A Reference Vessel for Acoustic Cavitation: Initial Characterisation of the Spatial Distribution of Cavitation Activity Derived Using an Acoustic Emission Sensor

Bajram Zeqiri
Acoustics Team
Quality of Life Division
National Physical Laboratory
Tedington, Middlesex,
United Kingdom.

Acoustic cavitation provides the driving force behind many industrial and medical applications, where the aim is to bring about irreversible changes in the bulk or surface properties of a material. Industrial examples include cleaning, materials processing and, in medicine, shock-wave lithotripsy and high-intensity focused ultrasound fields. Developing characterisation methods for the degree of cavitation being applied has proved to be remarkably difficult, due to complexity of the environments and the hostile nature of the applied fields. This presentation describes a programme of work carried out at the UK National Standards laboratory, NPL, to investigate suitable methods.

In particular, it will describe a system being established as a reference cavitating environment of known and repeatable properties, sufficiently well described for it to act as a test bed for various monitoring techniques: erosion, light emission, chemical and acoustic emission. This reference facility consists of a cylindrical reactor of thirty transducers operating at 25 kHz and generating 1.8 kW. Measurements of the spatial variation of cavitation activity made in the vessel using the NPL cavitation sensor, a broadband sensor detecting emissions up to 10 MHz, will be presented. Various aspects of NPL's work in this area will be described: development of electronic instrumentation for the sensors, industrial trialling of the new technology within the UK and collaborations with universities to understand and exploit the potential of the acoustic emission method of cavitation detection.

Bajram Zeqiri

He joined NPL in 1984 after completing a PhD in solid-state chemistry at the University of Kent at Canterbury. Over the years, he has been involved in a range of technical areas relating to the development of ultrasonic measurement techniques and standards. This includes: determination of the acoustic properties of materials, calibration and the use of ultrasonic hydrophones, characterisation of ultrasonic power and developing standards for physiotherapy equipment. Within the last five years, his major area of research interest has been in developing methods to characterise the essential properties of high power ultrasonic systems as used within the cleaning industry. Currently the Technology Head for Medical and Industrial Ultrasonics at NPL, he is a member of IEC Technical Committee 87, contributing to Working Groups 6,8 and 3. He is also Knowledge Leader for the Acoustics Team at NPL, having responsibility for the strategy and quality of the Acoustics Team at NPL over its three technical areas: Sound-in-Air, Underwater Acoustics and Medical and Industrial Ultrasound.

Rock Sampling Using the Ultrasonic/Sonic Driller/Corer (USDC) for In-situ Planetary Exploration

Xiaoqi Bao, Yoseph Bar-Cohen, Zensheu Chang, Stewart Sherrit and Mircea Badescu

Jet Propulsion Laboratory, California Institute of Technology,
4800 Oak Grove Drive, Pasadena, CA 91109-8099[1]

Future NASA exploration missions to Mars, Europa, Titan, comets and asteroids are seeking to perform sampling, in-situ analysis and possibly the return of material to Earth for further tests. Existing drilling techniques are limited by the need for large axial forces and holding torques, high power consumption and an inability to efficiently duty cycle. Lightweight robots and rovers have difficulties accommodating these requirements. To address these key challenges to the NASA objective of planetary in-situ rock sampling and analysis, an ultrasonic/sonic driller/corer (USDC) was developed. The actuator of the USDC is an ultrasonic horn transducer that is driven by a piezoelectric stack. Unlike the typical ultrasonic drill where the drill stem is acoustically coupled to the transducer, the horn transducer in the USDC drives a free flying mass (free-mass), which bounces between the horn tip and a drill stem at sonic frequencies. The impacts of the free-mass create stress pulses that propagate to the interface of the stem tip and the rock. The rock fractures when its ultimate strain is exceeded at the rock/bit interface. This novel drilling mechanism has been shown to be more efficient and versatile than conventional ultrasonic drills under a variety of conditions. The low mass of a USDC device and the ability to operate with minimum axial load with near zero holding torque offers an important tool for sample acquisition and in-situ analysis. The details of the design, computer simulation and the test results of the USDC prototypes will be presented.

