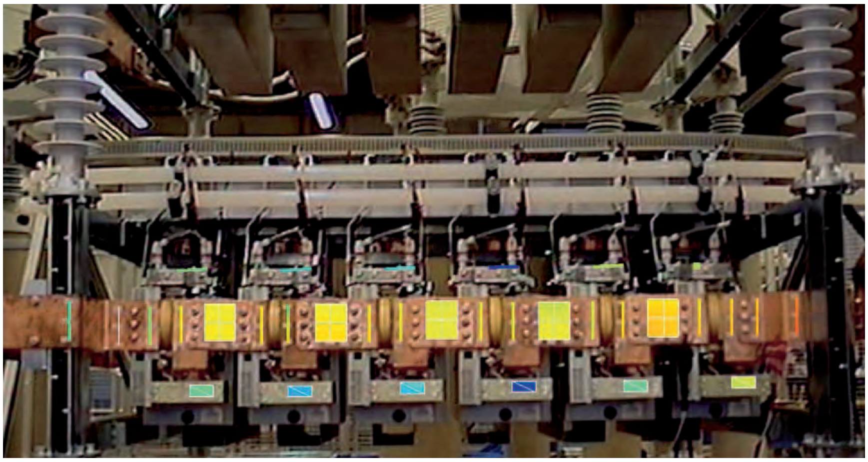

Fig. 3: Vibration modes on the semiconductor modules on the front of the converter.

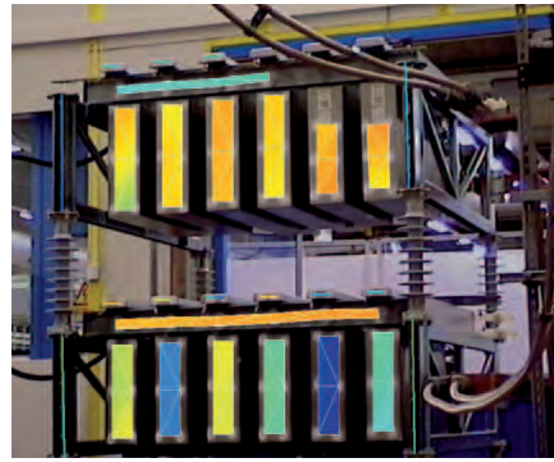

Fig. 4: Vibration modes of the converter measured on the rear side of the power capacitors.

## Experimental Set-up

The vibrations occurring on a converter module during operation were measured using a PSV-400-3D Scanning Vibrometer. The module forms part of a test facility which is supplied from the national grid and functions as a “miniature model” with similar characteristics to the original. (fig. 1 and 2). Due to high voltages, much of the measurement instrumentation was set up outside the test area. Only the measuring heads were positioned inside, close to the module. An OFV-505/5000 Single-Point Vibrometer was used as a reference sensor, transmitting its output signal via BNC cable to the data management system (DMS). The reference signal enables subsequent stitching of data obtained from measurements taken from different directions.

## Pre-tests

In a first test series, the vibration properties of selected components were investigated. Various positions on the mechanical structure were of interest. Loading spectra had to be determined for qualification prior to design and development.

The measurements took place at various levels up to full load and under many operating scenarios. In total, including setting up and determining the noise levels, some 20 measurements were carried out, each of which lasted 10 minutes. Each measurement comprised 52 measurement points with a frequency span of 800 Hz, a resolution of 1 Hz and 10 averages (complex measurements, i.e. both real and imaginary parts).

## Validation Experiment

Additional measurements were made in order to validate vibration-optimized converter modules, comprising six power modules and their corresponding power capacitors. The entire block was initially measured from the front and in the original state under various current loads (fig. 3).

Further measurements were carried out, systematically exchanging various components. Later, additional measurements were performed on the rear side of the converter (fig. 4).

A major advantage was that data from both front and rear measurements could be subsequently combined, resulting in an overall visualization of the vibration characteristics of the entire system.

