Electromagnetic And Thermal Modeling Of A Permanent Magnet

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Electromagnetic And Thermal Modeling Of A Permanent Magnet *2020-01-09*

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Coupled Electromagnetic Thermal and Kinetic Modeling for Microwave Processing of Polymers with Temperature- and Cure-dependent Permittivity Using 3D FEM John Wiley & Sons
Written by specialists of modeling in electromagnetism, this book provides a comprehensive review of the finite element method for low frequency applications. Fundamentals of the method as well as new advances in the field are described in detail. Chapters 1 to 4 present general 2D and 3D static and dynamic formulations by the use of scalar and vector unknowns and adapted interpolations for the fields (nodal, edge, face or volume). Chapter 5 is dedicated to the presentation of different macroscopic behavior laws of materials and their implementation in a finite element context: anisotropy and hysteretic properties for magnetic sheets, iron losses, non-linear permanent magnets and superconductors. More specific formulations are then proposed: the modeling of thin regions when finite elements become misfit (Chapter 6), infinite domains by using geometrical transformations (Chapter 7), the coupling of 2D and 3D formulations with circuit equations (Chapter 8), taking into account the movement, particularly in the presence of Eddy currents (Chapter 9) and an original approach for the treatment of geometrical symmetries when the sources are not symmetric (Chapter 10). Chapters 11 to 13 are devoted to coupled problems: magneto-thermal coupling for induction heating, magneto-mechanical coupling by introducing the notion of strong and weak coupling and magneto-hydrodynamical coupling focusing on electromagnetic instabilities in fluid conductors. Chapter 14 presents different meshing methods in the context of electromagnetism (presence of air) and introduces self-adaptive mesh refinement procedures. Optimization techniques are then covered in Chapter 15, with the adaptation of deterministic and probabilistic methods to the numerical finite element environment. Chapter 16 presents a variational approach of electromagnetism, showing how Maxwell equations are derived from thermodynamic principles.
Modelling of Large Non-linear Systems Integrating Thermal and Electromagnetic Models Butterworth-Heinemann
The continuous miniaturization of electronic systems using the three-dimensional (3D) integration technique has brought in new challenges for the computer-aided design and modeling of 3D integrated circuits (ICs) and systems. The major challenges for the modeling and analysis of 3D integrated systems mainly stem from four aspects: (a) the interaction between the electrical and thermal domains in an integrated system, (b) the increasing modeling complexity arising from 3D systems requires the development of multiscale techniques for the modeling and analysis of DC voltage drop, thermal gradients, and electromagnetic behaviors, (c) efficient modeling of microfluidic cooling, and (d) the demand of performing fast thermal simulation with varying design parameters. Addressing these challenges for the electrical/thermal modeling and analysis of 3D systems necessitates the development of novel numerical modeling methods. This dissertation mainly focuses on developing efficient electrical and thermal numerical modeling and co-simulation methods for 3D integrated systems. The developed numerical methods can be classified into three categories. The first category aims to investigate the interaction between electrical and thermal characteristics for power delivery networks (PDNs) in steady state and the thermal effect on characteristics of through-silicon via (TSV) arrays at high frequencies. The steady-state electrical-thermal interaction for PDNs is addressed by developing a voltage drop-thermal co-simulation method while the thermal effect on TSV characteristics is studied by proposing a thermal-electrical analysis approach for TSV arrays. The second category of numerical methods focuses on developing multiscale modeling approaches for the voltage drop and thermal analysis. A multiscale modeling method based on the finite-element non-conformal domain decomposition technique has been developed for the voltage drop and thermal analysis of 3D systems. The proposed method allows the modeling of a 3D multiscale system using independent mesh grids in sub-domains. As a result, the system unknowns can be greatly reduced. In addition, to improve the simulation efficiency, the cascadic multigrid solving approach has been adopted for the voltage drop-thermal co-simulation with a large number of unknowns. The focus of the last category is to develop fast thermal simulation methods using compact models and model order reduction (MOR). To overcome the computational cost using the computational fluid dynamics simulation, a finite-volume compact thermal model has been developed for the microchannel-based fluidic cooling. This compact thermal model enables the fast thermal simulation of 3D ICs with a large number of microchannels for early-stage design. In addition, a system-level thermal modeling method using domain decomposition and model order reduction is developed for both the steady-state and transient thermal analysis. The proposed approach can efficiently support thermal modeling with varying design parameters without using parameterized MOR techniques.
Compendium On Electromagnetic Analysis - From Electrostatics To Photonics: Fundamentals And Applications For Physicists And Engineers (In 5 Volumes) LAP Lambert Academic Publishing
This dissertation describes the design and study of a retinal prosthesis for individuals who have suffered loss of vision from degeneration of the outer retina. Retinitis pigmentosa and age-related macular degeneration lead to blindness through

