ultran

redefining
the limits of
ultrasound

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GETTING STARTED WITH ULTRASONIC NDC

Industry has long desired a reliable and accurate NonDestructive Characterization (NDC) tool that would provide significant information about a material's development, manufacture, and eventual use. A cursory glance at the elementary physics text book is enough to demonstrate that properly applied mechanical (ultrasonic) waves yield a wealth of information about a material without every destroying it.

Although the knowledge about ultrasound has existed for over 100 years, only during the last decade has it begun to attract the attention of the materials community. The major and practical advancements in ultrasonic hardware and applications technologies are very recent. At Ultran we present this well-developed technology for a variety of materials' applications.

Having advanced the fundamentals of NDC transducer technology for nearly 10 years, today Ultran has reached the stage of being able to offer know-how in the NDC of materials. Since many major developments in ultrasound originated in our laboratory, we feel obligated to present their applications and limitations. A basic familiarity with the principles of ultrasound and its interaction with materials will enable you to generate much useful information about your materials.

The purpose of this note is to help in "getting started" with ultrasonic characterization of materials. Considering the enormous diversity of materials that can be examined by ultrasound, a single "starter kit," relevant to all applications is impossible. However, the following description shows the applications and limitations of a variety of ultrasonic isntruments and transducers. In case you are in doubt, we strongly recommend that you get in touch with us.

One final word: contrary to the popular notion that new and advanced technologies are expensive, Ultran's ultrasonic NDC is cost-effective and provides a wealth of useful information. While shopping for ultrasonic hardware and applications technologies, ask in-depth questions related to your test objectives and insist upon the quality of ultrasound that allows you to make precise and repeatable measurements.

EPN-111

1. ULTRASONIC INSTRUMENTS

There are basically four types of ultrasonic instruments and systems, each with a distinct purpose:

a. DIGITAL THICKNESS/THINNESS/VELOCITY GAUGE

This is utilized in making velocity or thickness measurements (determining one when the other is known) on simple shapes. It is best suited for the examination of high and medium density materials. Ultran thickness gauges are battery operated and are suitable for laboratory, factory, or field use. They can also be used with an auxiliary oscilloscope for observations of ultrasonic waveforms, sometimes necessary to explain "mystery" gauge readings.

ADVANTAGES: Low cost, very portable, easy to use.

LIMITATIONS: Unsuitable for complex shapes, highly porous and attenuative materials.

INSTRUMENTS: ULTRAN T-4501 and T-4551.

b. PULSER-RECEIVER-GATE

This can be used on a variety of materials with a separate oscilloscope. It is more versatile than a simple digital gauge because the operator has access to front-panel controls for adjusting the test parameters under a variety of conditions. With this system it is also possible to control the position and time duration of the electronic "gate" which selects the signals to be processed for velocity/thickness measurements, attenuation measurements, or frequency analysis. The oscilloscope can range from a basic unit for transit time measurement only to a digital storage oscilloscope for frequency dependent studies.

ADVANTAGES: Usable for direct reflection, direct transmission, or separate T-R methods on a wide range of materials and shapes. Because pulser-receivers and oscilloscopes are separate units, it is possible to "mix-and-match" to meet changing needs.

LIMITATIONS: "Transportable," but not readily "portable." Not suitable for use in dirty or dusty environments unless housed in a proper protective cabinet.

INSTRUMENTS: ULTRAN HP-705 for low-density, coarse grained and porous materials.
ULTRAN SP3025 for medium to high density materials.
ULTRAN SP-10001 for very thin and long-wavelength materials.

c. SELF-CONTAINED PORTABLE INSTRUMENTS

These combine pulser, receiver, gate, oscilloscope display and (optionally) digital velocity/time/thickness readouts in a single package for AC or battery operation. They are equipped with signal outputs for a more comprehensive signal analysis. The range of material applications falls between HP-705 and SP-3025 and overlaps the functions of both considerably.

ADVANTAGES: Portable, suitable for shop and field use, easy to use. Lower initial investment than separate pulser-receiver and oscilloscope.

LIMITATIONS: Lacks the high penetrating power of the HP-705 for very difficult materials and the high resolution for thin sections.

INSTRUMENTS: ULTRAN MINI 4400A and MINI 4400G.

d. AUTOMATED AND SEMI-AUTOMATED SYSTEMS

Ultran's comprehensive range of ultrasonic electronics can be used in a variety of combinations to build systems for repetitive sampling or on-line testing and evaluation. System outputs can include calculated elastic properties, pass/fail decisions, internal flaw evaluations, and statistical analysis of groups of test objects. We welcome your inquiries and ideas.

2. OSCILLOSCOPES

Ultran does not sell oscilloscopes, but we gladly recommend one to meet your requirements and budget. If it is highly desirable for you to purchase a complete "package" including an oscilloscope in a single purchase order, we can make arrangements for this.