## Conclusions and Outlook

The 3-D scanning vibrometer measurements rapidly provided eigenmode data over large areas of critical converter module components. The customer was highly satisfied with the measurement service provided and the system used, especially the PSV Software, due to its simple operation and visualization tools. Besides the improvement of the design aimed at preventing failure due to the operating frequencies, low frequency resonance vibrations in the Hz-range of the entire system can also be determined, which could, for example, be of importance in earthquake simulations. For this purpose a sufficiently large vibrating table or shaker can be controlled by the Polytec system interface, generating the frequencies required for measurement of complex motion spectra. The 3-D scanning vibrometer shown here can therefore sample the motion of the system and visualize the motion characteristics and areas where resonance may occur.

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# Bringing Ultrasonic Fatigue to Light

## High Frequency Stress and Strain Measurements During Ultrasonic Fatigue Testing with 3-D Scanning Vibrometry

**In recent years piezoelectric ultrasonic facilities have been used more and more to investigate the fatigue behavior of high performance metals, e.g. titanium alloys or metal matrix composites (MMC) in the very high cycle fatigue regime. This innovative testing technique requires adequate tools for calibration and measurement such as 3-D scanning vibrometry, which offers a lot of advantages.**


**Fig. 1: Experimental setup for ultrasonic fatigue testing.**

### Motivation

Many modern engineered systems, such as heavily stressed motor parts or offshore structures, have to resist more than 10 million cycles due to either high frequency loading or a lifetime of up to more than 30 years. This cycle range is named the Very High Cycle Fatigue (VHCF) regime. For a reliable application of these high performance components, a detailed knowledge of the fatigue behavior of materials used in the VHCF regime becomes more and more important. Conventional testing facilities can only perform long duration tests at frequencies of up to 200 Hz.

### The Ultrasonic Testing Facility

In order to realize for example $10^{10}$ cycles in short time periods, an innovative ultrasonic testing facility for tension-compression experiments was developed at the Institute of Materials Science and Engineering (WKK) at the University of Kaiserslautern in Germany. The loading principle of the testing system is based on a piezoelectric converter, which is designed to resonate fatigue specimens at a frequency of 20 kHz with a standing longitudinal wave that causes fatigue in the material. An eigenfrequency of 20 kHz is therefore an essential property of the specimen. Finite element analysis is used during the design process in order to ensure an adequate specimen design.

The 3-D scanning laser vibrometer promised to be an effective instrument to measure the eigenfrequencies and eigenmodes and verify our finite element model. Stress and strain evaluation using conventional techniques such as strain gages is quite difficult due to their tactile nature during high frequency oscillation. Therefore the potential of 3-D scanning laser vibrometry for high resolution non-contact stress and strain measurement during ultrasonic fatigue was evaluated.

### Experimental Setup

A PSV-400-3D Scanning Vibrometer from Polytec was used for the experiments at the WKK. The positioning of the three laser heads, shown in fig. 1, was chosen to ensure accessibility to the tapered region of the fatigue specimen. Very low displacement amplitudes of 30 nm were selected for determining the eigenfrequency and eigenmodes, and to prevent unwanted fatigue damage of the material. The strain measurements were focused

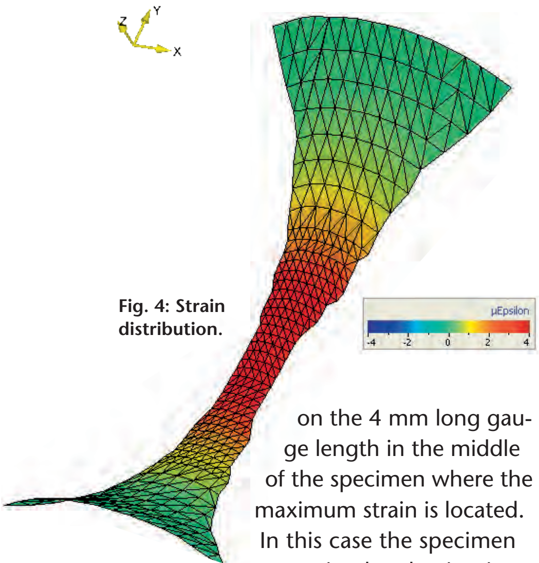


Fig. 4: Strain distribution.

on the 4 mm long gauge length in the middle of the specimen where the maximum strain is located. In this case the specimen was stimulated at its eigenfrequencies with high displacement amplitudes of up to 42 µm.

