Development Of Ultrasonic Transducer For In Situ High

The objective of this research is to enable deployment of Ultrasonic Thermometers (UTs) in irradiations of ceramic and metallic fuels. Research was broken into two main areas; out-of-core development and testing of the UT and its components in a laboratory environment and in-core assessment of the radiation tolerance of the magnetostrictive transducers used to generate and sense the acoustic signals. Significant progress was made toward the deployment of UTs. Appropriate sensor materials were identified. For applications below 1000 °C stainless steel was identified. For temperatures between 1000 and 2500 °C, a variety of molybdenum doped with tungsten and potassium silicate was selected. A new, high frequency coil was developed and used to improve spatial resolution of reflectors by allowing minimization of reflector spacing. This effect is enhanced by the use of a new method of damping developed to remove “back end” reflections, eliminating interference caused by them and simplifying signal processing. A signal processing method was also identified and tested, which changed the difficult identification of Gaussian sinusoids into simple peak detection. An irradiation test capsule design was developed that includes both piezoelectric and magnetostrictive materials, transducers, and sensors. It is the first to include both piezoelectric and magnetostrictive materials, and is scheduled to surpass other ultrasonic transducer irradiations in terms of total fluence. As part of this research, a new design of magnetostrictive transducers was developed, fabricated, evaluated in a laboratory setting, and included in this irradiation test. The irradiation test was initiated to identify transducer materials that can survive in a high radiation environment. The included transducers were operated online during irradiation; and the test capsule was heavily instrumented with real time sensors, resulting in a high degree of confidence in the results. The results shows ultrasonic transducers based on magnetostrictive materials, such as Remendur and Galfenol, to be highly resistant to degradation caused by neutron and gamma radiation.

An ultrasonic test technique was developed for the inspection of fuel plates, uranium alloy cores, amd fuel plates in subassemblies for the Experimental Boiling Water Reactor (EBWR). For these tests a special scanner was designed and fabricated. The equipment could serve as a research tool as well as being used for inspecting numerous items of diversified lengths and shapes. A transmission technique was used at am ultrasonic frequency of 5 megacycles. The mechanical motion of the inspecting transducers was synchronized to a helix recorder so as to provide a permanent two-dimensional recording on electrosensitive paper. It was possible to detect piping, shrink, porosity, inclusions and microinclusions in the uranium alloy castings. In the completed fuel plates, a nonbond area of 1/8 of an ineh in diameter could be located. With the construction of a special two-arm probe, fuel plates installed in subassemblies were successfully tested by a transmission technique. (auth).

Ultrasonic Transducer MaterialsSpringer Science & Business Media

This book presents a wealth of valuable up-to-date information for active researchers and engineers, and will certainly form a solid basis for any future research, in the field of abrasive technology, which is aimed at creating new and practical machine tools, systems and processes, or at identifying new characteristics.

This book was planned in order to announce the contents discussed in the 13th International Congress on the Ultrasound Examination of the Breast. Breast ultrasound has become a indispensable method for the diagnosis of cancer of the breast. Breast ultrasound will become more convenient and precise diagnostic method according to the development of the device. In addition, application to breast screening or medical check has started, on the other hand the interventional method has also developed.

Known as the bible of biomedical engineering, The Biomedical Engineering Handbook, Fourth Edition, sets the standard against which all other references of this nature are measured. As such, it has served as a major resource for both skilled professionals and novices to biomedical engineering.Biomedical Signals, Imaging, and Informatics, the third v

A correlation was developed between ultrasonic wave propagation factors and fracture toughness for Ti-6Al-6V-2Sn alloy. The important microstructural dimension for ultrasonic wave attenuation in this two-phase alloy appears to be the width of the .beta. phase between the needlelike .cap alpha.-phase subgrains. Test specimens must have flat and parallel surfaces and be coupled to the ultrasonic transducer by a thin, uniform couplant layer. Good impedance matching of the specimen-couplant-transducer combination to the ultrasonic pulser-receiver is necessary for obtaining acceptable echo waveforms. This technique is a research test and requires a very knowledgable operator for application to a two-phase metal.