New Research in Energy Applications of High Power Ultrasonics

O.V. Abramov *, V.O. Abramov *, A.Zolezzi**

*Centre of Applied Acoustics, Moscow, Russia
** Technova, Vin del Mar, Chile

Analysis shows that elastic oscillations can be used in many technological processes of extraction, transportation and oil refining. Thus, in the processes of oil recovery, ultrasound can be applied in following technologies: Stimulation of oil extraction from well bottom zone, stimulation of heavy oil recovery from tar sand, improvement of the drilling mud quality (increase of clay dispersion and stimulation of filtration process).
In particular, research thus far has shown that the use of ultrasound for stimulation of the process of oil extraction allows an increase in reportable reserves of oil with no addition of acids, hot water or other solvents and without environment effects. It is achieved by application of high power ultrasound in the bottom zone of the well. High power ultrasound increases the permeability of the reservoir and fluidity of heavy oil. Ultrasonic action removes near wellbore damage caused by fines and mud solids and paraffin depositions, and leads to the destruction and removal of deposits accumulated in the narrow spots of porous channels. The ultrasonic technology has proved itself highly successful in achieving more than 100 % increase in gross production and at least 50% increase in oil production.

The ultrasonic unit consists of a power supply (380 V, 3 phases, 50 Hz, 10 kW) working in the frequency range 23 ± 1 kHz and connected through a 2000 m ROCHESTER Type 7 – H -464 K geophysical cable with electroacoustical transducers of the magnetostrictive type and sonotrodes with developed irradiating surface. These sonotrodes transfer longitude vibration into radial ones. Two types of acoustic devices with diameter 42 and 100 mm were developed.

At oil and gas transportation processes high power ultrasonics can be used for reducing the risk of plugging (hydrate deposition) in pipeline at gas transportation process; increasing the oil fluidity during transportation (pipelines, pouring of heavy petroleum products from tanks at reduced temperatures); Mixing of fuel oil and gas condensate to simplify the transportation technology of the latter.

In processes of oil refining the ultrasound can be applied to; Stimulation of the regeneration of catalysts poisoned during petroleum refining; Stimulation of low temperature petroleum cracking and desulphurization.

A new direction on possible uses of ultrasonics is that of hydrogen power. Examples include:

- Intensifications of processes of an electrolysis and radiolysis of water.
- Intensifications of processes of low temperature (up to 250 ^{0}C) conversion of hydrocarbons (in particular, of a rich glucose biomass).
- Stimulation of activity cyan bacteria.
- Incresaing of heat transfer rate in liquid (type PAFC, MCFC, Alkaline, Regenerative Fuel Cells) and solid (type PEM, SOFC, DMFC, ZAFC, PCFC) electrolytes, decreasing of working temperature, augmentation of service life and efficiency of action of the catalyst, rising of efficiency of devices.
- Obtaining of nanosize catalysts on the basis of alloys of system Ni - Al - Sn for the use in processes of producing of hydrogenium from the molecules extracted from a vegetative biomass.
- Use of sign-variable strength of ultrasonic frequency for adjustment of kinetics of processes of a sorption - desorptions of hydrogenium in a material of the store (a palladium, ruthenium. Hydrides of metals, etc. materials).
- Modifying (crushing) of cast structure of fragile metals (ruthenium), rising of characteristics of its plasticity.
- Processing by pressure of hard-deformed materials, thin-walled capillary pipes.

Ultrasonic Metal Welding of Aluminum Sheet

Janet Devine, Joe Walsh, Sonobond Ultrasonics, Inc.;
Rick Baer, Elizabeth Hetrick, Ray Jahn, Al Krause, Haset Mariam,
Larry Reatherford, Susan Ward and Daniel Wilkosz, Ford Motor Co.

Ultrasonic metal welding of copper refrigerator tubes, aluminum wire and foils is well known; however, ultrasonic welding of thicker aluminum sheet is less common. Ultrasonic metal welding provides advantages over traditional joining methods of aluminum such as resistance spot welding since there is no heat-affected zone and riveting as there is no cost of a physical part, e.g. rivet.