### Selected Results

Correlation with the FE model was performed with specimens in their initial state (prior to fatigue). The frequency response (in fig. 2a) indicates an eigenfrequency of 20.06 kHz and the eigenmode at this frequency (top of fig. 3) shows the expected longitudinal oscillation. Both results fit very well to the calculated FE results. Furthermore, the detailed visualization of the high frequency oscillation confirms that the specimens are oscillating correctly for this investigation.

Similar investigations were carried out on a specimen that had been loaded with a stress amplitude of only 50% of the yield strength. In spite of this, fatigue failure occurred after 1.2 * $10^9$ cycles due to interior fatigue damage. In comparison to the initial state, the eigenfrequencies reduced because of this subsurface fatigue damage. The eigenmodes in the range of 20 kHz also show clear differences (lower half of fig. 3). An asymmetric velocity distribution along the specimen and a considerable inhomogeneity in the area of the fatigue failure were observed.

Fig. 4 shows the strain distribution during the high frequency oscillation with a maximum in the middle of the specimen. The correlation between stress amplitude in the gauge length measured with the 3-D scanning system and displacement amplitude at the free end measured by Polytec´s CLV-2534-2 single-spot vibrometer shows an increase of stress amplitude with an increasing displacement amplitude. A comparison with the correlation based on the FE model shows a high degree of congruence (fig. 5).

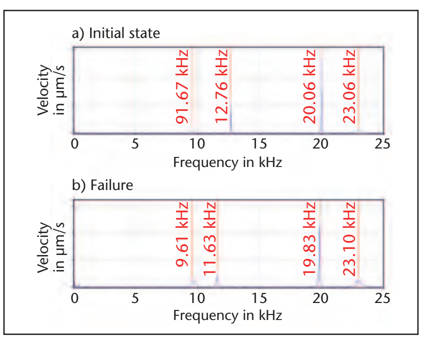


Fig. 2: Frequency response.
a) initial; b) after fatigue damage.

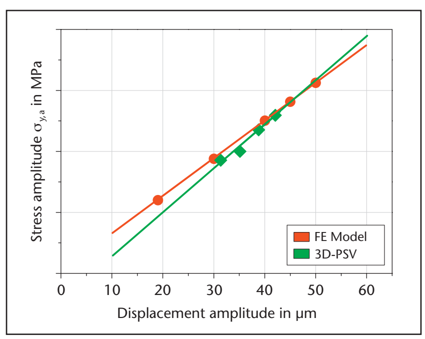


Fig. 5: Comparison of FE model and measurement.

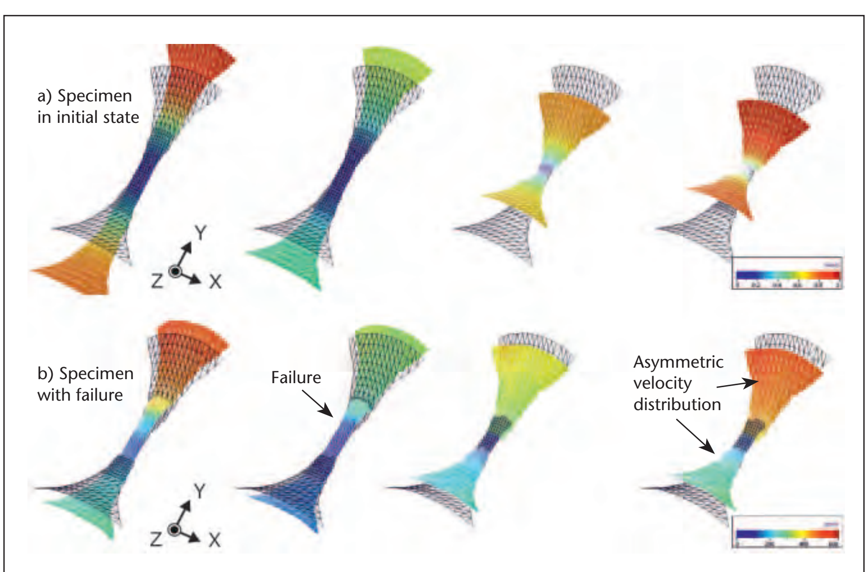


Fig. 3: Deflection shape; above: initial; below: after fatigue damage.