This thesis presents the design and development of a microorganism activity monitoring transducer by using ultrasonic sensors as the main part in detecting the signal of microrganism activity.

This research work is focused on the development of a spherically focused (no-mirror) capacitive-film air-coupled ultrasonic transducer and a leak location array sensor for long-endurance spacecraft. For the development of a spherically focused capacitive-film air-coupled ultrasonic transducer, two transducers have been designed, fabricated, and their performance characterized, using a spherically deformed backplate and film. One has a 10-mm diameter and 25.4-mm geometric focal length, and another has a 50-mm diameter and 50.8-mm geometric focal length. Both spherically focused transducers have frequency spectra centered at 805 kHz with -6-dB points at 400 kHz and 1200 kHz. By performing rigorous feasibility tests, a flexible copper/polyimide circuit board material is employed as a backplate in place of the conventional silicon substrate. Utilizing its deformability and ease of microfabrication, we have demonstrated that spherically focused air-coupled ultrasonic transducers can be made to function without the need of an external focusing device, such as a zone plate or an acoustic mirror. We have also invented a simple and easily applied method to conform the metalized polymer film onto a spherically curved backplate, while suppressing wrinkling on the film. Good agreement has been shown between measurement and theory, suggesting that our transducers behave as ideal spherically focused piston transducers. For the development of a leak location array sensor for long-endurance spacecraft, we have developed and experimentally demonstrated a sensitive and reliable means to locate an air leak in a plate-like structure. The goals of this work are accomplished by developing a sophisticated leak location algorithm and a two-dimensional PZT array sensor. The proposed leak location algorithm is highly effective in finding the direction of the leaks, using a minimal number of sensors, and needing less computation time while still achieving high accuracy. In addition, it accounts for the multi-mode dispersive characteristics in a plate-like structure, and utilizes structure-borne noise generated by turbulence at an air leak. This leak location algorithm is implemented by a prototype of a 64-element array sensor.