In this study, various types of ultrasonic welders were modified or manufactured to enable welding of various gauges of aluminum sheet from 0.9 to 3 mm thick. Progress of the weld formation has been quantified by measurements on cross-sections of welds and the results will be presented. Typical lap-shear failure loads for 0.9 mm 6XXX aluminum sheet are 3.0 to 4.0 kN and up to 8.5 kN for 3 mm 5xxx aluminum sheet. Fatigue life is similar to other types of aluminum joining methods, e.g. RSW, GMAW, etc. The performance of aluminum ultrasonic spot-welds compares favorably to joints made from other types of welding or mechanical fasteners.

Acoustic Loss at Substantial Ultrasonic Strain in 6Al-6V-2Sn and Sintered 6Al-4V Titanium

Dave Wuchinich
Modal Mechanics
431 Hawthorne Avenue
Yonkers, NY 10705

The mechanical Q of the high strength 6Al-6V-2Sn titanium alloy and of two alloys of sintered 6Al-4V is measured using both thermal and electric power loss methods and compared with values obtained for standard cast and rolled 6Al-4V at 20 kHz cyclic strains ranging for 0.18 to

0.42 percent. Limitations and recommendations on the use of these materials for fabrication of high intensity ultrasonic horns is discussed.

Novel Actuator Application for New High Drive Piezoceramic Materials

Adam Morris, Jared Brosch
PiezoTechnologies
8431 Georgetown Road
Suite 300
Indianapolis, IN 46268

It is the intent of this paper to discuss the use of some new piezoelectric materials in novel miniature actuator designs for the electronics industry. I will give a brief overview of the market conditions driving this need followed by the basic engineering principles of the designs. The relevant electromechanical properties and comparative test data will be presented for the new materials as well as the standard piezo material typically used for this type of actuator. Finally, a brief summary of future work will be discussed.

Ultrasonic Application for Purification of Waste Water

O.V. Abramov, V.O. Abramov, O.M.Gradov, G.B. Veksler

Institute of General and Inorganic Chemistry of RAS,
Leninsky Prospekt 31, Moscow, 119991, Russia

The capabilities of practical usage of potent ultrasoni in a speed key with other physico-chemical methods for purification of waste water contaminated by heavy metals, petroleum, hazardous organic compounds, dies, surface active materials, pathogenic microorganisms are investigated.

The influence of ultrasonics on processes of electrocoagulative purification of waste water of heavy metals (Cu, Zn, Cr, Pb, Cd etc.) is detected. It is established that the ultrasonic effect on processes of electrocoagulation of water from heavy metals in all cases results in acceleration in 2 -10 times of a purification process of polluted waters and increase of its depth. The possibilities of using of ultrasonics in processes of reagent purification of oily water are examined. The ultrasonic effect allows to speed up purification processes in 3 - 4 times and to increase its depth, to reduce the place indispensable for arrangement of the equipment.

The possibilities of using of ultrasoni in a speed key with other physico-chemical methods (electrolysis, catalysts, ozonization) for an advanced oxidation of hazardous organic compounds (nitro aroma substances, azo dyes etc.) are investigated. In addition, the influence of ultrasonics on processes of an advanced oxidation of 1,3-dinitrobenzene (DNB) and 2,4-dinitrotoluene (DNT) in aqueous solutions in conditions of a small current electrolysis is studied. It is revealed that the ultrasonic effect results in considerable acceleration of reacting of an advanced oxidation DNB and DNT only at simultaneous electrochemical and ozone processing.

The joint action of ultrasonic sound and pulse ultraviolet radiation on pot-life of pathogenic microorganisms (Escherichia Coli and Sarcina Lutea) is investigated. In experiments, at least, tenfold amplification of bactericidal effect of processing of water by UV radiation, after it's preliminary processing by ultrasonic sound was detected.

In a half industry scale pilot plant, it is found that the application of combined physico-chemical methods of purification with usage of ultrasonic sound reduces run time, lowers input power and improves the quality of clean water.

