrated passives; Derives models, implements and compares to each other different control mechanisms.

Proceedings Springer Science & Business Media

Although they are some of the main components in the design of power electronic converters, the design of inductors and transformers is often still a trial-and-error process due to a long

working-in time for these components. Inductors and Transformers for Power Electronics takes the guesswork out of the design and testing of these systems and provides a broad overview of all aspects of design. Inductors and Transformers for Power Electronics uses classical methods and numerical tools such as the finite element method to provide an overview of the basics and technological aspects of design. The authors present a fast approximation method useful in the early design as well as a more detailed analysis. They address design aspects such as the magnetic core and winding, eddy currents, insulation, thermal design, parasitic effects, and measurements. The text contains suggestions for improving designs in specific cases, models of thermal behavior with various levels of complexity, and several loss and thermal measurement techniques. This book offers in a single reference a concise representation of the large body of literature on the subject and supplies tools that designers desperately need to improve the accuracy and performance of their designs by eliminating trial-and-error.
Micromachining and Microfabrication Process Technology The Electrochemical Society
Power Electronics Handbook, Fourth Edition, brings together over 100 years of combined experience in the specialist areas of power engineering to offer a fully revised and updated expert guide to total power solutions. Designed to provide the best technical and most commercially viable solutions available, this handbook undertakes any or all aspects of a project requiring specialist design, installation, commissioning and maintenance services. Comprising a complete revision throughout and enhanced chapters on semiconductor diodes and transistors and thyristors, this volume includes renewable resource content useful for the new generation of engineering professionals. This market leading reference has new chapters covering electric traction theory and motors and wide band gap (WBG) materials and devices. With this book in hand, engineers will be able to execute design, analysis and evaluation of assigned projects using sound engineering principles and adhering to the business policies and product/program requirements. Includes a list of leading international academic and professional contributors Offers practical concepts and developments for laboratory test plans Includes new technical chapters on electric vehicle charging and traction theory and motors Includes renewable resource content useful for the new generation of engineering professionals
Fundamentals of Microfabrication CRC Press
Based on the fundamentals of electromagnetics, this clear and concise text explains basic and applied principles of transformer and inductor design for power electronic applications. It details both the theory and practice of inductors and transformers employed to filter currents, store electromagnetic energy, provide physical isolation between circuits, and perform stepping up and down of DC and AC voltages. The authors present a broad range of applications from modern power conversion systems. They provide rigorous design guidelines based on a robust methodology for inductor and transformer design. They offer real design examples, informed by proven and working field examples. Key features include: emphasis on high frequency

design, including optimisation of the winding layout and treatment of non-sinusoidal waveforms a chapter on planar magnetic with analytical models and descriptions of the processing technologies analysis of the role of variable inductors, and their applications for power factor correction and solar power unique coverage on the measurements of inductance and transformer capacitance, as well as tests for core losses at high frequency worked examples in MATLAB, end-of-chapter problems, and an accompanying website containing solutions, a full set of instructors' presentations, and copies of all the figures. Covering the basics of the magnetic components of power electronic converters, this book is a comprehensive reference for students and professional engineers dealing with specialised inductor and transformer design. It is especially useful for senior undergraduate and graduate students in electrical engineering and electrical energy systems, and engineers working with power supplies and energy conversion systems who want to update their knowledge on a field that has progressed considerably in recent years.

Analysis, Design, and Measurement The Electrochemical Society

Power consumption has become a major design consideration for battery-operated, portable systems as well as high-performance, desktop systems. Strict limitations on power dissipation must be met by the designer while still meeting ever higher computational requirements. A comprehensive approach is thus required at all levels of system design, ranging from algorithms and architectures to the logic styles and the underlying technology. Potentially one of the most important techniques involves combining architecture optimization with voltage scaling, allowing a trade-off between silicon area and low-power operation. Architectural optimization enables supply voltages of the order of 1 V using standard CMOS technology. Several techniques can also be used to minimize the switched capacitance, including representation, optimizing signal correlations, minimizing spurious transitions, optimizing sequencing of operations, activity-driven power down, etc. The high- efficiency of DC-DC converter circuitry required for efficient, low-voltage and low-current level operation is described by Stratakos, Sullivan and Sanders. The application of various low-power techniques to a chip set for multimedia applications shows that orders-of-magnitude reduction in power consumption is possible. The book also features an analysis by Professor Meindl of the fundamental limits of power consumption achievable at all levels of the design hierarchy. Svensson, of ISI, describes emerging adiabatic switching techniques that can break the CV2f barrier and reduce the energy per computation at a fixed voltage. Srivastava, of AT&T, presents the application of aggressive shut-down techniques to microprocessor applications.