Since Paul Langevins discovery of active sonar in 1917, ultrasound transducers have evolved in multiple forms that include single element, single element on a wedge, single element with cylindrical lens, single element with spherical lens, linear arrays, annular arrays, two- dimensional (2D) arrays, and phased arrays, among others. They have been applied in sound navigation and ranging (SONAR), structural health monitoring (SHM), nondestructive testing (NDT), nondestructive evaluation (NDE), medical/biomedical sensing/imaging, and biometric sensing/imaging. This dissertation focuses on the development of high frequency phased array transducers for two specific applications scanning acoustic microscopy, and biometric imaging for small electronics. Closed-loop finite element studies were conducted in three dimensions using PZFlex, a commercial finite-element method software. A 5 MHz, thickness-mode, linear array for an acoustic microscope, and a flexible 10 MHz, bending-mode, piezoelectric, micromachined ultrasonic transducer (PMUT) 2D array, plus a flexible 38 MHz bending-mode, PMUT 2D array for finger-print and finger-vein imaging, were virtually prototyped and their respective performances were predicted. The scanning acoustic microscope (SAM) has been a well-recognized tool for both visualization and quantitative evaluation of materials at the microscale, since its invention in 1974. While there have been multiple advances in SAM over the past four decades, some issues still remain to be addressed. First, the measurement speed is limited by the mechanical movement of the acoustic lens. Second, a single element transducer acoustic lens only delivers a predetermined beam pattern for a fixed focal length and incident angle, thereby limiting control of the inspection beam. Here, a development of a phased array probe as an alternative is proposed to overcome these issues. Preliminary studies to design a practical, high frequency, phased array, acoustic microscope probe were explored. A linear phased array, comprising 32 elements and operating at 5 MHz, was modeled using PZFlex. This phased array system was characterized in terms of electrical input impedance response, pulse-echo and impulse response, surface displacement profiles, mode shapes, and beam profiles.PMUT using lead-zirconate-titanate, PbZr0.52Ti0.48O3 (PZT), thin films are currently being investigated for miniaturized, high frequency, ultrasound systems, and their microfabrication processes explored. For example, Liu et al. developed a process to remove the PZT from an underlying rigid Si substrate, creating the potential for developing curved arrays [138, 139]. This dissertation aims to improve the design of flexible PMUT arrays by developing 3D models using PZFlex. A 10 MHz 2D array PMUT device, working in 3-1 bending mode, was designed. A circular unit-cell was structured from the top, comprising a platinum (Pt) electrode, a PZT active layer, a bottom Pt electrode and a titanium (Ti) passive layer, all placed concentrically on a polyimide (PI) substrate. The active PZT layer had a diameter of 46 m and a thickness of 1 m. The passive Ti layer was 59.8 m diameter and 1 m in thickness. The PI substrate was 20 m thick. Below the passive Ti layer, another 7 m thick PI passive layer and 13 m deep cavity with 46 m diameter was added concentric to the PZT layer. The dimensions were selected to have a resonance frequency at 10 MHz under water load and air backing. The pulse-echo and spectral response analysis of the unit-cell predicted its bandwidth to be 87%. Mode shapes of the unit-cell were modeled to discover undesirable cross coupling to higher modes. A 2D array, consisting of 256 (1616) unit-cells, was created and characterized in terms of pulse-echo response, spectral response, surface displacement profile, cross-talk, and beam profiles.Iterations to find a robust design of the flexible PMUT array with increased resonance frequency and low operating voltage were continued. A PMUT array has to be operated at very low voltage to be embedded and run in small electronic devices, such as smart-phones, and smart-watches. A 38 MHz, flexible, PMUT array operating at 3 Volt peak-to-peak (Vpp) driving voltage was designed. To achieve these goals, a unit-cell, consisting of four 3-1 bending mode diaphragms, were devised. The quad diaphragm unit-cell was structured with 40 m 40 m 500 nm PZT layer on top of 40 m 40 m 1 m Ti elastic layer which had four (22)10 m 10 m 5 m cavities beneath it. The cavities had 11 m of interspacing to next cavities. Four pairs of 10 m 10 m top and bottom Pt electrodes were placed concentrically with the cavities by sandwiching the PZT layer. The top and bottom Pt electrodes had thicknesses of 50 nm and 100 nm, respectively. A PI substrate was placed beneath the Ti layer, surrounding the cavities, with 8 m thick, including the 5 m deep cavities. The pulse-echo and spectral response analysis of the quad diaphragm unit-cell revealed its bandwidth to be 32.2 %. A 2D array was constructed with 1616 unit-cells, consisting of 1024 (3232) diaphragms. This array was evaluated in terms of pulse-echo response, spectral response, surface displacement profile, cross-talk, and beam profiles.

This volume contains the Proceedings of the International Workshop on the Design of Power Sonic and Ultrasonic Transducers, which was held in the Maison de l'Entreprise et des Technologies Nouvelles, Marcq en Baroeul, near Lille, France, on May 26 and 27, 1987. The main objective of this Workshop was to discuss all aspects of high power problems in the design of electroacoustic transducers and to stimulate an exchange of knowledge and experience between researchers and industrial ists involved in this multidisciplinary field. The scientific program included 13 invited contributions, and there were 80 participants from England, France, Italy, Spain, Sweden and the United States. The editors wish to thank the authors and attendees for their active par ticipation, and they hope that these Proceedings will allow readers to share in the stimulating atmosphere of the sessions. They also wish to thank eve ryone who undertook simultaneous translation, clerical work, typing of the Proceedings, production of the illustrations, or any other of the numerous tasks connected with this venture. Special mention has to be made of Mrs. E. Litton (ISEN, Lille) for her constant and kind help from the beginning of the project to the very end of the editing, Dr. R. Bossut (ISEN, Lille) for his efficient proofreading, and Dr. H.U. Daniel (Springer-Verlag) for his interest in these Proceedings as well as his kind and efficient support.