### Conclusion

The work presented here illustrates possible applications of 3-D scanning vibrometry in the field of ultrasonic fatigue testing of metals. The results of investigations of the eigenmodes of specimens with different fatigue states indicate the potential to characterize the current fatigue status and to locate fatigue failure. 3-D scanning vibrometry is capable of non-contact local strain measurement with a high spatial resolution and offers an alternative to strain gages for evaluation of high mechanical stresses along the gauge length during ultrasonic fatigue testing.


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# Measuring with Lasers

## Optimizing Valvetrain Dynamics at Porsche Engineering

**Laser vibrometry has established a firm place in the automotive sector over the past few years. This non-contact process is used at Porsche Engineering to investigate and improve the dynamic behavior of valvetrains during engine development.**

### Valvetrain Design

Top performance with optimum fuel consumption requires a perfectly tuned engine. The valvetrain, at the foundation of such tunings, always has the potential for improvement. Heavy demands are placed on these components, particularly in the case of sports car engines, by offering the largest possible opening cross-section in combination with short valve opening periods at high rpm. It is for this reason that developers in this area are constantly striving to improve the properties of valvetrains.

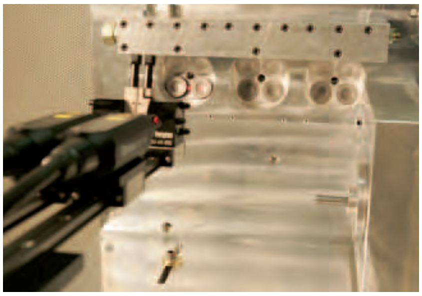

**Fig. 1: View of the valves of the test sample, mounted to the cylinder head mock-up. In the foreground is the laser vibrometer.**

**Fig. 2: Pre-validation of a valvetrain layout on a single-valve test bench.**

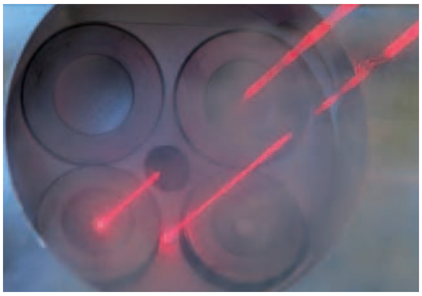

**Fig. 3: Measurement and reference laser beams of the vibrometer.**

Polytec

A test bench (fig. 1) can be used during the early stages of development to ascertain whether or not the valvetrain can actually offer the characteristics indicated in a specification document, and whether it will be able to withstand the demands placed on it as a result. The engineers at Porsche Engineering use special lasers to examine valvetrain dynamics without physical contact and therefore no interference. This allows the behavior of the valve to be measured at different speeds. The title image reveals the measurement and reference beams using smoke.

### Measurements on the Test Bench

To take measurements, the cylinder head is pressurized with oil just as in normal operation on a mock-up test bench (fig. 2). Oil temperature and expansion can be adjusted accordingly. These parameters are specified in an electronic database and are monitored.

A high-performance electric asynchronous motor drives the entire timing assembly and can be programmed to simulate actual operation.

The chain drive is replicated in full with all intermediate gears, guides and tensioning rails, including the chain tensioner. In this way valvetrain dynamics can be examined along with all the external influences and reactions, such as the chain drive polygon effect, damping influence of the hydraulic chain tensioner, and variable camshaft moments.

