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Electromagnetic And Thermal Modeling Of A Permanent Magnet

Lecture 16: Thermal Modeling and Heat Sinking Webinar - Simulation of Coupled Electromagnetic Thermal Systems Understanding Thermal Radiation Perform Quick Thermal Analysis of Electromagnetic Designs THERMAL MODELLING OF HEATING SYSTEM IN A HOUSE | MATLAB SIMULINK SIMULATION PROJECT Lecture 14: Modeling Thermal Systems Power of CST Studio Suite® for Electromagnetic Simulations - LaunchTech Radiometry with FLIR Lepton | Thermal Integration Made Easy Thermal Cinch Book Binding Machine - Everything You Should Know Use of the DJI Thermal Analysis Tool Materialism Podcast Ep 60: Materials Modeling at General Electric How to thermo-bind a book A Complete Guide to Emissivity for Thermal Imaging What is Infrared Radiation \u0026 Electromagnetic Spectrum? - [4] Gravity Colors- Using Gravity Colors Paint on the Moebius 1965 Mercury Comet Cyclone ABAQUS Tutorial : Coupled Electromagnetic and Heat Transfer Analysis | Induction Heating | 17-23 Coils and electromagnetic induction | 3d animation #shorts Easy Electromagnetics for General Engineers | Simulation Series PART 3 : THERMAL ENERGY TRANSFER #thermal How to Model Radiation in Ansys Fluent — Lesson 5 The relationship of Thermal Radiation and the Electromagnetic Spectrum Just physics student things #shorts #math #astrophysics EM-Thermal Coupled Simulation (Set-up - Part 1) How small are atoms? Bro’s hacking life □□ magnetic fields lines of solenoid #shorts #class10science #scienceexperiment The Photoelectric Effect Van de graff Generator #shorts #physics #education #neet #iit Become An Electrical Lineworker Drone insects caught spying in Africa. Is it true?#shorts

Analysis and Modeling of Uncooled Microbolometers with Tunable Thermal Conductance

Time Domain Modeling of Hybrid Electromagnetic and Thermal Processes

Thermal and Electromagnetic Modeling of a Canned Switched Reluctance Machine

Thermal Food Processing

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

Pulsed Eddy Current and Transient Eddy Current Thermography

Electrical-thermal Modeling and Simulation for Three-dimensional Integrated Systems

Finite Element Modeling of Electromagnetic Radiation and Induced Heat Transfer in

the Human Body
Thermal Analysis of Electromagnetic Launcher Rails
Compendium On Electromagnetic Analysis - From Electrostatics To Photonics: Fundamentals And Applications For Physicists And Engineers (In 5 Volumes)
The Finite Element Method for Electromagnetic Modeling
New Technologies and Quality Issues, Second Edition
Modeling of Electromagnetic Behavior and Local Temperature Increase
The Architecture, Design, and Electromagnetic and Thermal Modeling of a Retinal Prosthesis to Benefit the Visually Impaired
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Electromagnetic and Thermal Modeling of Highly Utilized PM Machines
Thermal Modeling for Pulsed Inductive FRC Plasmoid Thrusters
Modeling and Application of Electromagnetic and Thermal Field in Electrical Engineering
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FOLEY KAISER

Analysis and Modeling of Uncooled Microbolometers with Tunable Thermal Conductance John Wiley & Sons
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

World Scientific

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.

Thermal and Electromagnetic Modeling of a Canned Switched Reluctance Machine Butterworth-Heinemann

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 Food Processing Elsevier

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
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.
Pulsed Eddy Current and Transient Eddy Current Thermography 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

The sectional high-frequency internally-cooled window, as proposed by General Atomics, has unique potential for allowing microwave sources to reach multi-megawatt CW levels with application to ECRH. Designs are being investigated using computational electromagnetic (EM), thermal, and mechanical codes at 110 GHz and 170 GHz to examine the design tradeoffs between RF performance and thermal mechanical safety margins. The EM analyses are for the window, under vacuum at one MW and includes variations in the shapes of the cooling fins, the surface treatment of the window elements themselves, the cooling fin tip treatment, the window pitch angle, and the waveguide effects. One advantage of the distributed cooled window is it's extensibility to higher power levels. Results in the modeling efforts are presented showing the EM field concentrations (which then will feed into the thermal analysis), the energy scattering/reflection, the transmitted launch angle variation as a function of physical geometry, and the spatial energy distribution and loss as a function of time and position.

Electrical-thermal Modeling and Simulation for Three-dimensional Integrated Systems

CRC Press
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.