Special UT transducer parts, capable of focusing incident signals within a 25 mm x 25 mm x 25 mm volume in an austenitic stainless weld metal at depths that varied from 25 mm to 127 mm, were developed and demonstrated to be capable of detecting a defect with cross section equivalent to that of a 4.76 mm-dia flat-bottom hole. Defect length sizing could be accomplished to ±50% for 100% of the time and to ±25% on selected defect types as follows: porosity groups, 100%; cracks, 67%; combined slag and porosity, 60%; and linear slag indications, 59%. Extensive linear elastic-fracture-mechanics analyses were performed to establish allowable defect sizes at functions of stress, based on a cyclic-life criterion of 103 full power cycles of the MFTF-B magnet system. These defect sizes were used to determine which UT indicating were to be removed and repaired and which were to be retained and their recorded sizes and locations.

THIS PAPER DESCRIBES THE DEVELOPMENT OF A MANUALLY OPERATED MULTIPLE-TRANSDUCER ULTRASONIC PLATE-TESTER. THIS TESTER MAKES IT POSSIBLE TO DETECT INTERNAL DEFECTS IN PLATE STEEL IN LESS TIME THAN PREVIOUSLY

POSSIBLE. IN ADDITION, THE ULTRASONIC SIGNAL VARIATION CAUSED BY VARIATIONS IN THE COUPLING OF SOUND ENERGY TO A PLATE HAS BEEN REDUCED BY AN IMPROVED TRANSDUCER MOUNTING AND COUPLING ARRANGEMENT, A FEATURE WHICH PERMITS GREATER CONFIDENCE IN TEST RESULTS. THE DEVELOPMENTAL WORK- FROM INITIAL CONCEPTS THROUGH LABORATORY AND MILL TRIALS TO THE PRESENT FORM OF THE TESTER-IS OUTLINED. DESCRIBED IN DETAIL ARE THE DESIGN AND TESTING OF 1) THE ELECTRONIC INSTRUMENTATION, 2) THE TRANSDUCERS AND 3) THE ULTRASONIC COUPLING. OTHER POSSIBLE APPLICATIONS FOR THIS INSTRUMENT ARE NOTED.

Ultrasonic technologies offer the potential for high-accuracy and -resolution in-pile measurement of a range of parameters, including geometry changes, temperature, crack initiation and growth, gas pressure and composition, and microstructural changes. Many Department of Energy-Office of Nuclear Energy (DOE-NE) programs are exploring the use of ultrasonic technologies to provide enhanced sensors for in-pile instrumentation during irradiation testing. For example, the ability of small diameter ultrasonic thermometers (UTs) to provide a temperature profile in candidate metallic and oxide fuel would provide much needed data for validating new fuel performance models. Other ongoing efforts include an ultrasonic technique to detect morphology changes (such as crack initiation and growth) and acoustic techniques to evaluate fission gas composition and pressure. These efforts are limited by the lack of identified ultrasonic transducer materials capable of long term performance under irradiation test conditions. For this reason, the Pennsylvania State University (PSU) was awarded an ATR NSUF project to evaluate the performance of promising magnetostrictive and piezoelectric transducers in the Massachusetts Institute of Technology Research Reactor (MITR) up to a fast fluence of at least 1021 n/cm2. The goal of this research is to characterize and demonstrate magnetostrictive and piezoelectric transducer operation during irradiation, enabling the development of novel radiation-tolerant ultrasonic sensors for use in Material Testing Reactors (MTRs). As such, this test is an instrumented lead test and real-time transducer performance data is collected along with temperature and neutron and gamma flux data. The current work bridges the gap between proven out-of-pile ultrasonic techniques and in-pile deployment of ultrasonic sensors by acquiring the data necessary to demonstrate the performance of ultrasonic transducers. To date, one piezoelectric transducer and two magnetostrictive transducers have demonstrated reliable operation under irradiation. The irradiation is ongoing.