Before taking measurements, the laser beam is positioned to strike the valve head perpendicularly. A second laser beam is positioned as a reference beam parallel to the first and adjacent to the valve seat. In fig. 3, both measurement and reference laser beams can be seen as they have been made visible by smoke. With the reference established, the relative movement between the two points is then measured and can therefore show the isolated movement of the valve without the influence of sprung mass. In this way, valve lift and valve speed can be recorded exactly.

### Data Acquisition and Evaluation

Porsche Engineering uses a Polytec HSV-2002 High-Speed Vibrometer that was developed especially for measuring Formula 1 engines. It can record speeds of up to 30 m/s as well as displacements (strokes) up to 160 mm.

The data acquired are recorded and saved in a time-synchronous manner. The Rotec RAS system used by Porsche Engineering can record analog signals at a resolution of 16 bits and a sampling rate of 400 kHz. Speed signals up to a frequency of 1 MHz and a resolution of 40 bits can be recorded. An integrated software package enables rapid analysis of the data obtained (fig. 4).

Deploying this system enables Porsche to measure the effects of different cam contours, spring stiffnesses, spring progressions and valve drive masses, for example. The influence of these modifications can then be assessed by examining valve closure speeds (fig. 5) and valve accelerations and by calculating contact power processes and Hertzian stresses. Additionally, analyses of torsional vibrations can provide further information on operational behavior.

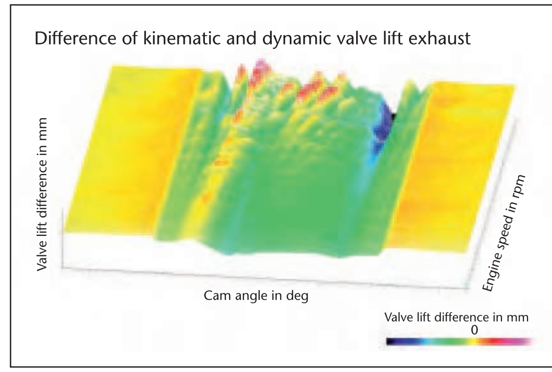


**Fig. 4: Differences of kinematic and dynamic valve lift due to dynamic effects.**

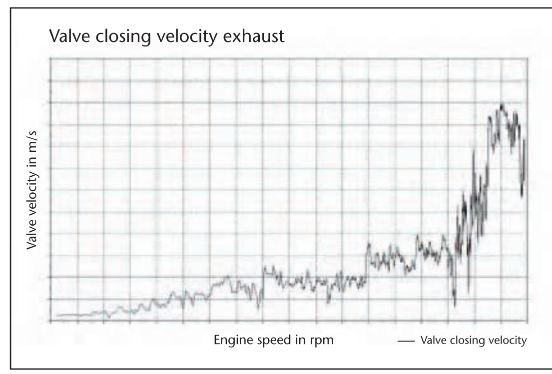


**Fig. 5: Increasing valve closing velocity with rising engine speed.**

Owing to increasingly complex valvetrains now being produced with ever shorter development periods, valvetrain analysis is gaining more and more significance. By using laser vibrometry at an early stage of development, Porsche Engineering is examining the valvetrain for kinematic properties, dynamics, and stress in the desired RPM range. The necessary valvetrain development modifications were targeted and evaluated on several projects through the use of laser vibrometry, and thus avoided costly and time-intensive development loops.

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# Bad Vibrations

## An Investigation of the 3-D Vibration Transmissibility on the Human Hand-Arm System Using a 3-D Scanning Laser Vibrometer

### Introduction

Vibration transmissibility on the hand-arm system is very important in order to understand and simulate the biodynamic response of the system. Such knowledge can be further used to help understand vibration-induced discomforts, injuries, and disorders. Both conventional accelerometers (which, however, affect the results due to their mass) and single-axis laser vibrometers [1, 2, 3] have been used to measure the transmitted vibration. Further simulations of the system require multi-axis transfer functions. Therefore, the objective of this study is to investigate the vibration transmissibility on the human hand-arm system subjected to vibrations in three orthogonal directions ($x_h$, $y_h$, and $z_h$).