Characterisation of Industrial High Power Ultrasound Fields Using the NPL Cavitation Sensor

Mark Hodnett
Acoustics Team
Quality of Life Division
National Physical Laboratory
Tedington, Middlesex,
United Kingdom.

Applications of high power ultrasound span many industrial sectors, from healthcare, through sonochemistry and sonoprocessing, to ultrasonic cleaning. The reproducible characterisation of the primary driving force behind these applications, cavitation, has hitherto proved difficult.

NPL has developed an acoustic cavitation sensor to address this need. Passively detecting the acoustic emissions from oscillating and collapsing bubbles, the sensor design includes an acoustically absorbing outer shield layer that endows it with spatial resolution. The piezoelectric polymer film used provides a measurement bandwidth of 10 MHz, sufficient to detect the broadband 'white' noise associated with violent inertial cavitation.

The sensor has been used to characterise the cavitation activity produced by three examples of industrial high power ultrasound fields – a 40 kHz cleaning vessel, a 25 kHz cylindrical sonochemical processor, and a 20 kHz sonochemical horn. The results of measurements made using the cavitation sensor over a range of system driving conditions will be shown, and compared with assessments of cavitation activity made using erosive, and chemical methods.

Mark Hodnett

Mark Hodnett received the BSc degree with Upper Second Class Honours in Physics from the University of Surrey, UK in 1994. He joined the National Physical Laboratory later that year to work on a feasibility stage Strategic Research Project whose objective was to investigate methods of measurement for high power ultrasonic fields and cavitation. Since then, he has maintained a strong involvement in NPL's subsequent projects in the high power area. He is also active in low power ultrasonic field characterisation, and manages NPL's Measurement Services in this area.

Compact Power Circuit Design for an Ultrasonic Generator

Alan Lipsky, Consultant

A typical ultrasonic generator consists of a line interface and rectifier compatible with international standard 61000-3-2 (limits for harmonic current emissions) that converts AC mains power to DC, a rail supply that responds to amplitude control signals from generator control, and an inverter that converts the rail supply output to an appropriate AC signal for the transducer. Each of these three circuits must be embody a switch mode design in order to fit on a small portion of a single printed wiring board. For circuitry that processes 500 VA, this represents a challenge: MOSFETS and diodes ordinarily require large heat sinks exposed to moving air and, an even greater hazard, switch mode circuits generate large amounts of EMI that particularly when packaged close together compromises the performance of adjacent circuits. This paper estimates losses in each of these three circuits, chooses the necessary heat sinks, and suggests means of reducing these losses and controlling EMI.

Alan Lipsky

Mr. Alan Lipsky has over 40 years experience with system design, implementation and integration for degaussing/magnetic treatment systems, magnetic ranges, RADAR simulator/training systems, inertial navigation, and SONAR systems. He has held engineering and senior management positions at companies such as Gould Simulation Systems, EMS Development Corp and Sperry Gyroscope.

During that time, he developed:

- Precision feedback control systems optimized for stability, performance, and accuracy, in some cases to a few seconds of arc
- State-of-the-art switch-mode-power electronics that included 10 KW power amplifiers with accuracies to a few tenths of a 1%, with EMI compliance to MIL-STD-461
- Analog instrumentation including low noise, high precision circuitry and data acquisition systems
- Single-phase high-power-factor converters compliant with IEC 61000-3-2
- Three phase AC-DC converters compliant with DOD-STD-1399
- Power electronics for an ultrasonic generator compliant with IEC 61000-4-5

Alan holds a BEE from Rensselaer Polytechnic Institute and a SMEE MIT from the Massachusetts Institute of Technology. He is a member of the Engineering Honor Societies TAU BETA PI and ETA KAPPA NU.

Mr. Lipsky currently provides consulting services in the field of power electronic design from 100 Watts to multiple Kilowatts, feedback control systems, and analog instrumentation.