In this Special Issue of Sensors, seven peer-reviewed manuscripts appear on the topic of ultrasonic transducer design and operation in harsh environments: elevated temperature, high gamma and neutron radiation fields, or the presence of aggressive chemicals. Motivations for these research and development projects are strongly focused on nuclear power plant inspections (particularly liquid-sodium cooled reactors), and nondestructive testing of high-temperature piping installations. It is anticipated that extensive use of permanently mounted robust transducers for in-service monitoring of petrochemical plants and power generations stations; quality control in manufacturing plants; and primary and secondary process monitoring in the fabrication of engineering materials will soon be made.

The optimization of mill control could yield significant cost benefits for the mining industry. In the 1960s, Gold Fields of South Africa Ltd embarked on a mill-control programme to reduce milling costs and to improve throughput, final product consistency, and gold recovery. The lack of suitable sensors restricted the development of control systems until the 1970s, when suitable commercial instruments became available. A joint development venture, involving the CSIR, Mintek, and Gold Fields, was undertaken in the late 1970s and culminated in the successful implementation of multivariable control on the no. 1 milling unit at East Driefontein Gold Mine. This success led to the installation of multivariable controlled milling at the East Driefontein, West Driefontein, and Kloof Gold Mines. These installations are to be commissioned in the near future. The key measurement in the mill-control strategy was found to be the on-line real-time measurement of the particle size of the mill product. Without this measurement, the whole control strategy would collapse. The consequences could be serious, since there is currently only one concern, a small foreign firm, that is capable of supplying a reliable on-line instrument. This situation is unsatisfactory from several points of view; the price of the instrument has risen from R40 000 to R150 000 in the space of a few years; the instrument limits the optimization of mill control since it can measure only a single point on the particle-size curve (for maximum benefit, measurements at several points on the curve would be necessary); and, technically, the design of the instrument, particularly of the air-elimination unit, is unsatisfactory. The problems experienced with this unit are currently responsible for 90 per cent of the downtime and operating costs of the particle-size monitor. Because of the importance of this measurement and the disadvantages of the present instrument, Mintek was asked to undertake a study of ultrasound and its application to the mineral-processing industry, particularly its use in the measurement of particle size. If the latter was found to be promising, Mintek would develop the expertise required for the manufacture of a local instrument for multi-particle sizing. The development of ultrasound techniques would be far-reaching, not only for the manufacture of an instrument for multi-particle sizing, but in areas such as the monitoring of screen breakage and the measurement of the carbon and resin concentrations in the in-pulp recovery of gold and uranium.

In order to further improve the filtration efficiency, polypropylene permeate spacer was replaced by stainless steel (S.S.) permeate spacers with various porosities. Six sets of S.S. permeate spacers were inserted into CF module to evaluate the effect of porosity on permeate flux as well as on RAE filtration enhancement when irradiating with ultrasound in both US enhanced and integrated system. Without proper support to membrane, higher frictional resistance as well as localized turbulent induced by flow across the membrane surface became reasons for significant DI-H2O flux loss. In the contrast, under the irradiation of US, these reasons turned into positive driving forces for enhanced permeation. The relative RAE filtration enhancement factors presented completely contrary tendencies for the two CF systems when plotting as the function of spacer porosity. The different mechanisms of US effect in these two CF systems played important role. By simply replacing the PP spacer with S.S spacer in permeate channel, the RAE filtration enhancement increased 28% more in US enhanced system and 45% more in US integrated system. Response Surface Methodology (RSM) coupled with BoxBehnken design (BBD) of experiments were employed to investigate the effects of control variables (ultrasound output power, porosity of permeate spacer and transmembrane pressure) on the absolute permeate collection for RAE Ultrafiltration in US integrated CF system. The optimal operational conditions established by RSM and desirability function approach were as follow: a US output power of 120W, a spacer porosity of 60.8% and a TMP of 20 psi. By applying these process parameter values, maximal responses have been predicted. Under these conditions, the permeation efficiency can be improved up to 211%.