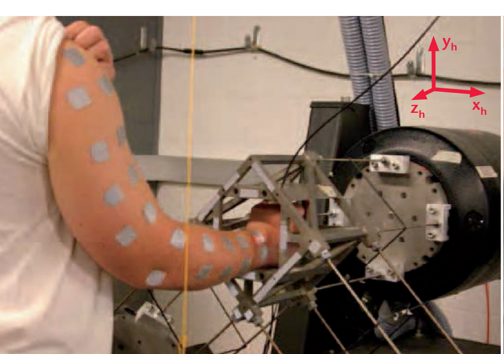


**Fig. 1: 3-D hand-arm test system, together with the posture of a test subject.**

**Fig. 2: Attachment of retro-reflective tape.**

### Method

Seven healthy male subjects participated in the study. As shown in fig. 1, the experiment was carried out on a novel 3-D vibration test system (MB Dynamics, 3-D Hand-Arm Test System). The $z_h$ direction is along the forearm, $y_h$ direction is along the centerline of the instrumented handle in the vertical direction and $x_h$ direction is in the horizontal plane normal to $y_h$-$z_h$ plane. Each subject was instructed to maintain grip and push forces at 30±5 N and 50±8 N, respectively, with his dominant right hand with elbow angle between 90° and 120°, and shoulder abduction between 0° and 30°.

The vibration controller was programmed to generate broadband random vibration in the frequency range of 16 – 500 Hz along each direction. The overall rms acceleration in each direction was 19.6 m/s$^2$. The coherence of the three axial spectra was taken as 0.9. The three-axis accelera-

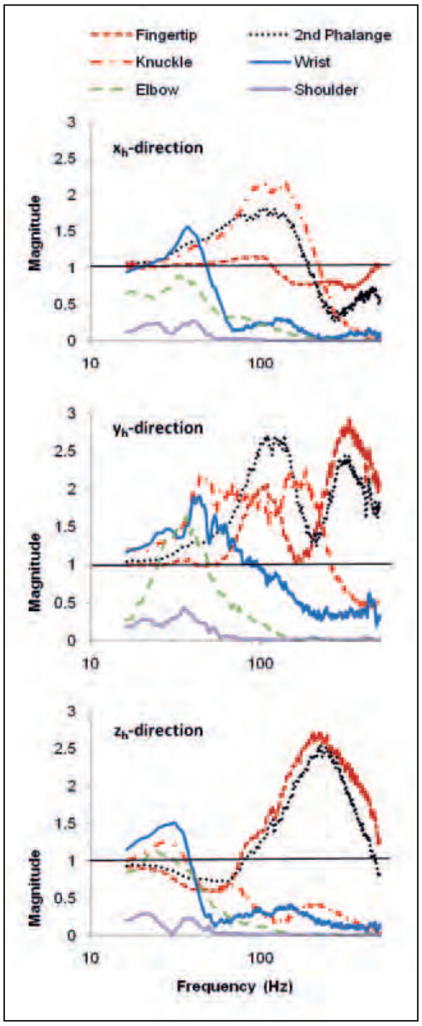


**Fig. 3: Magnitudes of the tri-axial vibration transmissibility at the different locations.**

tions on the handle were measured using a tri-axis accelerometer installed inside the handle, which provided the reference signals for deriving the vibration transfer functions in the three directions.

The vibration transmitted to the top surfaces of the major substructures of the system (fingers, back of the hand, wrist, forearm, upper arm, and shoulder) was measured using a Polytec PSV-400-3D Scanning Vibrometer. To avoid the effect of hairs and to obtain a good reflection, a piece of retro-reflective tape was attached to a piece of first-aid tape that was firmly attached to the skin of the hand-arm system at the desired measuring locations, as shown in fig. 2. Each transfer function was expressed in the frequency domain from 16 to 500 Hz, with an equal frequency interval of 0.5 Hz.