progressive loss of retinal photoreceptors. Experiments reveal that direct electrical stimulation of remaining ganglion cells in degenerate retina elicits visual percepts in blind RP/AMD patients. This motivates research toward the development of a retinal prosthesis system involving an implantable stimulator microchip to compensate the defective photoreceptors. Many prostheses do not reside fully inside the body, but consist of an implantable stimulation unit and an external unit. This underscores a need in the retinal prosthesis to deliver power and support high-speed bi-directional communication with the implant wirelessly. The current progress in the types of non-invasive connections to bio-implants is reviewed as it relates to the power and communication needs of prostheses. The extraocular unit is a hardware-reconfigurable system based on FPGA technology which produces real-time instructions for the implantable micro-stimulator IC. The current retinal stimulator IC is designed to provide electrical stimulation to the remaining ganglion cells of post-degenerative retina. Also described is a design technique to significantly reduce the on-chip area of the stimulus circuits. This yields more output channels per chip area, thereby raising the stimulation resolution. Temperature elevation in the eye and head tissues associated with the retinal prosthesis is studied. A high resolution 2D human head and eye model is developed at 0.25mm spatial resolution with associated dielectric and thermal properties suitable for numerical simulations. The Finite Difference Time domain method (FDTD) with material independent absorbing boundary conditions is used to predict the specific absorption rate (SAR) induced from electromagnetic expo. *Electromagnetic and Thermal Analysis of Distributed Cooled High Power Millimeter Wave Windows* Electromagnetic and Thermal Modeling of Highly Utilized PM MachinesFinite-difference Time-domain Electromagnetic and Thermal Modeling of Skeletal Muscle Exposed to Millimeter WavesThis thesis describes a systematic process to develop and characterize a geometric computer model of the mouse foot flexor digitorum brevis (FDB) skeletal muscle, which was then used to compute detailed electric fields (E-fields) within the muscle when exposed to 94 GHz millimeter wave (MMW) fields. The purpose of this research was to investigate the possibility that MMW fields can affect the contractile performance of skeletal muscle through non-thermal mechanisms. Experiments performed in our laboratory documented some possible non-thermal effects on the FDB muscle. When electrically stimulated to contract in the presence of 94 GHz MMW fields, the muscle, which was maintained at a constant temperature, exhibited a decrease in contractile force that was not reversible when the fields were removed. It was not known if high E-fields or temperature changes were occurring within the muscle that could potentially cause such performance deviations. Since it was not possible to measure E-field and temperature distributions within the muscle due to its very small size, computer simulations of these experiments were needed to predict these distributions. To accomplish this, a highly detailed geometric computer model of the FDB muscle was developed and assigned appropriate dielectric properties, which are necessary for EM simulation. Then detailed numerical calculations of the E-fields and temperature changes within the muscle were performed using commercially available Finite-Difference Time-Domain (FDTD) software. Analysis of the results showed little evidence of E-field or temperature "hot spots" within the muscle, which would indicate that the effects observed in the laboratory were non-thermal in nature.Combined Electric, Electromagnetic and Thermal Modeling Based on a PEEC ApproachElectromagnetic and Thermal Modeling of Microwave Applicators Using the Hybrid FDTD TechniquesThe Architecture, Design, and Electromagnetic and Thermal Modeling of a Retinal Prosthesis to Benefit the Visually ImpairedKeywords: Retinal stimulator microchip, Visual Prosthesis, Retinal prosthesis.A Coupled Electromagnetic-thermal Model of Heating During Radiofrequency AblationAbstract: Radiofrequency ablation is an important surgical method for eliminating cancer; however, the lack of adequate technology to image the internal organ temperature profile forces surgeons to often guess at the ablation margin. If a sufficient temperature is not reached and all of the cancerous tissue is not destroyed, a recurrence is likely. Therefore, we propose to develop a numerical electromagnetic and thermal model of radiofrequency ablation that will be used in future surgical planning. The model is based on the finite element method and couples the electromagnetic and thermal models by considering the electric fields as the heat source. Furthermore, the two physical phenomena are coupled through temperature-dependent material properties. To verify our models, we compare them to experiments conducted on excised bovine liver. Internal temperatures are measured with thermocouples and lesion shape and size are compared after ablation. At the same time, we attempt to predict surface temperature during ablation in order to investigate the possibility of correlating surface temperature to internal temperatures. During the experiments, surface temperature was measured with an infrared camera. Over the course of three experiments, we found that internal temperatures are predicted with good accuracy (within 2 0C) when the ablation ground plane is placed more than 8 cm away from the electrode. If the ground plane is closer, then some error is introduced into our approximate model. Also, we found that the lesion shape and size predicted by the simulation are similar to the lesion observed after ablation. Finally, the simulation predictions for surface temperature were mixed. In one case, the temperature values were predicted closely but the distribution was somewhat different. In the other case, the isothermal contours were very similar but the simulated temperatures were as much as 25 0C above what was measured.Modeling of Electromagnetic Behavior and Local Temperature Increase A computer program is developed to determine the temperature profile in an electromagnetic window as a function of the point in the vehicle trajectory. The program was written in FORTRAN IV for the CDC 6600 computer. A study which examines the effect of independently varying the thermophysical properties of the window material, the convective heat transfer rate, the initial temperature profile in the window, and the computational node size is presented. The results of this study show that many of the above parameters have a considerable influence on design considerations of the electromagnetic window. (Author).

