

Jesse Zheng

**Optical  
Frequency-  
Modulated  
Continuous-  
Wave (FMCW)  
Interferometry**



Springer

# Optical Frequency Modulated Continuous Wave Fmcw Interferometry

**Adolf Goetzberger, Volker Uwe  
Hoffmann**



## **Optical Frequency Modulated Continuous Wave Fmcw Interferometry:**

Optical Frequency-Modulated Continuous-Wave (FMCW) Interferometry Jesse Zheng, 2005-08-25 Optical interference plays a prominent role in scientific discovery and modern technology Historically optical interference was instrumental in establishing the wave nature of light Nowadays optical interference continues to be of great importance in areas such as spectroscopy and metrology Thus far the physical optics literature has discussed the interference of optical waves with the same single frequency i e homodyne interference and the interference of optical waves with two different frequencies i e heterodyne interference but it hardly ever deals with the interference of optical waves whose frequencies are continuously modulated i e frequency modulated continuous wave interference Frequency modulated continuous wave FMCW interference which was originally investigated in radar in the 1950s has been recently introduced in optics The study of optical FMCW interference not only updates our knowledge about the nature of light but also creates a new advanced technology for precision measurements This book introduces the principles applications and signal processing of optical FMCW interference The layout of this book is straightforward Chapter 1 gives a short introduction to optical FMCW interferometry by considering the historical development general concepts and major advantages provided by this new technology Chapter 2 focuses on the principles of optical FMCW interference Three different versions of optical FMCW interference sawtooth wave optical FMCW interference triangular wave optical FMCW interference and sinusoidal wave optical FMCW interference are discussed in detail Moreover multiple beam optical FMCW interference and multip wavelength optical FMCW interference are also discussed by this chapter

**Sensors, Optical Sensors** Wolfgang Göpel, Joachim Hesse, J. N. Zemel, 2008-09-26 Sensors is the first self contained series to deal with the whole area of sensors It describes general aspects technical and physical fundamentals construction function applications and developments of the various types of sensors This volume provides a unique overview of optical sensors Fundamentals technical aspects applications and various measuring techniques in the wide field of optics are described It also covers light propagation its measurement the principles of photoelectric conversion as well as a survey of light sources detectors and different kinds of optical parts Five chapters describe detection schemes depending on wavelength phase and pulsetime It also presents topics such as Instruments approved in industry and novel concepts of optical sensors Fiber and integrated optics as more recent techniques Different techniques of optical sensing such as machine vision and signal processing and for the determination surface morphology and deformation are covered This volume is an indispensable reference work and text book for both specialists and newcomers researchers and developers

**Sensor Systems Simulations** Willem Dirk van Driel, Oliver Pyper, Cornelia Schumann, 2019-06-18 This book describes for readers various technical outcomes from the EU project IoSense The authors discuss sensor integration including LEDs dust sensors LIDAR for automotive driving and 8 more demonstrating their use in simulations for the design and fabrication of sensor systems Readers will benefit from the coverage of topics such as sensor technologies for both

discrete and integrated innovative sensor devices suitable for high volume production electrical mechanical security and software resources for integration of sensor system components into IoT systems and IoT enabling systems and IoT sensor system reliability Describes from component to system level simulation how to use the available simulation techniques for reaching a proper design with good performance Explains how to use simulation techniques such as Finite Elements Multi body Dynamic stochastics and many more in the virtual design of sensor systems Demonstrates the integration of several sensor solutions thermal dust occupancy distance awareness and more into large scale system solutions in several industrial domains Lighting automotive transport and more Includes state of the art simulation techniques both multi scale and multi physics for use in the electronic industry

**Optical Nonlinearities in Chalcogenide Glasses and Their Applications** A. Zakery, S.R. Elliott, 2007-06-19 This book reviews techniques used to characterize non linear optical constants of chalcogenide glasses in bulk or thin films and presents the properties of many chalcogenide systems A range of applications of these glasses are surveyed including ultra fast switching optical limiting second harmonic generation and electro optic effects Also addressed are suitability of chalcogenide films in all optical integrated circuits fabrication of rib as well as ridge waveguides and of fiber gratings