### Preliminary Results and Discussions

The measured transmissibility functions varied greatly among the subjects but their basic distributions are similar and are demonstrated here using the data measured with one of the subjects. Fig. 3 shows the magnitudes of the tri-axial transmissibility, which is generally a function of frequency, measured at six important locations. The function varied greatly with the measurement location and vibration direction. There is at least one dominant peak or resonance in each transmissibility function. The dominant resonances at the wrist, elbow, and shoulder in the $x_h$- and $y_h$-directions were in a similar frequency range (30 to 50 Hz). In the $z_h$-direction, they were at marginally lower frequencies (20 to 40 Hz). The resonances on the fingers were at higher frequencies and they varied in a wide frequency range (80 to 400 Hz).

The resonances observed at the wrist, elbow, and shoulder were fairly consistent with the first resonance observed in the driving-point biodynamic response [4]. This suggests that the entire hand-arm system vibrates more or less in phase in this resonance frequency range and that this resonance primarily depends on the biodynamic properties of the palm-wrist-arm substructures. The major finger resonance was also well correlated to that observed in the corresponding driving-point response, suggesting that it primarily depends on the biodynamic properties of the fingers.

A reported study [5] found that the frequency dependence of the vibration power absorption density (VPAD) of a finger is similar to that of the vibration transmissibility at frequencies higher than the first resonance of the hand-arm system. While the finger VPAD may be a good measure of the finger vibration exposure, the finger resonances observed in this study suggest that the frequency weighting defined in the current standard (ISO 5349-1, 2001 [6]) is unlikely to be suitable for assessing the risk of the finger vibration injuries and disorders.

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### Disclaimers



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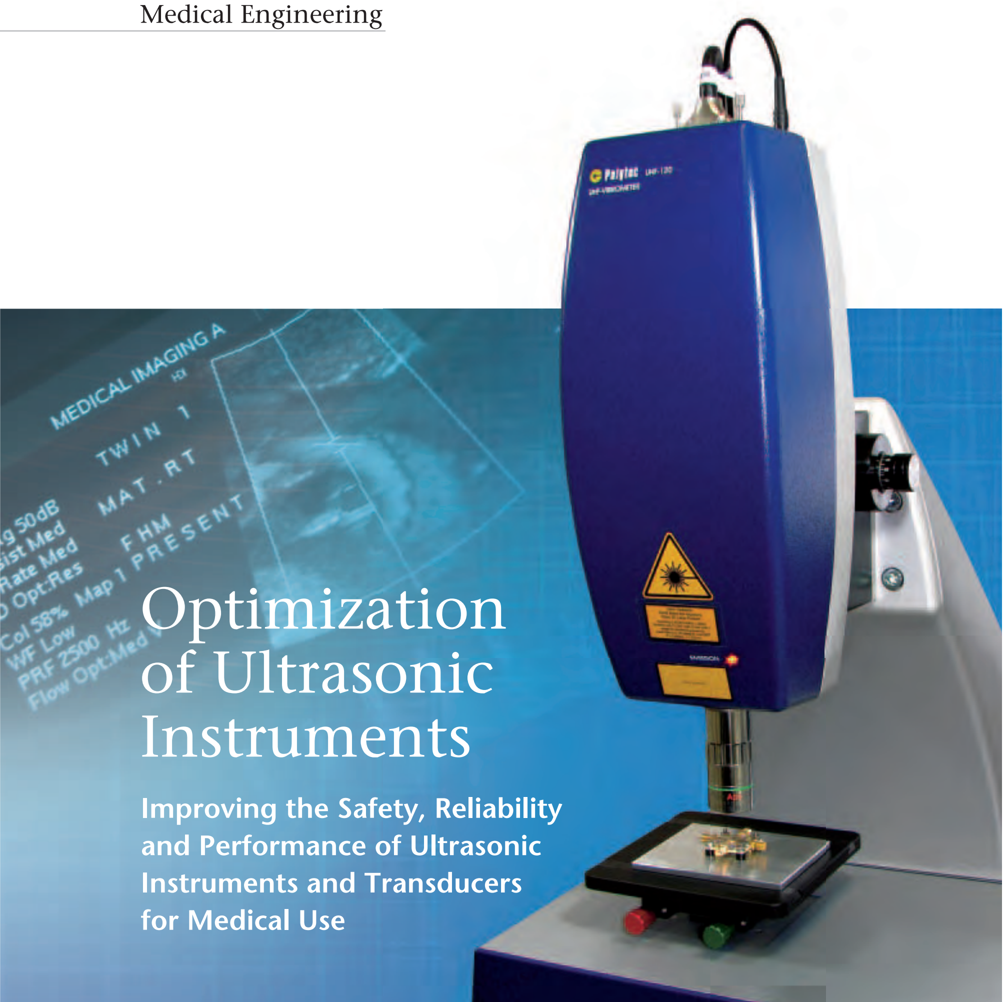
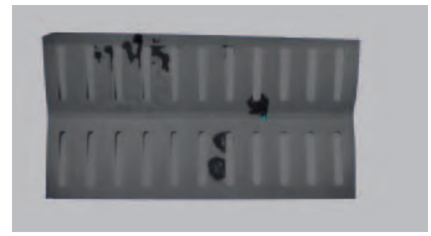