3. TRANSDUCERS

The transducer is the single most important part of any ultrasonic system. Ultran offers an unmatched variety of transducer frequencies, acoustic characteristics, dimensions, and physical styles. This wide range is intended to make ultrasonics as versatile as possible, but we realize it can make your initial shopping difficult. We urge you to discuss your specific applications and needs with us before making your transducer selection, and we offer the following general guidelines for the various transducer types.

a. DIRECT CONTACT TRANSDUCERS

For general purpose use on surfaces where contact with liquid or gel couplants is not a problem. More durable than dry-coupling transducers

if used on rough or abrasive surfaces. Suitable with all types of instruments, except the SP-10001. Ability to resolve thin sections and near surface discontinuities is limited by the entry-surface reflection. Frequency range: <100KHz to >25MHz. Dimensional range: <0.062 in (1.6mm) to >3.0in (76mm).

b. DELAY LINE TRANSDUCERS

Delay line transducers give better near-surface resolution than direct contact types, and more accurate time/distance measurements. In direct reflection applications, testing range is limited by multiple reflections from the end of the delay line. Frequency range: <500KHz to 100MHz. Dimensional range: <0.062in (1.6mm) to >1.0in (25.4mm).

c. ZERO DEGREE INCIDENCE SHEAR WAVE TRANSDUCERS

Used mainly for shear wave velocity measurements for calculation of elastic properties. In several materials research applications these devices can also be used to generate a variety of complex surface waves by proper refraction of shear waves emitted by these transducers. They require coupling to test objects with highly viscous fluids such as ordinary honey. Dry coupling types are preferable when they are effective because of convenience and better repeatability. Frequency range: <250KHz to >20MHz. Dimensional range: <0.125in (3mm) to >1.0in (25.4mm).

d. SEPARATE TRANSMITTER-RECEIVER (T-R) TRANSDUCERS

Used when there is access to only one side of the test material and when a direct contact transducer with enough sensitivity/penetrating power creates problems due to prolonged "ringing" of the entry surface reflection. Also good for gauging on surfaces where the opposite surface is rough or pitted and it is desirable to "lock on" to points of minimum thickness to evaluate corrosion or to make calculations based on minimum dimensions. Frequency range: <500KHz to >10.0MHz. Dimensional range: <0.125in (3mm) to >1.0in (25mm).

e. DRY COUPLING TRANSDUCERS (AVAILABLE IN ALL THE ABOVE TYPES)

For any surface which could be damaged by liquid contact, or when liquid couplants are expected to alter the material characteristics. Most accurate evaluation of porous materials, when applicable. Dry coupling transducer or delay line tips are not durable when used on rough surfaces, but may be very cost-effective because of the time saved when large numbers of measurements must be made. Frequency range: <500KHz to >20MHz. Dimensional range: <0.125in (3mm) to >1.0in (25mm).

f. AIR/GAS PROPAGATION TRANSDUCERS

Not for materials characterization because virtually all ultrasonic energy is reflected at the gas or solid interface. Used for dimensional measurements or contour measurements where surfaces are subject to damage from contact with mechanical contacts or laser beams. Frequency range: <100KHz to >5.0MHz. Dimensional range: <0.25in (6mm) to >3.0in (76mm).

g. IMMERSION TRANSDUCERS

Ultrasound is coupled to test objects by water-based or other liquid columns. Maximum resolution for very thin materials and long wave length materials. Fastest and easiest to automate for scanning large areas. Porous materials cause problems since water intrusion alters a material's properties. Usually done with a mechanical scanning system, also available from Ultran. Frequency range: <100KHz to >100MHz. Dimensional range: <0.062in (1.6mm) to >3.0in (76mm).

h. HIGH TEMPERATURE TRANSDUCERS

For characterization of materials at high temperature or for those applications where the transducer must be subject to high environmental temperatures. Can be used continuously in excess of 250^{o}C, and with appropriate buffer zones, in excess of 1000^{o}C. Frequency range: <500KHz to >15.0MHz. Dimensional range: <0.25in (6mm) to >1.0in (25mm).

i. LAMBDA SERIES TRANSDUCERS

Available in direct contact, delay line contact, and immersion styles. Features shortest possible pulse widths and highest possible bandwidths. Unsurpassed resolutions capability without excessively increasing the frequencies. Suggested for ultrasonic wideband spectroscopy and materials research. Frequency range: <500KHz to >20MHz. Dimensional range: <0.62in (1.6mm) to >1.0in (25mm).

4. SPECIFIC EXAMPLES OF COMPLETE SYSTEMS RECOMMENDATIONS

In order to further familiarize you with ultrasonic hardware selection, we are pleased to offer the following specific examples targeted at solving specific problems with ultrasonic NDC.

Although these examples will give you a good idea about your requirements, we strongly suggest that you discuss your application with us. The vast amount of experience gained at Ultran proves that each application must be considered on an individual basis, and when needed some preliminary work must be done.

a. CHARACTERIZATION OF HIGH DENSITY Al_2O_3, SiC, Si_3N_4, BeO, TiN, TiB_2, WC, AND OTHER ALIKE MATERIALS

ULTRASONIC INSTRUMENT: SP-3025
OSCILLOSCOPE: Tektronix 2215A or 2236
LONGITUDINAL WAVE TRANSDUCERS: Dry coupling delay line types in 5, 10, and 20MHz frequencies.
SHEAR WAVE TRANSDUCERS: Dry coupling delay line types in 5, 10, and 20MHz frequencies.