Use of IR technology in Sensing and Control of Ultrasonic Metal Welding

Karl Graff, Jay Eastman, Tim Frech, Yu-Ping Yang, EWI

The ultrasonic metal welding process is obviously based on ultrasonic vibrations to create a weld. At the same time, ultrasonic vibrations radiated into the structure may influence previously made welds or the fatigue performance of the structure. Under either circumstance, whether at or remote from the weld, the ultrasonic vibrations of the metal will create heat that is detectable by infrared (IR) sensors.

This paper will examine two aspects if IR detection of ultrasonically generated heat, namely heat generated at the weld itself, and heat generated by vibrations remote from the weld – so called 'hot spots.' In the case of heating at the weld zone itself, the interest is in using the IR signature as a means of monitoring weld quality, and ultimately as a control technique for the process. Studies carried out to relate weld strength to IR signature will be reported, as well as work correlating IR response to FEA predictions of heating based on a current model of the welding process.

In the IR study of ultrasonic vibrations in structures, the purpose is to use IR in a qualitative, transient manner to observe the vibrational modes of a structure and to detect high stress hot spots arising remote from a weld. Results for work on beams and plates, and assessment of clamping effects will be given, as well as FEA modeling of the structural vibrations.

A Methodology for Ultrasound Product Development — Applications in HIFU and High Frequency

Claudio I. Zanelli and Samuel M. Howard

Developing new ultrasound products for medicine tends to be complicated because biology, physics, engineering, business, and regulatory concerns are intertwined. Each participant representing one of these disciplines tends to function in isolation of the others, and this tendency must be overcome by developing a common language and clear goals.

While from the engineering vantage the key is a clear specification for the device, often the specification does not lead to success because one or more of the non-engineering needs is not met. For instance, the resulting device may meet a specification but it may fail to do what was intended once exposed to the tissue – biology has a different degree of repeatability than, say, transducers. Other hurdles are the need to meet regulatory constraints, be manufacturable at low cost, etc. The solution may have a complicated Intellectual Property position (not protectable or already protected by somebody else) or a competing technology may render the present solution impractical. Finally, it is sadly too common that a poor choice of operating parameters and protocols result in failed clinical trials, thus scrapping the whole project for reasons that, on the surface, are non-technical.

To efficiently navigate this process, the authors have evolved, after a number of projects, a methodology that addresses the needs and inputs of each discipline and leads to an efficient development. The main features and steps in this process are presented, exemplified with cases of HIFU and high frequency imaging applications.

Claudio I. Zanelli, Ph.D.

As the President and C.E.O of Onda Corporation, Claudio oversees the design and manufacturing of a complete line of ultrasound metrology devices, a brisk acoustic testing laboratory, and the exciting work of new medical device development.

Prior to founding Intec Research (now Onda), Claudio played key roles in the development of new ultrasonic transducers at Acuson (now Siemens), pioneered the field of endovascular imaging at Endosonics (now Volcano Therapeutics) and helped to bring from the lab to production the first phased arrays at General Electric (still General Electric).

From the vantage point of a company that gets involved in the early development of medical devices, Onda has accumulated a wealth of knowledge about the development process, its misconceptions, pitfalls, and unique paths to success. In this process, he has been at the whirlwind of startups, that unique combination of needs, inventions and venture capital, resulting in many novel products.

Claudio holds an M.S.E.E. and a Ph.D. degree in Physics from the University of California at Davis.

Measurement and Assessment of a Non-contact Ultrasound Therapeutic System

Mark E. Schafer, Ph.D., Sonic Tech, Inc.
Michael Peterson, Ryan Tetzloff, Celleration, Inc.

The Celleration MIST™ Therapy system is a non-contact therapeutic ultrasound system for wound debridement and healing. This presentation reviews some of the theoretical, experimental, manufacturing, and clinical data obtained with the device to date.

We have conducted a series of measurements to characterize the system and compare the results with acoustical theory. A series of experiments documented the radiated pressure field from the system, as a function of distance and angle from the radiating horn. These were compared to both near and far field pressure models. The results showed excellent agreement, indicating both an acceptable experimental technique and a good knowledge of the relevant acoustic fundamentals.