Ultrasound imaging plays an important role in modern medical diagnosis. Recent progress in real-time 3-D ultrasound imaging can offer critical information such as the accurate estimation of organ, cyst, or tumour volumes. However, compared to conventional 2-D ultrasound imaging, the large amount of data and circuit complexity found in 3-D ultrasound imaging results in very expensive systems. Therefore, a simplification scheme for 3-D ultrasound imaging technology is needed for a more wide-spread use and to advance clinical development of volumetric ultrasound. Row-column addressing 2-D array is one particular simplification scheme that requires only N + N addressing lines to activate each element in an N x N array. As a result, the fabrication, circuit, and processing complexity dramatically decrease. Capacitive micromachined ultrasonic transducer (CMUT) technology was chosen to fabricate the array as it offers micro-precision fabrication and a wide bandwidth, which make it an attractive transducer technology. The objective of this thesis is to investigate and demonstrate the imaging potential of row-column CMUT arrays for RT3D imaging. First, the motivation, physics, and modelling of both CMUTs and row-column arrays are described, followed by the demonstration of a customized row-column CMUT pseudo-real-time 3-D imaging system. One particular limitation about row-column arrays discovered as part of this dissertation work is the limited field-of-view of the row-column arrays' imaging performance. A curved row-column CMUT array was proposed to improve the field-of-view, and the resulting modelling of the acoustic field and simulated reconstructed image are presented. Furthermore, a new fabrication process was proposed to construct a curved row-column CMUT array. The resulting device was tested to demonstrate its flexibility to achieve the necessary curvature. Finally, a new wafer bonding process is introduced to tackle the next generation of RC-CMUT fabrication. Many of the new fabrication techniques reported in this work are useful for CMUT fabrication engineers. The analysis on row-column array also provides additional insights for 2-D array simplification research.

The industrial interest in ultrasonic processing has revived during recent years because ultrasonic technology may represent a flexible "green" alternative for more energy efficient processes. A challenge in the application of high-intensity ultrasound to industrial processing is the design and development of specific power ultrasonic systems for large scale operation. In the area of ultrasonic processing in fluid and multiphase media the development of a new family of power generators with extensive radiating surfaces has significantly contributed to the implementation at industrial scale of several applications in sectors such as the food industry, environment, and manufacturing. Part one covers fundamentals of nonlinear propagation of ultrasonic waves in fluids and solids. It also discusses the materials and designs of power ultrasonic transducers and devices. Part two looks at applications of high power ultrasound in materials engineering and mechanical engineering, food processing technology, environmental monitoring and remediation and industrial and chemical processing (including pharmaceuticals), medicine and biotechnology. Covers the fundamentals of nonlinear propagation of ultrasonic waves in fluids and solids. Discusses the materials and designs of power ultrasonic transducers and devices. Considers state-of-the-art power sonic applications across a wide range of industries.

Description of a program to develop an ultrasonic inspection design for the nondestructive evaluation of pipeline girth welds made by the mechanized gas metal arch welding process for onshore and offshore pipelines. Vol. 1 describes a design approach using specialized ultrasonic beams chosen to detect specific imperfections in the well-defined regions of the weld and evaluated on simulated and real weld imperfections. Vol. 2 investigates the feasibility of using creeping waves for examination of the cap region, resulting in the development and evaluation of specifications for an experimental creeping wave transducer. Vol. 3 studies the use of the pitch-catch technique to examine the body of the weld, carried out on simulated and real weld defects. Vol. 4 combines the technology developed in the 3 previous reports into the overall inspection of field girth welds using 2 full scale welds in 9.8 mm and 20.6 mm thick pipe.