Electromagnetic-thermal Modeling for High-frequency Air-core Permanent Magnet Motor of Aircraft Application

Elsevier

Uncooled microbolometers have attracted significant interest due to their small size, low cost and low power consumption. As the application range of microbolometers broadens, increasing the dynamic range becomes one of the main objectives of microbolometer research. Targeting this objective, tunable thermal conductance microbolometers have been proposed recently, in which the thermal conductance is tuned by electrostatic actuation. Being a new concept in the field, the current tunable thermal conductance microbolometers have significant potential for improvement in design and performance. In this thesis, an extensive analysis of tunable thermal conductance microbolometers is made, an analytical model is constructed for this purpose, and solutions are proposed to some potential problems such as in-use stiction and variation in spectral response. The current thermal conductance tuning mechanisms use the substrate for electrostatic actuation, which does not support pixel-by-pixel actuation. In this thesis, a new thermal conductance tuning mechanism is demonstrated, that enables pixel-by-pixel actuation by using the micromirror as an actuation terminal instead of the substrate. In addition, a stopper mechanism is used to decrease the risk of in-use stiction. With this new mechanism, the thermal conductance can be tuned by a factor of three at relatively low voltages, making it a promising thermal conductance tuning mechanism for adaptive infrared detectors. Effective estimation of the performance parameters of a tunable thermal conductance microbolometer in the design state requires an analytical model that combines the physics of infrared radiation detection and the thermal conductance tuning mechanisms. As a part of this research, an extensive analytical model is presented, which includes the electrostatic-structural modeling of the thermal conductance tuning mechanism, and electromagnetic and thermal modeling of the microbolometer. The accuracy of the thermal model is of significant importance as the operation of the tuning mechanism within the desired range should be verified in the design stage.