The next tests to be presented detail some of the manufacturing quality control testing, indicating the repeatability and design controls in place on the system. These tests indicate a high degree of production control, as is necessary when dealing with a medically regulated therapeutic device which involves patient exposure to an energy source (albeit a non-ionizing one), which involve biological processes with potentially dose dependent treatment effect. Clinical results will be presented which demonstrate the efficacy of the device.

In summary, the Celleration MIST Therapy system represents a breakthrough technological application of ultrasound energy to treat patients with chronic wound issues.

High Intensity Focused Ultrasound Catheter Dosimetry using Gel Phantom

by

Yegor D. Sinelnikov1*, Oleg Y. Polyakov2, Oleg A. Sapozhnikov3,
Jaime E. Merino1, Dmitry Mayorov1, and Eugene Jung1
1 ProRhythm, 105 Comac St, Ronkonkoma, NY 11779, USA
2 Columbia University, Physics Department, New York, NY 10027, USA.
3 Moscow State University, Physics Department, Moscow 119992, Russia.

Atrial fibrillation (AF) is the most common sustained cardiac arrhythmia identified as a leading risk factor for stroke afflicting about two million people in United States and more than four million worldwide. Recently, it has been demonstrated that AF originates in pulmonary veins (PV) [1] and that ablation or isolation of PV markedly reduces episodes of AF. One of the most effective way for PV ablation is application of High Intensity Focused Ultrasound (HIFU). The ProRhythm has designed the HIFU PV ablation System to create a circumferential lesion in the left atrium surrounding the ostium to electrically isolate the problematic PVs. This paper describes the design of the catheter and focuses on the thermal dose characterization using gel phantom.

Yegor D. Sinelnikov obtained his Ph.D. in Geophysics, focusing in ultrasound interferometery at high pressure, from Stony Brook University, and M.S. in Physics from Moscow State University. He joined ProRhythm in 1998 as a physicist to develop the HIFU integrated single-sided MRI scanner. In 2002 Dr. Sinelnikov was appointed to be the research and development manager. He is mainly responsible for the catheter design, transducer development, acoustic characterization, simulation, and modeling. While working with ProRhythm, he gained substantial experience in project management, material selection, regulatory compliance, testing, commercialization, and other aspects of medical product development. He published 11 research papers, and has been included in 3 patent applications.

Development of a High Intensity Focused Ultrasound (HIFU) Hydrophone System

Mark E. Schafer
Sonic Tech, Inc.
Ambler, PA, 19002 USA
marks@sonictech.com

James Gessert and Wayne Moore
Sonora Medical Systems
Longmont, CO, 80503, USA
jim@4sonora.com

In the past few years, High Intensity Focused Ultrasound (HIFU) has developed from a scientific curiosity to an accepted therapeutic modality. Concomitant with HIFU's growing clinical use, there has been a need for reliable, economical and reproducible measurements of HIFU acoustic fields. A number of approaches have been proposed and investigated, most notably by Kaczkowski et al [Proc. 2003 IEEE Ultrasonics Symposium, 982-985]. We are developing a similar reflective scatterer approach, incorporating several novel features which improve the hydrophone's bandwidth, reliability, and reproducibility. For the scattering element, we have used a fused silica optical fiber with a polyamide protective coating. The fused silica core is 73 microns in diameter with a 5 micron thick polyamide coating for a total diameter of 83 microns. The fiber was prepared by cleaving to yield a perpendicular/flat cut. The fiber is maintained in position using a capillary tube arrangement which provides structural rigidity with minimal acoustic interference. The receiver is designed as a segmented, truncated spherical structure with a 10cm radius; the scattering element is positioned at the center of the sphere. Each segment is approximately 6.3 cm square. The receiver is made from 25 micron thick, biaxially stretched PVDF, with a Pt-Au electrode on the front surface. Each segment has its own high impedance, wideband preamplifier, and the signals from multiple segments are summed coherently. As an additional feature, the system is designed to pulse the PVDF elements so that the pulse-echo response can be used to align the fiber at the center. This is important when the need arises to change the fiber due to, for instance, cavitation damage. The hydrophone can also be designed with a membrane structure to allow the region around the scatterer to be filled with a fluid which suppresses cavitation. Initial tests of the system have demonstrated a receiver array sensitivity of -279 dB re 1 microVolt/Pa (before preamplification), with a scattering loss at the fiber of approximately 39dB, producing an effective sensitivity of -318 dB re 1 microVolt/Pa. The addition of the closely coupled wideband preamplifiers boosts the signal to a range which is sufficient for the measurement of HIFU transducers. The effective bandwidth of the system exceeds 15MHz, through careful design and the use of PVDF as a sensor material. In order to test the system, a HIFU transducer in the 4.0MHz frequency range was tested at low output settings using a conventional PVDF membrane hydrophone. The prototype system was then used to characterize the same HIFU transducer at full power. The results showed good correlation between waveforms and cross-axis beam measurements, taking into account the additional shock losses at higher output settings.