**Laser Ablation and Its Applications** Claude Phipps, 2007 Laser ablation describes the interaction of intense optical fields with matter in which atoms are selectively driven off by thermal or nonthermal mechanisms This is the first book that combines the most recent results in this rapidly advancing field with authoritative treatment of laser ablation and its applications including the physics of high power laser matter interaction

*Photovoltaic Solar Energy Generation* Adolf Goetzberger, Volker Uwe Hoffmann, 2005-09-06 The intention of this book is to provide an impression of all aspects of photovoltaics PV It is not just about physics and technology or systems but it looks beyond that at the entire environment in which PV is embedded The first chapter is intended as an introduction to the subject It can also be considered an executive summary Chapters 2-4 describe very briefly the basic physics and technology of the solar cell The silicon cell is the vehicle for this description because it is the best understood solar cell and also has the greatest practical importance A reader who is not interested in the physical details of the solar cell can skip Chap 2 and still understand the rest of the book In general it was the intention of the authors to keep the book at a level that does not require too much previous knowledge of photovoltaics Chapter 5 is devoted to other materials and new concepts presently under development or consideration It intends to provide an impression of the many possibilities that exist for the conversion of solar radiation into electricity by solid state devices These new concepts will keep researchers occupied for decades to come Chapter 6 gives an introduction to cell and module technology and also informs the reader about the environmental compatibility and recycling of modules The following chapters are devoted to practical applications Chapters 7 and 8 introduce systems technology for different applications The environmental impact of PV systems and their reliability is the subject of Chap 9

**Semiconductor Lasers** Junji Ohtsubo, 2006 This monograph describes fascinating recent progress in the field of chaos stability and instability of

semiconductor lasers Applications and future prospects are discussed in detail The book emphasizes the various dynamics induced in semiconductor lasers by optical and electronic feedback optical injection and injection current modulation Recent results of both theoretical and experimental investigations are presented Demonstrating applications of semiconductor laser chaos control and noise Semiconductor Lasers describes suppression and chaotic secure communications For those who are interested in optics but not familiar with nonlinear systems a brief introduction to chaos analysis is presented

**Quantum Well Infrared Photodetectors** Harald Schneider, Hui C. Liu, 2006-10-18 Addressed to both students as a learning text and scientists engineers as a reference this book discusses the physics and applications of quantum well infrared photodetectors QWIPs It is assumed that the reader has a basic background in quantum mechanics solid state physics and semiconductor devices To make this book as widely accessible as possible the treatment and presentation of the materials is simple and straightforward The topics for the book were chosen by the following criteria they must be well established and understood and they should have been or potentially will be used in practical applications The monograph discusses most aspects relevant for the field but omits at the same time detailed discussions of specialized topics such as the valence band quantum wells

**Transmission Electron Microscopy** Ludwig Reimer, Helmut Kohl, 2008-08-28 The aim of this monograph is to outline the physics of image formation electron specimen interactions and image interpretation in transmission electron microscopy Since the last edition transmission electron microscopy has undergone a rapid evolution The introduction of monochromators and proved energy filters has allowed electron energy loss spectra with an energy resolution down to about 0.1 eV to be obtained and aberration correctors are now available that push the point to point resolution limit down below 0.1 nm After the untimely death of Ludwig Reimer Dr Koelsch from Springer Verlag asked me if I would be willing to prepare a new edition of the book As it had served me as a reference for more than 20 years I agreed without hesitation Distinct from more specialized books on specific topics and from books intended for classroom teaching the Reimer book starts with the basic principles and gives a broad survey of the state of the art methods complemented by a list of references to allow the reader to find further details in the literature The main objective of this revised edition was therefore to include the new developments but leave the character of the book intact The presentation of the material follows the format of the previous edition as outlined in the preface to that volume which immediately follows A few derivations have been modified to correspond more closely to modern textbooks on quantum mechanics scattering theory or solid state physics