These Proceedings, consisting of Parts A and B, contain the edited versions of most of the papers presented at the annual Review of Progress in Quantitative Nondestructive Evaluation held at the University of California San Diego, in La Jolla, California on July 19- July 24, 1992. The Review was organized by the Center for NDE at Iowa State University and the Ames Laboratory of the USDOE in cooperation with a number of organizations including the Air Force Wright Laboratory Materials Directorate, the American Society for Nondestructive Testing, the Center for NDE at Johns Hopkins University, the Department of Energy, the Federal Aviation Administration, the National Institute of Standards and Technology, the National Science Foundation IndustrylUniversity Cooperative Research Centers, and the Working Group in Quantitative NDE. This year's Review of Progress in QNDE was attended by approximately 475 participants from the U. S. and many foreign countries who presented over 380 papers. With such a large volume of work to review, the meeting was divided into 36 sessions with as many as four sessions running concurrently. The Review covered all phases of NDE research and development from fundamental investigations to engineering applications or inspection systems, and it included all methods of inspection science from acoustics to x-rays. During the last twenty years, the participants of the Review have contributed to its steady growth. Thanks to their efforts, the Review is today one of the largest and most significant gatherings of NDE researchers and engineers anywhere in the world.

Intravascular ultrasound (IVUS) is increasingly employed for detection and evaluation of coronary artery diseases. Tissue Harmonic Imaging provides different tissue information that could additionally be used to improve diagnostic accuracy. However, current IVUS systems, with their unfocussed transducers, may not be capable of operating in harmonic imaging mode. Thus, there is a need to develop suitable transducers and appropriate techniques to allow imaging in multi modes for complementary diagnostic information. Focused PVDF TrFE transducers were developed using MEMS (Micro-Electro-Mechanical-Systems) compatible protocols. The transducers were characterized using pulse-echo techniques and exhibited broad bandwidth (110% at -6dB) with axial resolutions of Such promising results suggest that focused, broadband PVDF TrFE transducers have opened up the potential to incorporate harmonic imaging modality in IVUS and also improve the image quality. In addition, the transducer's multimodality imaging capability, not possible with the current systems, could enhance the functionality and thereby the clinical use of IVUS.

The report summarizes the work done toward the development of ultrasonic Doppler blood flow velocity measurement catheters and multipurpose catheters which included ultrasonic transducers developed during the program. A prototype split-disc type ultrasonic transducer developed previously was used as a basis of design. Five operating ultrasonic catheters, which were thoroughly tested in vitro were delivered for in vivo tests in experimental animals. Three of these transducers were of split-disc construction and two were the solid-disc type with electrically isolated active electrodes. All catheters were operable but their performance characteristics differed. Intravascular blood flow velocity information was acquired at various points within the great vessels with four of the five catheters. One catheter contained a lumen for blood sampling and a stiffener for pre-positioning the tip. Another contained a pressure transducer with which simultaneous blood pressure and blood flow velocity data were acquired. Operating characteristics and as-built drawings were supplied for all catheters. A brief review of the state-of-the-art of catheter tip ultrasonic flowmeters is presented and suggestions for approaches to further development are made. (Author).

Capacitive micromachined ultrasonic transducers (CMUTs), have been widely studied in academia and industry over the last decade. CMUTs provide many benefits over traditional piezoelectric transducers including improvement in performance through wide bandwidth, and ease of electronics integration, with the potential to batch fabricate very large 2D arrays with low-cost and high-yield. Though many aspects of CMUT technology have been studied over the years, packaging the CMUT into a fully practical system has not been thoroughly explored. Two important interfaces of packaging that this thesis explores are device encapsulation (the interface between CMUTs and patients) and full electronic integration of large scale 2D arrays (the interface between CMUTs and electronics). In the first part of the work, I investigate the requirements for the CMUT encapsulation. For medical usage, encapsulation is needed to electrically insulate the device, mechanically protect the device, and maintain transducer performance, especially the access of the ultrasound energy. While hermetic sealing can protect many other MEMS devices, CMUTs require mechanical interaction to a fluid, which makes fulfilling the previous criterion very challenging. The proposed solution is to use a viscoelastic material with the glass-transition-temperature lower than room temperature, such as

Polydimethylsiloxane (PDMS), to preserve the CMUT static and dynamic performance. Experimental implementation of the encapsulated imaging CMUT arrays shows the device performance was maintained; 95 % of efficiency, 85% of the maximum output pressure, and 91% of the fractional bandwidth (FBW) can be preserved. A viscoelastic finite element model was also developed and shows the performance effects of the coating can be accurately predicted. Four designs, providing acoustic crosstalk suppression, flexible substrate, lens focusing, and blood flow monitoring using PDMS layer were also demonstrated. The second part of the work, presents contributions towards the electronic integration and packaging of large-area 2-D arrays. A very large 2D array is appealing for it can enable advanced novel imaging applications, such as a reconfigurable array, and a compression plate for breast cancer screening. With these goals in mind, I developed the first large-scale fully populated and integrated 2D CMUTs array with 32 by 192 elements. In this study, I demonstrate a flexible and reliable integration approach by successfully combining a simple UBM preparation technique and a CMUTs-interposer-ASICs sandwich design. The results show high shear strength of the UBM (26.5 g), 100% yield of the interconnections, and excellent CMUT resonance uniformity (? = 0.02 MHz). As demonstrated, this allows for a large-scale assembly of a tile-able array by using an interposer. Interface engineering is crucial towards the development of CMUTs into a practical ultrasound system. With the advances in encapsulation technique with a viscoelastic polymer and the combination of the UBM technique to the TSV fabrication for electronics integration, a fully integrated CMUT system can be realized.

In recent years remarkable progress has been made in the development of materials for ultrasonic transducers. There is a continuing trend towards increasingly higher frequency ranges for the application of ultrasonic trans ducers in modern technology. The progress in this area has been especially rapid and articles and papers on the subject are scattered over numerous technical and scientific journals in this country and abroad. Although good books have appeared on ultrasonics in general and ultrasonic transducers in particular in which, for obvious reasons, materials play an important part, no comprehensive treatise is available that represents the state-of-the-art on modern ultrasonic transducer materials. This book intends to fill a need for a thorough review of the subject. Not all materials are covered of which, theoretically, ultrasonic trans ducers could be made but those that are or may be of technical impor tance and which have inherent electro acoustic transducer properties, i.e., materials that are either magnetostrictive, electrostrictive, or piezoelectric. The book has been devided into three parts which somewhat reflect the historic development of ultrasonic transducer materials for important tech nical application. Chapter 1 deals with magnetostrictive materials, magnetostrictive met als and their alloys, and magnetostrictive ferrites (polycrystalline ceramics). The metals are useful especially in cases where ruggednes of the transducers are of overriding importance and in the lower ultrasonic frequency range.

This is the final report of a one-year, Laboratory-Directed Research and Development (LDRD) project at the Los Alamos National Laboratory (LANL). This project sought to continue development of the ultrasensitive ultrasonic transducers that won a 1994 R & D 100 Award. These transducers have a very smooth response across a broad frequency range and thus are extremely well- suited for resonant ultrasound spectroscopy as well as pulsed-echo and acoustic-emission applications. Current work on these transducers has indicated that bonding the piezoelectric and wear surface to a metal foil and attaching the foil to a body is less expensive and produces a transducer that is as good or better than commercially produced transducers. We have diffusion- bonded piezoelectric crystals and backings to stainless-steel-foil and wear surfaces. These are then attached onto stainless-steel tubes with electrical connectors to form the transducers. The transducers have been characterized using a reciprocity technique, electrical response, and optical interferometry. After characterization, the transducers have been compared to existing transducers by measuring and testing identical properties.

The necessity for the design and evaluation of ultrasonic transducers for use in mineral slurries is motivated, and a general description of an ultrasonic transducer is presented with details of circle diagrams and equivalent circuit analysis. An ultrasonic transducer calibration system (UTCS) and a transducer analysis system (TAS) developed at the Council for Mineral Technology (Mintek) are described. The usefulness of the UTCS in the evaluation of the designs of different ultrasonic transducers is illustrated, and the effectiveness of the TAS in the development of a transducer to measure mineral pulp densities is demonstrated.