Conference Record of the 1998 IEEE Industry Applications Conference : Thirty-Third IAS Annual Meeting : 12-15 October, 1998, St. Loius, Missouri, USA Materials Research Forum LLC

Trends in the miniaturisation of electronic products, especially in the portable products area, has sparked considerable interest in the miniaturisation of the energy processing electronics i.e. the power conversion circuits such as the

switched mode power supply (SMPS). Unlike digital electronics which have benefited from miniaturisation and integration in microelectronics, power conversion electronics have not significantly reduced in size. This is directly due to the fact that power conversion requires energy storage components such as inductors and capacitors. The value of the inductors and capacitors required can be reduced if the switching frequency of the power converter is increased. In order to miniaturise the power converter, the switching frequency must be increased so that passive components can be miniaturised and integrated. Traditionally the inductive components have been difficult to integrate on chip. This work focused on the design and fabrication of integrated inductors-on-silicon for very high frequency power conversion (20 {u2013} 100 MHz). Initially an analytical model for micro-inductors which was developed in previous work was used to design inductors for operation up to 20 MHz. The designs selected for fabrication had a footprint area between 5 {u2013} 9 mm2 and a predicted device efficiency of 90% and above. These models were validated by finite element analysis before fabrication. The fabricated prototypes displayed a low loss of inductance to 20 MHz and current handling ability to 0.5 A. The micro-inductors were then interfaced with a high frequency dc-dc converter (20 {u2013} 100 MHz) developed by NXP Semiconductor, and achieved an inductor efficiency of 93% at 20 MHz. The maximum converter efficiency with the micro-inductor was measured to be 78.5%, which to date is highest quoted inductor-on-silicon device efficiency in a converter application at 20 MHz. Circuit equivalent lumped-element models of the micro-inductor for use in circuit simulation software were also developed. This equivalent circuit model includes elements such as capacitance, which are not accounted for in the previously developed analytical model. The initial micro-inductor devices performance was found to be comparable to commercial chip inductors for inductor efficiency when used in a converter. However, if the micro-inductor technology is to compete as a viable alternative to commercial devices, it needed to reduce its footprint area dramatically. This was achieved by using an optimisation software engine to find the inductor designs with maximum efficiency for a given footprint area. The footprint of these optimised devices ranged from 0.5 {u2013} 2.5 mm2 for a range of inductances to 200 nH. A range of optimised devices were fabricated and the measured optimised devices displayed a low loss of inductance to tens of MHz and good current handling capability. However, measured dc resistance was found to be substantially higher than design, due to issues in the fabrication process. The fabricated inductors also highlighted the trade-offs that are introduced in micro-inductor performance vs. footprint area. This design trade-off was also reflected in micro-inductor performance in a converter. An optimised 2.5 mm2 area device was tested in a dc-dc converter at 20 MHz, which resulted in a slightly lower peak micro-inductor efficiency of 90.5% than the previous larger devices. The fabricated optimised micro-inductors achieve an inductance density (inductance per unit area) ranging from 66 - 110 nH/mm2 and display current handling ability of 500mA for the 2.5 mm2, 250mA

for the 1.3 mm2 and 150mA for the 0.5 mm2 area device. For inductors aimed at power conversion applications, this work shows a significant improvement to what is reported in literature - in high frequency operation to tens of MHz, inductance density and current handling.

30 March-1 April 1999, Paris, France

Butterworth-Heinemann

Issues for 1973- cover the entire IEEE technical literature.

Index to IEEE Publications John Wiley & Sons

This text comprises the proceedings of the 1999 International Symposium on Microelectronics.

The International Journal of Microcircuits and Electronic Packaging Springer Science & Business Media

Now in its third edition, Fundamentals of Microfabrication and Nanotechnology continues to provide the most complete MEMS coverage available. Thoroughly revised and updated the new edition of this perennial bestseller has been expanded to three volumes, reflecting the substantial growth of this field. It includes a wealth of theoretical and practical information on nanotechnology and NEMS and offers background and comprehensive information on materials, processes, and manufacturing options. The first volume offers a rigorous theoretical treatment of micro- and nanosciences, and includes sections on solid-state physics, quantum mechanics, crystallography, and fluidics. The second volume presents a very large set of manufacturing techniques for micro- and nanofabrication and covers different forms of lithography, material removal processes, and additive technologies. The third volume focuses on manufacturing techniques and applications of Bio-MEMS and Bio-NEMS. Illustrated in color throughout, this seminal work is a cogent instructional text, providing classroom and self-learners with worked-out examples and end-of-chapter problems. The author characterizes and defines major research areas and illustrates them with examples pulled from the most recent literature and from his own work.

Integrated Hybrid Resonant DCDC Converters Springer Science & Business Media

Metallic films play an important role in modern technologies such as integrated circuits, information storage, displays, sensors, and coatings. Metallic Films for Electronic, Optical and Magnetic Applications reviews the structure, processing and properties of metallic films. Part one explores the structure of metallic films using characterization methods such as x-ray diffraction and transmission electron microscopy. This part also encompasses the processing of metallic films, including structure formation during deposition and post-deposition reactions and phase transformations. Chapters in part two focus on the properties of metallic films, including mechanical, electrical, magnetic, optical, and thermal properties. Metallic Films for Electronic, Optical and Magnetic Applications is a technical resource for electronics components manufacturers, scientists, and engineers working in the semiconductor industry, product developers of sensors, displays, and other optoelectronic devices, and academics working in the field. Explores the structure of metallic films using characterization methods such as x-ray diffraction and transmission electron microscopy Discusses processing of metallic films,

including structure formation during deposition and post-deposition reactions and phase transformations Focuses on the properties of metallic films, including mechanical, electrical, magnetic, optical, and thermal properties