Surface Plasmon Nanophotonics Mark L. Brongersma, Pieter G. Kik, 2007-09-18 This book discusses a new class of photonic devices known as surface plasmon nanophotonic structures The book highlights several exciting new discoveries while providing a clear discussion of the underlying physics the nanofabrication issues and the materials considerations involved in designing plasmonic devices with new functionality Chapters written by the leaders in the field of plasmonics provide a solid background to each topic

Progress in Nano-Electro-Optics V Motoichi Ohtsu, 2007-01-10 Focusing on nanophotonics

which has been proposed by M Ohtsu in 1993 this volume begins with theories for operation principles of characteristic nanophotonic devices and continues with novel optical near field phenomena for fabricating nanophotonic devices Further topics include unique properties of optical near fields and their applications to operating nanophotonic devices and nanophotonic information and communications systems that can overcome the integration density limit with ultra low power operation as well as unique functionalities Taken as a whole this overview will be a valuable resource for engineers and scientists working in the field of nano electro optics

*Integrated Ring Resonators* Dominik G. Rabus, 2007-04-26 The optical filter is resonator based The required passband shape of ring resonator filters can be custom designed by the use of configurations of various ring coupled resonators This book describes the current state of the art on these devices It provides an in depth knowledge of the simulation fabrication and characterization of ring resonators for use as example filters lasers sensors

*Solid-State Laser Engineering* Walter Koechner, 2007-11-06 This book written from an industrial vantage point describes the characteristics design and operation of solid state lasers As the title implies the emphasis is placed on the technical aspects of these systems rather than on theoretical concepts Lengthy mathematical derivations have been avoided because the theory is not treated as an end in itself but rather serves to explain the experimental results observed in the laboratory However there is sufficient theoretical background provided in each chapter to make the book self contained Solid State Laser Engineering is mainly intended for the practicing scientist or engineer who is interested in the design or use of solid state lasers The response from readers has shown that the comprehensive treatment of the subject makes the work useful also to students of laser physics who want to supplement their theoretical knowledge with the engineering aspects of lasers Although not written in the form of a college text the book might be used in an advanced college course on laser technology After a historical overview the book starts with a review of the basic concepts of laser physics Chap 1 Analytical expressions of the threshold condition gain and output of laser oscillators are derived in Chap 3 An oscillator followed by one or more amplifiers is a common architecture in pulsed solid state laser systems to boost output energy Energy storage and gain of amplifiers is discussed in Chap 4 Four chapters deal with the basic subsystems of solid state lasers These are the active medium the optical resonator the pumping system and the thermal management Properties of solid state laser hosts and active ions are reviewed in Chap 2

High Power Diode Lasers Friedrich Bachmann, Peter Loosen, Reinhart Poprawe, 2007-05-26 This book summarizes a five year research project as well as subsequent results regarding high power diode laser systems and their application in materials processing The text explores the entire chain of technology from the semiconductor technology through cooling mounting and assembly beam shaping and system technology to applications in the processing of such materials as metals and polymers Includes theoretical models a range of important parameters and practical tips

**Optoelectronics of Molecules and Polymers** André Moliton, 2010-05-30 Optoelectronic devices are currently being developed at an extraordinary rate Organic light

emitting diodes photovoltaic devices and electro optical modulators are pivotal to the future of displays photosensors and solar cells and communication technologies This book details the theories underlying the mechanisms involved in the relevant organic materials and covers at a basic level how the organic components are made The first part of the book introduces the fundamental theories used to describe ordered solids and goes onto detail on concepts applicable to localised energy levels Then the methods used to determine energy levels particular to perfectly ordered molecular and macromolecular systems are discussed along with a detailed consideration of the effects of quasi particles The function of excitons and their transfer between two molecules is studied and in addition the problems associated with interfaces and charge injection into resistive media are presented More technological aspects are covered in the second part which details the actual methods used to fabricate devices based on organic materials such as dry etching The principal characterisation techniques are also highlighted Specific attention is paid to visual displays using organic light emitting diodes the conversion of photons into electrical energy the photovoltaic effect and for communications and information technologies the electro optical modulation of signals