Finite Element Modeling of Electromagnetic Radiation and Induced Heat Transfer in the Human Body

Createspace Independent Publishing Platform

This dissertation develops adaptive hp-Finite Element (FE) technology and a parallel sparse direct solver enabling the accurate modeling of the absorption of Electro-Magnetic (EM) energy in the human head. With a large and growing number of cell phone users, the adverse health effects of EM fields have raised public concerns. Most research that attempts to explain the relationship between exposure to EM fields and its harmful effects on the human body identifies temperature changes due to the EM energy as the dominant source of possible harm. The research presented here focuses on determining the temperature distribution within the human body exposed to EM fields with an emphasis on the human head. Major challenges in accurately determining the temperature changes lie in the dependence of EM material properties on the temperature. This leads to a formulation that couples the BioHeat Transfer (BHT) and Maxwell equations. The mathematical model is formed by the time-harmonic Maxwell equations weakly coupled with the transient BHT equation. This choice of equations reflects the relevant time scales. With a mobile device operating at a single frequency, EM fields arrive at a steady-state in the micro-second range. The heat sources induced by EM fields produce a transient temperature field converging to a steady-state distribution on a time scale ranging from seconds to minutes; this necessitates the transient formulation. Since the EM material properties depend upon the temperature, the equations are fully coupled; however, the coupling is realized weakly due to the different time scales for Maxwell and BHT equations. The BHT equation is discretized in time with a time step reflecting the thermal scales. After multiple time steps, the temperature field is used to determine the EM material properties and the time-harmonic Maxwell equations are solved. The resulting heat sources are recalculated and the process continued. Due to the weak coupling of the problems, the corresponding numerical models are established separately. The BHT equation is discretized with H1 conforming elements, and Maxwell equations are discretized with H(curl) conforming elements. The complexity of the human head geometry naturally leads to the use of tetrahedral elements, which are commonly employed by unstructured mesh generators. The EM domain, including the head and a radiating source, is terminated by a Perfectly Matched Layer (PML), which is discretized with prismatic elements. The use of high order elements of different shapes and discretization types has motivated the development of a general 3D hp-FE code. In this work, we present new generic data structures and algorithms to perform adaptive local refinements on a hybrid mesh composed of different shaped elements. A variety of isotropic and anisotropic refinements that preserve conformity of discretization are designed. The refinement algorithms support one-irregular meshes with the constrained approximation technique. The algorithms are experimentally proven to be deadlock free. A second contribution of this dissertation lies with a new parallel sparse direct solver that targets linear systems arising from hp-FE methods. The new solver interfaces to the hierarchy of a locally refined mesh to build an elimination ordering for the factorization that reflects the h-refinements. By following mesh refinements, not only the computation of element matrices but also their factorization is restricted to new elements and their ancestors. The solver is parallelized by exploiting two-level task parallelism: tasks are first generated from a parallel post-order tree traversal on the assembly tree; next, those tasks are further refined by using algorithms-by-blocks to gain fine-grained parallelism. The resulting fine-grained tasks are asynchronously executed after their dependencies are analyzed. This approach effectively reduces scheduling overhead and increases flexibility to handle irregular tasks. The solver outperforms the conventional general sparse direct solver for a class of problems formulated by high order FEs. Finally, numerical results for a 3D coupled BHT with Maxwell equations are presented. The solutions of this Maxwell code have been verified using the analytic Mie series solutions. Starting with simple spherical geometry, parametric studies are conducted on realistic head models for a typical frequency band (900 MHz) of mobile phones.

Thermal Analysis of Electromagnetic Launcher Rails Springer Nature

This 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.

Compendium On Electromagnetic Analysis - From Electrostatics To Photonics: Fundamentals And Applications For Physicists And Engineers (In 5 Volumes)

LAP Lambert Academic Publishing 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

The Finite Element Method for Electromagnetic Modeling 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.

New Technologies and Quality Issues, Second Edition

John Wiley & Sons

Thermal processing remains one of the most important processes in the food industry. Now in its second edition, Thermal Food Processing: New Technologies and Quality Issues continues to explore the latest developments in the field. Assembling the work of a worldwide panel of experts, this volume highlights topics vital to the food industry today an

Modeling of Electromagnetic Behavior and Local Temperature Increase

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

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.

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

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.

Electromagnetic and Thermal Modeling of Highly Utilized PM Machines

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.

Thermal Modeling for Pulsed Inductive FRC Plasmoid Thrusters

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.

Modeling and Application of Electromagnetic and Thermal Field in Electrical Engineering

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.

Modeling and Application of Electromagnetic and Thermal Field in Electrical Engineering

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.

Electromagnetic and Thermal Analysis of Permanent Magnet Synchronous Machines

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.

Related with Electromagnetic And Thermal Modeling Of A Permanent Magnet: