

Mark R. Hornung and Oliver Brand

**MICROMACHINED  
ULTRASOUND-BASED  
PROXIMITY  
SENSORS**



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# Micromachined Ultrasound Based Proximity Sensors Microsystems

**S.G.K. Ananthasuresh**



## **Micromachined Ultrasound Based Proximity Sensors Microsystems:**

*Micromachined Ultrasound-Based Proximity Sensors* Mark R. Hornung, Oliver Brand, 1999-04-30 *Micromachined Ultrasound Based Proximity Sensors* presents a packaged ultrasound microsystem for object detection and distance metering based on micromachined silicon transducer elements It describes the characterization optimization and the long term stability of silicon membrane resonators as well as appropriate packaging for ultrasound microsystems *Micromachined Ultrasound Based Proximity Sensors* describes a cost effective approach to the realization of a micro electro mechanical system MEMS The micromachined silicon transducer elements were fabricated using industrial IC technology combined with standard silicon micromachining techniques Additionally this approach allows the cointegration of the driving and read out circuitry To ensure the industrial applicability of the fabricated transducer elements intensive long term stability and reliability tests were performed under various environmental conditions such as high temperature and humidity Great effort was undertaken to investigate the packaging and housing of the ultrasound system which mainly determine the success or failure of an industrial microsystem A low stress mounting of the transducer element minimizes thermomechanical stress influences The developed housing not only protects the silicon chip but also improves the acoustic performance of the transducer elements The developed ultrasound proximity sensor system can determine object distances up to 10 cm with an accuracy of better than 0.8 mm *Micromachined Ultrasound Based Proximity Sensors* will be of interest to MEMS researchers as well as those involved in solid state sensor development

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Mark R. Hornung, Oliver Brand, 2012-12-06 *Micromachined Ultrasound Based Proximity Sensors* presents a packaged ultrasound microsystem for object detection and distance metering based on micromachined silicon transducer elements It describes the characterization optimization and the long term stability of silicon membrane resonators as well as appropriate packaging for ultrasound microsystems *Micromachined Ultrasound Based Proximity Sensors* describes a cost effective approach to the realization of a micro electro mechanical system MEMS The micromachined silicon transducer elements were fabricated using industrial IC technology combined with standard silicon micromachining techniques Additionally this approach allows the cointegration of the driving and read out circuitry To ensure the industrial applicability of the fabricated transducer elements intensive long term stability and reliability tests were performed under various environmental conditions such as high temperature and humidity Great effort was undertaken to investigate the packaging and housing of the ultrasound system which mainly determine the success or failure of an industrial microsystem A low stress mounting of the transducer element minimizes thermomechanical stress influences The developed housing not only protects the silicon chip but also improves the acoustic performance of the transducer elements The developed ultrasound proximity sensor system can determine object distances up to 10 cm with an accuracy of better than 0.8 mm *Micromachined Ultrasound Based Proximity Sensors* will be of interest to MEMS researchers as well as those involved in solid state sensor development

*Principles and Applications of NanoMEMS Physics* Hector Santos, 2006-07-02 *Principles and Applications of NanoMEMS Physics* presents the first unified exposition of the physical principles at the heart of NanoMEMS based devices and applications. In particular, after beginning with a comprehensive presentation of the fundamentals and limitations of nanotechnology and MEMS fabrication techniques, the book addresses the physics germane to this dimensional regime, namely quantum wave particle phenomena including the manifestation of charge discreteness, quantized electrostatic actuation and the Casimir effect, and quantum wave phenomena including quantized electrical conductance, quantum interference, Luttinger liquids, quantum entanglement, superconductivity, and cavity quantum electrodynamics. Potential building blocks are also addressed for NanoMEMS applications, including nanoelectromechanical quantum circuits and systems such as charge detectors, the which path electron interferometer, and the Casimir oscillator, as well as a number of quantum computing implementation paradigms. Finally, NanoMEMS applications in photonics are addressed, including nanophotonic light sources and plasmonic devices.

**Micromachined Mirrors** Robert Conant, 2013-04-17 *Micromachined Mirrors* provides an overview of the performance enhancements that will be realized by miniaturizing scanning mirrors like those used for laser printers and barcode scanners, and the newly enabled applications, including raster scanning projection video displays and compact high speed fiber optic components. There are a wide variety of methods used to fabricate micromachined mirrors, each with its advantages and disadvantages. There are, however, performance criteria common to mirrors made from any of these fabrication processes. For example, optical resolution is related to the mirror aperture, the mirror flatness, and the scan angle. *Micromachined Mirrors* provides a framework for the design of micromirrors and derives equations showing the fundamental limits for micromirror performance. These limits provide the micromirror designer tools with which to determine the acceptable mirror geometries and to quickly and easily determine the range of possible mirror optical resolution and scan speed.

**Microfabrication in Tissue Engineering and Bioartificial Organs** Sangeeta N. Bhatia, 2012-12-06 The Microsystems Series has as its goal the creation of an outstanding set of textbooks, references, and monographs on subjects that span the broad field of microsystems. Exceptional PhD dissertations provide a good starting point for such a series, because unlike monographs by more senior authors, which must compete with other professional duties for attention, the dissertation becomes the sole focus of the author until it is completed. Conversion to book form is then a streamlined process, with final editing and book production completed within a few months. Thus, we are able to bring important and timely material into book form at a pace which tracks this rapidly developing field. Our first four books in the series were drawn from the more physics oriented side of the microsystems field, including such diverse subjects as computer aided design, atomic force microscopy, and ultrasonic motion detection. Now, with Sangeeta Bhatia's work, we enter the realm of biology. Her use of artificially structured substrates to encourage the liver cells to form orderly assemblies is a fine example of how microfabrication technology can contribute to cell biology and medicine. I am pleased to be able to add this very new

and very interesting work to the Microsystems Series Stephen D Senturia Cambridge MA Microfabrication in Tissue Engineering and Bioartificial Organs Foreword One of the emerging applications of microsystems technology in biology and medicine is in the field of tissue engineering and artificial organs In order to function cells need to receive proper signals from their environment Optical Microscanners and Microspectrometers using Thermal Bimorph Actuators Gerhard Lammel, Sandra Schweizer, Philippe Renaud, 2013-03-09 Optical Microscanners and Microspectrometers using Thermal Bimorph Actuators shows how to design and fabricate optical microsystems using innovative technologies and original architectures A barcode scanner laser projection mirror and a microspectrometer are explained in detail starting from the system conception discussing simulations choice of cleanroom technologies design fabrication device test packaging all the way to the system assembly An advanced microscanning device capable of one and two dimensional scanning can be integrated in a compact barcode scanning system composed of a laser diode and adapted optics The original design of the microscanner combines efficiently the miniaturized thermal mechanical actuator and the reflecting mirror providing a one dimensional scanning or an unique combination of two movements depending on the geometry The simplicity of the device makes it a competitive component The authors rethink the design of a miniaturized optical device and find a compact solution for a microspectrometer based on a tunable filter and a single pixel detector A porous silicon technology combines efficiently the optical filter function with a thermal mechanical actuator on chip The methodology for design and process calibration are discussed in detail The device is the core component of an infrared gas spectrometer **Scanning Probe Lithography** Hyongsok T. Soh, Kathryn Wilder Guarini, Calvin F. Quate, 2013-03-14 Scanning Probe Lithography SPL describes recent advances in the field of scanning probe lithography a high resolution patterning technique that uses a sharp tip in close proximity to a sample to pattern nanometer scale features on the sample SPL is capable of patterning sub 30nm features with nanometer scale alignment registration It is a relatively simple inexpensive reliable method for patterning nanometer scale features on various substrates It has potential applications for nanometer scale research for maskless semiconductor lithography and for photomask patterning The authors of this book have been key players in this exciting new field Calvin Quate has been involved since the beginning in the early 1980s and leads the research time that is regarded as the foremost group in this field Hyongsok Tom Soh and Kathryn Wilder Guarini have been the members of this group who in the last few years have brought about remarkable series of advances in SPM lithography Some of these advances have been in the control of the tip which has allowed the scanning speed to be increased from  $\mu\text{m/s}$  to  $\text{mm/s}$  Both non contact and in contact writing have been demonstrated as has controlled writing of sub 100 nm lines over large steps on the substrate surface The engineering of a custom designed MOSFET built into each microcantilever for individual current control is another notable achievement Micromachined arrays of probes each with individual control have been demonstrated One of the most intriguing new aspects is the use of directly grown carbon nanotubes as robust high resolution emitters In this book

the authors concisely and authoritatively describe the historical context the relevant inventions and the prospects for eventual manufacturing use of this exciting new technology **Heat Convection in Micro Ducts** Yitshak Zohar,2013-03-09

As the field of Microsystems expands into more disciplines and new applications such as RF MEMS Optical MEMS and Bio MEMS thermal management is becoming a critical issue in the operation of many microdevices including microelectronic chips Heat Convection in Micro Ducts focuses on the fundamental physics of convective heat transfer in microscale and specific applications such as microchannel heat sinks micro heat pipes microcoolers and micro capillary pumped loops This book will be of interest to the professional engineer and graduate student interested in learning about heat removal and temperature control in advanced integrated circuits and microelectromechanical systems **Microfluidics and BioMEMS Applications** Francis E. H. Tay,2013-04-17

Microfluidics and BioMEMS Applications central idea is on microfluidics a relatively new research field which finds its niche in biomedical devices especially on lab on a chip and related products Being the essential component in providing driving fluidic flows an example of micropump is chosen to illustrate a complete cycle in development of microfluidic devices which include literature review designing and modelling fabrication and testing A few articles are included to demonstrate the idea of tackling this research problem and they cover the main development scope discussed earlier as well as other advanced modelling schemes for microfluidics and beyond Scientists and students working in the areas of MEMS and microfluidics will benefit from this book which may serve both communities as both a reference monograph and a textbook for courses in numerical simulation and design and development of microfluidic devices

**Optimal Synthesis Methods for MEMS** S.G.K. Ananthasuresh,2012-12-06 The field of microelectromechanical systems or MEMS has gradually evolved from a discipline populated by a small group of researchers to an enabling technology supporting a variety of products in such diverse areas as mechanical and inertial sensors optical projection displays telecommunications equipment and biology and medicine Critical to the success of these products is the ability to design them and this invariably involves detailed modeling of proposed designs Over the past twenty years such modeling has become increasingly sophisticated with full suites of MEMS oriented computer aided design tools now available worldwide But there is another equally important side to the design process In my own book Microsystem figuring out what to build in the first place Design I chose to emphasize the modeling aspect of design The task of figuring out what to build was defined by a vague step called creative thinking I used practical product examples to illustrate the many subtle characteristics of successful designs but I made no attempt to systematize the generation of design proposals or optimized designs That systemization is called synthesis which is the subject of this book Microscale Heat Conduction in Integrated Circuits and Their Constituent Films Y. Sungtaek Ju,Kenneth E. Goodson,2012-12-06

The study of thermal phenomena in microdevices has attracted significant attention recently The interdisciplinary nature of this topic however makes it very difficult for researchers to fully understand details of research results presented in journal articles For many researchers intending to be