Three-dimensional Ultrasound Imaging

Thomas R. Nelson, Ph.D.
University of California, San Diego
La Jolla, California

Three-dimensional ultrasound (3DUS) has become an increasingly important component of clinical imaging. While early applications have been focused on cardiac, obstetric, and gynecologic applications its capabilities continue to expand throughout the clinical arena. This expansion is driven by important improvements in technology, image quality and clinical ease of use. This paper will provide a brief review of the technology behind 3D and 4D ultrasound imaging, clinical considerations in acquiring, displaying and analyzing 3D/4D ultrasound data and the clinical contributions this exciting technology is making.

Something new in spectrum analysis: Parameter imaging of harmonics

Robert Muratore and Ronald H. Silverman
Frederic L. Lizzi Center for Biomedical Engineering
Riverside Research Institute
New York NY USA

In typical ultrasound applications, radiofrequency (RF) backscatter data are available for analysis. Prima facie, Fourier analysis requires signals of infinite extent in the time domain in order to satisfy the lower and the upper integration limits. In practice, of course, one selects a finite duration RF signal for analysis. This process was made mathematically rigorous by Wigner 1, Gabor 2 and Page 3. The generalized concept is that of joint time frequency analysis (JTFA) 4. We define "weak JTFA" as the multiplication of a windowing function with the original signal in order to select a particular time interval for frequency analysis. We define "strong JTFA" as wavelet and related analyses. In this presentation, we are concerned only with weak JTFA.

Robert Muratore received his Ph.D. in Biophysics at Syracuse University and was a National Research Council Fellow at the NIH Clinical Center. After working at Cold Spring Harbor Labs and in academia for a few years, he joined the research staff at Riverside Research Institute in New York City. Here he has been investigating two related areas: the integration of therapeutic and diagnostic ultrasound for minimally invasive surgery and the use of acoustic radiation force as a probe of dynamic material properties.

Single Crystals for High Frequency Ultrasound

Kevin A. Snook1, Xiaoning Jiang1, Wesley S. Hackenberger1, Xuecang Geng2
1TRS Technologies, State College, PA 16801
2Blatek, Inc., State College, PA 16801

Bandwidth is of integral importance in ultrasonic imaging due to its relationship to spatial resolution and is of even more signi.cance in high frequency (HF) ultrasound, as it enables techniques to broaden its applicability. In medical ultrasound both harmonic imaging and improved depth of penetration have been enabled by wide bandwidth transducers. Composite piezoelectric ceramics provide a signi.cant improvement in bandwidth over conventional bulk materials, due to the higher electromechanical coupling from the decrease in clamping and the better acoustic matching of the composite structure. Commercial composites have been historically limited to 10 MHz, due to the constraints of dicing technology and grain-pullout in ceramics. Single crystal PMN-PT provides a step forward in this technology due to its signi.cantly higher coupling (k33 > 90%).

This paper gives an overview of ongoing research at TRS Technologies regarding development of single crystal PMN-PT 1-3 composites. Composites up to 15 MHz have been made using a traditional dice-and-.ll technique and composites in the range of 20-50 MHz have been developed using a novel processing approach. Composites made from this method have effective electromechanical coupling near 75%. Results from these composites will be reported.

Notes

2006 UIA Officers and Board of Directors