The above system is also applicable for examining materials in green or brown stages. For this we recommend direct contact dry coupling transducers in 2 and 5MHz range.

b. CHARACTERIZATION OF POROUS DIRECT-BONDED OR CHEMICALLY-BONDED AND OTHER ALIKE MATERIALS

ULTRASONIC INSTRUMENT: HP-705
OSCILLOSCOPE: Tektronix 2215
LONGITUDINAL WAVE TRANSDUCERS: Direct contact dry coupling types for reasonably smooth surfaces in 0.5, 1.0, and 2.25MHz frequencies.
SHEAR WAVE TRANSDUCERS: Direct contact dry coupling types for reasonably smooth surfaces in 0.5 and 1.0MHz.

c. THICKNESS/VELOCITY MEASUREMENT OF RELATIVELY DENSE MATERIALS

ULTRASONIC INSTRUMENT: T-4501
LONGITUDINAL WAVE TRANSDUCERS: Delay line contact in 5, 10, and 15MHz.

CONCLUSIONS

We trust the information provided in this note is of value to you. We also assume that you are in possession of more detailed technical information about ultrasonic hardware and applications technologies from Ultran. In case you do not possess complete information or are in need of further assistance, we are pleased to attach a current list of valuable publications available from our laboratories.

As we continue to be in the forefront of ultrasonic NDC technology, we suggest that you keep in touch with us from time to time.

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Transducers, Instrument Systems, & Publications
April 1987

Nondestructive Characterization (NDC)

Ultran has made Nondestructive Characterization (NDC), a practical reality. Our years of experience in ultrasound, coupled with our broad background in materials science, means success for you. That's because we understand your materials problems and the information you need. And because of our knowledge of ultrasound, we know what our ultrasonic equipment must do to provide this information to you.

This combination of abilities has allowed Ultran to redefine the limits of ultrasound. And, in turn, this allows you to further your quest in the understanding, description, and "on-line" testing of materials.

Listed here is Ultran's most current line of transducers, instrument systems, and publications.

Ultrasonic Transducers:

Standard Immersion , *<200KHz->25MHz*
VHF Immersion, *<10MHz->100MHz*
VHF Delay Line Immersion, *<30MHz->100MHz*
Standard Contact, *<200KHz->25MHz*
Anglebeam/Shearwave, *<500KHz->10MHz*
Transmitter/Receivers, *<500KHz->10MHz*
Replaceable Membrane, *<500KHz->5MHz*
Delay Line, *<1MHz-100MHz*
High Temperature (250°C) Contact, *<500KHz->10MHz*
High Temperature (1000°C) Delay Line, *<500KHz->20MHz*
Dry Coupling, Single Element, *<500KHz->10MHz*
Dry Coupling, Dual Element, *<500KHz->10MHz*
Dry Coupling, Delay Line, *<500KHz->20MHz*
Dry Coupling, 0° Shear Wave, Contact, *<500KHz->20MHz*
Dry Coupling, 0° Shear Wave, Delay Line, *<500KHz->20MHz*
Air Propagation, *<100KHz->10MHz*
0° Incident Shearwave, *<500KHz->15MHz*
Lambda, *>30MHz*
Lambda, High Acoustic Impedance, *<500KHz->20MHz*
Radiused Elements, *<500KHz- >10MHz*
Unique Applications, ∞

Ultrasonic Instruments:

MINI-4400A: Feather weight (8.6lb with six NiCd batteries) portable ultrasonic flaw detector, featuring bright crt, 102dB total gain and usable frequency response from 500KHz to 12MHz.

T4500 Series: Instruments for thickness thinness, and velocity measurements in relatively porous to dense materials. Small battery operated instruments with digital readouts and RS-232 interfaces.

HP-705: A high energy pulser, receiver, and stepless gate system featuring pulse and rf burst modes, respectively usable from 200KHz to 5MHz and 25KHz to 2MHz.

SP-3025: A square wave pulser, receiver, and stepless gate system featuring variable pulse from 50 to 300 volts with 5ns rise time and usable frequency response from 500KHz to 25MHz.

SP-10001: A pulser-receiver with extremely short pulse (<5ns) and extremely wide bandwidth (<10 to >100MHz).

Publications

U-777, a, b: Description and definition of Ultran's transducer series, styles, analysis services, and accessories.

EPN-101: Principles and Methods of Ultrasonic Characterization of Materials.

EPN-102: Application Notes on Ultran's Dry Coupling Transducers.

EPN-103: Application Notes on Ultran's Air/Gas Propagation Transducers.

EPN-104: Application Notes on Ultran's Unipolar Lambda Transducers.

EPN-105: Application Notes on Ultran's High Temperature Transducers.

EPN-106: Acoustic and Geometrical Characterization of Transducer s

EPN-107: Ultrasonic Nondestructive Characterization; Prospects for Materials & Processes

EPN-108: Importance and Use of Very High Frequency Ultrasound in NDC of Materials

EPN-109: Wideband Ultrasonic Spectroscopy

EPN-110: Ultrasonic Characterization of Ceramics by Dry Coupling