Modeling and Application of Electromagnetic and Thermal Field in Electrical Engineering Createspace Independent Publishing Platform

Presents applied theory and advanced simulation techniques for electric machines and drives This book combines the knowledge of experts from both academia and the software industry to present theories of multiphysics simulation by design for electrical machines, power electronics, and drives. The comprehensive design approach described within supports new applications required by technologies sustaining high drive efficiency. The highlighted framework considers the electric machine at the heart of the entire electric drive. The book also emphasizes the simulation by design concept—a concept that frames the entire highlighted design methodology, which is described and illustrated by various advanced simulation technologies. Multiphysics Simulation by Design for Electrical Machines, Power Electronics and Drives begins with the basics of electrical machine design and manufacturing tolerances. It also discusses fundamental aspects of the state of the art design process and includes examples from industrial practice. It explains FEM-based analysis techniques for electrical machine design—providing details on how it can be employed in ANSYS Maxwell software. In addition, the book covers advanced magnetic material modeling capabilities employed in numerical computation; thermal analysis; automated optimization for electric machines; and power electronics and drive systems. This valuable resource: Delivers the multi-physics know-how based on practical electric machine design methodologies Provides an extensive overview of electric machine design optimization and its integration with power electronics and drives Incorporates case studies from industrial practice and research and development projects Multiphysics Simulation by Design for Electrical Machines, Power Electronics and Drives is an incredibly helpful book for design engineers, application and system engineers, and technical professionals. It will also benefit graduate engineering students with a strong interest in electric machines and drives.

Transient Electromagnetic-Thermal Nondestructive Testing Springer Nature

Electromagnetic and Thermal Modeling of Highly Utilized PM MachinesFinite-difference Time-domain Electromagnetic and Thermal Modeling of Skeletal Muscle Exposed to Millimeter Waves

The Architecture, Design, and Electromagnetic and Thermal Modeling of a Retinal Prosthesis to Benefit the Visually Impaired CRC Press

The integration of thermal and electromagnetic modeling with traditional circuit simulation is becoming necessary for the analysis of large microwave and millimeter-wave systems. Issues relating to the abstraction required to interface these analyses are discussed particularly as they relate to spatial power combing systems.

FDTD Electromagnetic and Thermal Analysis of Interstitial Hyperthermic Applicators John Wiley & Sons

Many developments in finite-difference time domain (FDTD) computational modelling of Maxwell's equations and computed tomography (CT) imagery have caused important progress in heat delivery method, temperature monitoring, and thermal dosimetry. Electromagnetic hyperthermia method in the treatment of cancer is an application which had been revealed by these developments. The objective of electromagnetic hyperthermia is to destroy the tumor or cancer cells by achieving the highest possible temperature in the tumor or cancer cells without exceeding 42 C in the surrounding healthy tissues. Many studies have shown that high temperatures can damage and kill cancer cells. Electromagnetic field is supplied to induce a temperature increase on tumor or cancer cells. In this thesis, the electromagnetic power deposition within the discretized cells is observed by solving the Maxwell's equations with FDTD. Further the thermal process is investigated by solving the Pennes' bio-heat transfer equation with finite difference method. Moreover, this thesis is serving as an introduction for electromagnetic hyperthermia in the human issues. To that end an extensive study is planned.

Thermal and Electromagnetic Scale Modeling of Electrical Apparatus World Scientific

Accomplishments are described for the first year effort of a 5-year program to develop a methodology for coupled structural/thermal/electromagnetic analysis/tailoring of graded composite structures. These accomplishments include: (1) the results of the selective literature survey; (2) 8-, 16-, and 20-noded isoparametric plate and shell elements; (3) large deformation structural analysis; (4) eigenanalysis; (5) anisotropic heat transfer analysis; and (6) anisotropic electromagnetic analysis. Mcknight, R. L. and Chen, P. C. and Dame, L. T. and Huang, H. Unspecified Center COMPOSITE STRUCTURES; ELECTROMAGNETIC COUPLING; FINITE ELEMENT METHOD; HEAT TRANSFER; ISOPARAMETRIC FINITE ELEMENTS; STRUCTURAL ANALYSIS; THERMAL ANALYSIS; DEFORMATION; EIGENVALUES; ELECTROMAGNETIC FIELDS; EQUILIBRIUM EQUATIONS; STIFFNESS MATRIX...