*Spatial Filtering Velocimetry* Yoshihisa Aizu, Toshimitsu Asakura, 2006-01-04 The invention of lasers in the early 1960s enhanced the rapid development of optoelectronics which had introduced various optical measurement methods A typical example of the methods is found in measurements of velocity It is well recognized that optical velocity measuring methods have important advantages such as noncontacting and nondisturbing operations over conventional methods employed previously These fundamental advantages are indicated by the enormous research effort which has gone into their development for many years One of the optical methods proposed and studied to measure the velocity is laser Doppler velocimetry which was proposed in the early 1960s and extensively studied by many investigators and is at present applied to practical uses Another is spatial filtering velocimetry which was also proposed in the early 1960s and studied by a number of investigators In comparison with laser Doppler velocimetry spatial filtering velocimetry had not received much attention from investigators but was studied steadily by several research groups mainly in Japan and is now practically used in various fields of engineering Several important books on laser Doppler velocimetry have already been published but there has been no book on spatial filtering velocimetry This book is the first contribution to spatial filtering velocimetry Therefore the Introduction of Chapter 1 provides in detail a historical review of spatial filtering velocimetry relating it to other optical methods and discussing its practical relevance In the book following Chap

*Polarization Optics in Telecommunications* Jay N. Damask, 2005-08-25 I have written this book to fill a void between theory and practice a void that I perceived while conducting my own research and development of components and instruments over the last years In the chapters that follow I have pulled materials from the technical and patent literature that are relevant to the understanding and practice of polarization optics in telecommunications material that is often known by the respective experts in industry and academia but is rarely if ever found in one place By bringing this material into one monograph and by

applying a single formalism throughout I hope to create a base level upon which future research and development can grow Polarization optics in telecommunications is an ever evolving field Each year significant advancements are made punctuated by important discoveries The references upon which this book is based are only a snapshot in time Areas that remain unresolved at the time of publication may very well be clarified in the years to come Moreover the focus of the field changes in time for instance there have been few passive nonreciprocal component advancements reported in the last few years but PMD and PDL advancement continues with only modest abatement

**Light Scattering by Systems of Particles** Adrian Doicu, Thomas Wriedt, Yuri A. Eremin, 2006-10-19 This book develops the theory of the null field method also called T matrix method covering almost all aspects and current applications This book also incorporates FORTRAN programs and simulation results Worked examples of the application of the FORTRAN programs show readers how to adapt or modify the programs for their specific application

*Wavelength Filters in Fibre Optics* Herbert Venghaus, 2006-09-21 Information and communication technologies have been growing and developing steadily for as long as any of us can remember Growth was particularly strong in the last few decades and fibre optic communication systems have become predominant whenever information is to be transmitted over medium or long distances Even when the telecommunication bubble burst at the beginning of the new millennium the only thing which vanished was the expectation of making a fortune by buying and reselling telecom device and equipment manufacturing companies the upgrading of existing fibre optic links and the deployment of new ones continued unabated The reason for the predominance of communication via optical fibres is the vast amount of information a single fibre can carry However in order to take advantage of this potential it is mandatory to transmit different wavelength channels simultaneously over a single optical fibre and the handling of these wavelength channels requires wavelength selective devices or wavelength filters Among the functionalities optical filters have to accomplish are the selection of single or several channels out of a larger number of channels the separation of one channel wavelength from unwanted spurious noise at different wavelengths filters have to support routing enable the lossless or low loss combination of wavelengths and they have to compensate for wavelength dispersion effects

*Laser Resonators and Beam Propagation* Norman Hodgson, Horst Weber, 2005-12-19 Optical Resonators provides a detailed discussion of the properties of optical resonators for lasers from basic theory to recent research In addition to describing the fundamental theories of resonators such as geometrical optics diffraction and polarisation the characteristics of all important resonator schemes and their calculation are presented Experimental examples practical problems and a collection of measurement techniques support the comprehensive treatment of the subject Optical Resonators is the only book currently available that provides a comprehensive overview of the the subject Combined with the structure of the text and the autonomous nature of the chapters this work will be as suitable for those new to the field as it will be invaluable to specialists conducting research This second edition has been enlarged by new sections on Q switching and resonators with internal phase amplitude control



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