active in this field therefore a more comprehensive treatment complete with sufficient background information is urgently needed Advances in semiconductor device technology render the thermal characterization and design of ICs increasingly more important The present book discusses experimental and theoretical studies of heat transfer in transistors and interconnects A novel optical thermometry technique captures temperature fields with high temporal and spatial failures in devices that are subjected to electrical overstress EOS and electrostatic discharge ESD Also reported are techniques for determining the thermal transport properties of dielectric passivation layers and ultra thin silicon on insulator SOI layers Theoretical analysis on the data yields insight into the dependence of thermal properties on film processing conditions The techniques and data presented here will greatly aid the thermal engineering of interconnects and transistors *Materials & Process Integration for MEMS* Francis E. H. Tay, 2013-06-29 The field of materials and process integration for MEMS research has an extensive past as well as a long and promising future Researchers academicians and engineers from around the world are increasingly devoting their efforts on the materials and process integration issues and opportunities in MEMS devices These efforts are crucial to sustain the long term growth of the MEMS field The commercial MEMS community is heavily driven by the push for profitable and sustainable products In the course of establishing high volume and low cost production processes the critical importance of materials properties behaviors reliability reproducibility and predictability as well as process integration of compatible materials systems become apparent Although standard IC fabrication steps particularly lithographic techniques are leveraged heavily in the creation of MEMS devices additional customized and novel micromachining techniques are needed to develop sophisticated MEMS structures One of the most common techniques is bulk micromachining by which micromechanical structures are created by etching into the bulk of the substrates with either anisotropic etching with strong alk ali solution or deep reactive ion etching DRIB The second common technique is surface micromachining by which planar microstructures are created by sequential deposition and etching of thin films on the surface of the substrate followed by a final removal of sacrificial layers to release suspended structures Other techniques include deep lithography and plating to create metal structures with high aspect ratios LIGA micro electrodischarge machining J Microtransducer CAD Arokia Nathan, Henry Baltes, 2012-12-06 Computer aided design CAD of semiconductor microtransducers is relatively new in contrast to their counterparts in the integrated circuit world Integrated silicon microtransducers are realized using microfabrication techniques similar to those for standard integrated circuits ICs Unlike IC devices however microtransducers must interact with their environment so their numerical simulation is considerably more complex While the design of ICs aims at suppressing parasitic effects microtransducers thrive on optimizing the one or the other such effect The challenging quest for physical models and simulation tools enabling microtransducer CAD is the topic of this book The book is intended as a text for graduate students in Electrical Engineering and Physics and as a reference for CAD engineers in the microsystems industry **CMOS Cantilever Sensor Systems** D. Lange, O. Brand, H.

Baltes,2013-04-17 This book is intended for scientists and engineers in the field of micro and nano electro mechanical systems MEMS and NEMS and introduces the development of cantilever based sensor systems using CMOS compatible micromachining from the design concepts and simulations to the prototype It is also a useful resource for researchers on cantilever sensors and resonant sensors in general The reader will become familiar with the potential of the combination of two technological approaches IC fabrication technology notably CMOS technology and silicon micromachining and the resulting microstructures such as cantilever beams It was recognized early that these two technologies should be merged in order to make the microstructures smart and devise integrated microsystems with on chip driving and signal conditioning circuitry now known as CMOS MEMS or with the arrival of nanostructures CMOS NEMS One way to achieve the merger is the post processing micro or nano machining of finished CMOS wafers some of which is described in this book The book introduces this approach based on work carried out at the Physical Electronics Laboratory of ETH Zurich on arrays of cantilever transducers with on chip driving and signal conditioning circuitry These cantilevers are familiar from Scanning Probe Microscopy SPM and allow the sensitive detection of physical quantities such as forces and mass changes The book is divided into three parts First general aspects of cantilever resonators are introduced e g their resonant behavior and possible driving and sensing mechanisms *Dynamics of Microelectromechanical Systems* Nicolae Lobontiu,2007-10-03

Here is a textbook for senior undergraduate and graduate level students that offers a novel and systematic look into the dynamics of MEMS It includes numerous solved examples together with the proposed problems The material to be found here will also be of interest to researchers with a non mechanical background The book focuses on the mechanical domain specifically the dynamic sub domain and provides an in depth treatment of problems that involve reliable modeling analysis and design **CMOS - MEMS** Henry Baltes,Oliver Brand,Gary K. Fedder,Christofer Hierold,Jan G. Korvink,Osamu

Tabata,2013-03-26 This edition of CMOS MEMS was originally published in the successful series Advanced Micro Nanosystems Here the combination of the globally established billion dollar chip mass fabrication technology CMOS with the fascinating and commercially promising new world of MEMS is covered from all angles The book introduces readers to this field and takes them from fabrication technologies and material characterization aspects to the actual applications of CMOS MEMS a wide range of miniaturized physical chemical and biological sensors and RF systems Vital knowledge on circuit and system integration issues concludes this in depth treatise illustrating the advantages of combining CMOS and MEMS in the first place rather than having a hybrid solution *American Book Publishing Record* ,1999 **Sensors Update: Sensor**