Electromagnetic and Thermal Analysis of Microwave Heating in 915 MHz Single Mode Cavity Systems Springer

Multiphysics Modeling: Numerical Methods and Engineering Applications: Tsinghua University Press Computational Mechanics Series describes the basic principles and methods for multiphysics modeling, covering related areas of physics such as structure mechanics, fluid dynamics, heat transfer, electromagnetic field, and noise. The book provides the latest information on basic numerical methods, also considering coupled problems spanning fluid-solid interaction, thermal-stress coupling, fluid-solid-thermal coupling, electromagnetic solid thermal fluid coupling, and structure-noise coupling. Users will find a comprehensive book that covers background theory, algorithms, key technologies, and applications for each coupling method. Presents a wealth of multiphysics modeling methods, issues, and worked examples in a single volume Provides a go-to resource for coupling and multiphysics problems Covers the multiphysics details not touched upon in broader numerical methods references, including load transfer between physics, element level strong coupling, and interface strong coupling, amongst others Discusses practical applications throughout and tackles real-life multiphysics problems across areas such as automotive, aerospace, and biomedical engineering

Springer

Co-authored by an international research group with a long-standing cooperation, this book focuses on engineering-oriented electromagnetic and thermal field modeling and application. It presents important contributions, including advanced and efficient finite element analysis used in the solution of electromagnetic and thermal field problems for large and multi-scale engineering applications involving application script development; magnetic measurement of both magnetic materials and components under various, even extreme conditions, based on well-established (standard and non-standard) experimental systems; and multi-level validation based on both industrial test systems and extended TEAM P21 benchmarking platform. Although these are challenging topics, they are useful for readers from both academia and industry.

Electromagnetic Interference and Thermal Analysis of Electronic Systems

Chapter 3 describes faster browning of fructose under alkaline conditions as a time-temperature indicator in microwave pasteurization processes. Reaction kinetics of browning showed a log linear relationship in the temperature range of 60--90°C. This non-enzymatic browning of fructose in mashed potato model food provided an efficient, convenient and cost effective tool to determine the heating patterns in MAPS system.

The System Designer's Guide To...System Analysis

This book focuses on the electromagnetic and thermal modeling and analysis of electrical machines, especially canned electrical machines for hydraulic pump applications. It addresses both the principles and engineering practice, with more weight placed on mathematical modeling and theoretical analysis. This is achieved by providing in-depth studies on a number of major topics such as: can shield effect analysis, machine geometry optimization, control analysis, thermal and electromagnetic network models, magneto motive force modeling, and spatial magnetic field modeling. For the can shield effect analysis, several cases are studied in detail, including classical canned induction machines, as well as state-of-the-art canned permanent magnet machines and switched reluctance machines. The comprehensive and systematic treatment of the can effect for canned electrical machines is one of the major features of this book, which is particularly suited for readers who are interested in learning about electrical machines, especially for hydraulic pumping, deep-sea exploration, mining and the nuclear power industry. The book offers a valuable resource for researchers, engineers, and graduate students in the fields of electrical machines, magnetic and thermal engineering, etc.

Modeling of Electromagnetic Behavior and Local Temperature Increase

Abstract: Radiofrequency ablation is an important surgical method for eliminating cancer; however, the lack of adequate technology to image the internal organ temperature profile forces surgeons to often guess at the ablation margin. If a sufficient temperature is not reached and all of the cancerous tissue is not destroyed, a recurrence is likely. Therefore, we propose to develop a numerical electromagnetic and thermal model of radiofrequency ablation that will be used in future surgical planning. The model is based on the finite element method and couples the electromagnetic and thermal models by considering the electric fields as the heat source. Furthermore, the two physical phenomena are coupled through temperature-dependent material properties. To verify our models, we compare them to experiments conducted on excised bovine liver. Internal temperatures are measured with thermocouples and lesion shape and size are compared after ablation. At the same time, we attempt to predict surface temperature during ablation in order to investigate the possibility of correlating surface temperature to internal temperatures. During the experiments, surface temperature was measured with an infrared camera. Over the course of three experiments, we found that internal temperatures are predicted with good accuracy (within 2 0C) when the ablation ground plane is placed more than 8 cm away from the electrode. If the ground plane is closer, then some error is introduced into our approximate model. Also, we found that the lesion shape and size predicted by the simulation are similar to the lesion observed after ablation. Finally, the simulation predictions for surface temperature were mixed. In one case, the temperature values were predicted closely but the distribution was somewhat different. In the other case, the isothermal contours were very similar but the simulated temperatures were as much as 25 0C above what was measured.