**technology, applications, markets** Henry Baltes,W. Göpel,J. Hesse,1998 Smart Sensors and MEMS S Nihtianov,A.

Luque,2014-03-24 Smart sensors and MEMS can include a variety of devices and systems that have a high level of functionality They do this either by integrating multiple sensing and actuating modes into one device or else by integrating sensing and actuating with information processing analog to digital conversion and memory functions Part one outlines the



industrial applications for smart sensors covering direct interface circuits for sensors capacitive sensors for displacement measurement in the sub nanometer range integrated inductive displacement sensors for harsh industrial environments advanced silicon radiation detectors in the vacuum ultraviolet VUV and extreme ultraviolet EUV spectral range and advanced optical incremental sensors encoders and interferometers among other topics The second part of the book describes the industrial applications of smart micro electro mechanical systems MEMS Some of the topics covered in this section include microfabrication technologies used for creating smart devices for industrial applications microactuators dynamic behaviour of smart MEMS in industrial applications MEMS integrating motion and displacement sensors MEMS print heads for industrial printing Photovoltaic and fuel cells in power MEMS for smart energy management and radio frequency RF MEMS for smart communication microsystems Smart sensors and MEMS is invaluable reference for academics materials scientists and electrical engineers working in the microelectronics sensors and micromechanics industry and engineers looking for industrial sensing monitoring and automation solutions Outlines industrial applications for smart sensors and smart MEMS Covers smart sensors including capacitive inductive resistive and magnetic sensors and sensors to detect radiation and measure temperature Covers smart MEMS including power MEMS radio frequency MEMS optical MEMS inertial MEMS and microreaction chambers

*Praxiswissen Mikrosystemtechnik* Friedemann Völklein, Thomas Zetterer, 2008-10-08 1 1 Von der Mikroelektronik zur Mikrosystemtechnik Es gibt zweifellos kein Gebiet der Wissenschaft und Technik des 20. Jahrhunderts das eine vergleichbar stürmische Entwicklung erfahren hat wie die Mikroelektronik in den vergangenen 50 Jahren Mit der Erfindung des Transistors 1948 und der Herstellung erster integrierter Schaltungen auf der Basis des Halbleitermaterials Silizium 1958 begann eine technische Revolution die mit ihren Ergebnissen und Produkten inzwischen in fast alle Lebensbereiche unserer Gesellschaft hineinwirkt Ohne die Erfolge der Mikroelektronik wäre die moderne Informations- und Kommunikationstechnik die inzwischen die Berufswelt vieler Menschen wesentlich verändert hat nicht denkbar Das gilt auch für andere Bereiche wie z.B. die Medizin die Verkehrs- und die Produktionstechnik Der große technologische Fortschritt der Mikroelektronik beruht auf Miniaturisierung und Integration Vor der Mikroelektronik wurden elektrische elektronische Schaltungen aus mechanisch gefertigten Bauteilen wie Kondensatoren Widerständen oder Elektronenröhren samengefügt und individuell abgeglichen Aufgrund der Größe der Bauelemente war der Platzbedarf und das Gewicht hoch die Packungs- und Funktionsdichte gering Durch die Mikroelektronik wandelte sich die Fertigung elektronischer Systeme grundlegend Die Bauelemente einer Schaltung wurden nun durch photolithographische Strukturierung und durch Schichttechnologien auf einem gemeinsamen Halbleiter-Substrat dem Siliziumwafer erzeugt

## Unveiling the Magic of Words: A Overview of "**Micromachined Ultrasound Based Proximity Sensors Microsystems**"

In some sort of defined by information and interconnectivity, the enchanting power of words has acquired unparalleled significance. Their capability to kindle emotions, provoke contemplation, and ignite transformative change is actually awe-inspiring. Enter the realm of "**Micromachined Ultrasound Based Proximity Sensors Microsystems**," a mesmerizing literary masterpiece penned with a distinguished author, guiding readers on a profound journey to unravel the secrets and potential hidden within every word. In this critique, we shall delve in to the book is central themes, examine its distinctive writing style, and assess its profound effect on the souls of its readers.

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### **Micromachined Ultrasound Based Proximity Sensors Microsystems Introduction**

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