Finite-difference Time-domain Electromagnetic and Thermal Modeling of Skeletal Muscle Exposed to Millimeter Waves

The five-volume set may serve as a comprehensive reference on electromagnetic analysis and its applications at all frequencies, from static fields to optics and photonics. The material includes micro- and nanomagnetics, the new generation of electric machines, renewable energy, hybrid vehicles, low-noise motors; antennas and microwave devices, plasmonics, metamaterials, lasers, and more.Written at a level accessible to both graduate students and engineers, Electromagnetic Analysis is a comprehensive reference, covering methods and applications at all frequencies (from statics to optical). Each volume contains pedagogical/tutorial material of high archival value as well as chapters on state-of-the-art developments.

Electromagnetic and Thermal Analysis of Permanent Magnet Synchronous Machines

Transient Electromagnetic-Thermal Nondestructive Testing: Pulsed Eddy Current and Transient Eddy Current Thermography covers three key areas of theories, methods and applications, primarily the multi-physics field, including eddy current, heat conduction and Infrared radiation for defect evaluation, lateral heat conduction, which is analyzed to detect parallel cracks, and longitudinal heat conduction, which is analyzed to detect depth defect, or that which is beyond skin depth. In addition, the book explores methods, such as time domain, frequency domain and logarithm domain, also comparing A-scan , B-scan and C-scan. Sections on defect identification, classification and quantification are covered, as are advanced algorithms, principal components analysis (PCA), independent components analysis (ICA) and support vector machine (SVM). The book uses a lot of experimental studies on multi-layer aluminum structures, honeycomb structure, CFRP in the aerospace field, and steel and coating in the marine rail and transportation fields. Presents two kinds of transient NDT testing, from theory and methodology, to applications Includes time domain frequency domain and logarithm domain, which are all analyzed Introduces A-scan , B-scan and C-scan, which are compared Provides experimental studies for real damages, including corrosion and blister in steel, stress in aluminum, impact and delamination in CFRP laminates and RCF cracks are abundant

Microwave Assisted Thermal Sterilization and Pasteurization

Co-authored by an international research group with a long-standing cooperation, this book focuses on engineering-oriented electromagnetic and thermal field modeling and application. It presents important contributions, including advanced and efficient finite element analysis used in the solution of electromagnetic and thermal field problems for large and multi-scale engineering applications involving application script development; magnetic measurement of both magnetic materials and components under various, even extreme conditions, based on well-established (standard and non-standard) experimental systems; and multi-level validation based on both industrial test systems and extended TEAM P21 benchmarking platform. Although these are challenging topics, they are useful for readers from both academia and industry.

Thermal Modeling for Pulsed Inductive FRC Plasmoid Thrusters

Due to the rising importance of space based infrastructure, long-range robotic space missions, and the need for active attitude control for spacecraft, research into Electric Propulsion is becoming increasingly important. Electric Propulsion (EP) systems utilize electric power to accelerate ions in order to produce thrust. Unlike traditional chemical propulsion, this means that thrust levels are relatively low. The trade-off is that EP thrusters have very high specific impulses (Isp), and can therefore make do with far less onboard propellant than cold gas, monopropellant, or bipropellant engines. As a consequence of the high power levels used to accelerate the ionized propellant, there is a mass and cost penalty in terms of solar panels and a power processing unit. Due to the large power consumption (and waste heat) from electric propulsion thrusters, accurate measurements and predictions of thermal losses are needed. Excessive heating in sensitive locations within a thruster may lead to premature failure of vital components. Between the fixed cost required to purchase these components, as well as the man-hours needed to assemble (or replace) them, attempting to build a high-power thruster without reliable thermal modeling can be expensive. This paper will explain the usage of FEM modeling and experimental tests in characterizing the ElectroMagnetic Plasmoid Thruster (EMPT) and the Electrodeless Lorentz Force (ELF) thruster at the MSNW LLC facility in Redmond, Washington. The EMPT thruster model is validated using an experimental setup, and steady state temperatures are predicted for vacuum conditions. Preliminary analysis of the ELF thruster indicates possible material failure in absence of an active cooling system for driving electronics and for certain power levels.

Time Domain Modeling of Hybrid Electromagnetic and Thermal Processes

Keywords: Retinal stimulator microchip, Visual Prosthesis, Retinal prosthesis.