# Optimization of Ultrasonic Instruments

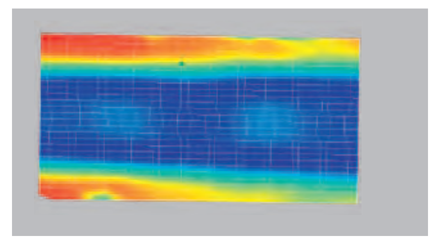
## Improving the Safety, Reliability and Performance of Ultrasonic Instruments and Transducers for Medical Use

**Ultrasonic imaging methods have been in use for many decades and are now an indispensable standard diagnostic tool in hospitals and in almost all doctors' practices and medical clinics. The next step is the use of ultrasound-supported or ultrasonics-based instruments in the operating theater and during outpatient treatment.**

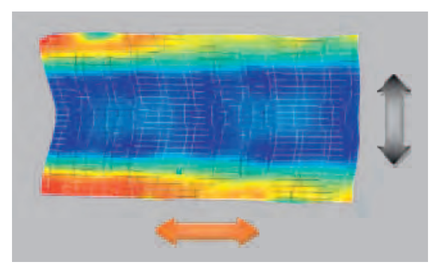
### Example: Ultrasonic Knife



Blade of an ultrasonic knife.



RMS distribution (effective amplitude values) of the vibration after measurement with the 3-D Scanning Vibrometer.



Deflection shape at 22.4 kHz. The motion is almost entirely in the direction of the orange arrow, perpendicular to the cutting direction (gray).

### The Aim: Verifiably Safer Design and Performance Optimization of Medical Ultrasonic Instruments

Two different applications can be distinguished from one another

1. Invasive instruments providing direct mechanical contact
2. Instruments with an indirect mode of action focusing ultrasound energy for either imaging or treatment of a condition

The first group includes ultrasonic scalpels, coagulators, aspirators and instruments for intravenous thrombus removal, liposuction and dental plaque removal. Common to all of them is that they come into direct contact with the tissue. If an instrument fails, for example due to fatigue, instrument fragments or detritus can remain inside the patient and cause acute or long-term injury. This must be absolutely avoided by the correct design and application of the instrument.

The second group includes instruments for shock wave therapy and for the application of focused ultrasound energy (HIFU). Here the site of the generation of the ultrasonic energy and its intended effect are spatially separated from each other. Efficiency and spatial precision play a greater role. The risk due to mechanical failure of the ultrasound generator is much smaller.

### Use of Laser Doppler Vibrometers

The following properties of laser-based vibration measurement are highly advantageous regarding the development of ultrasonic instruments in medicine:

- Complete freedom from the effects of contact feedback: The vibration of the test object is not influenced by the measuring instrument.
- High spatial resolution: Due to the high frequencies and often filigree-type structures, it must be possible to precisely spatially resolve deflection shapes in measurements. For example, the laser, with its few µm diameter beam is able to measure thin cuts or wires.

- The possibility to measure in transparent media, for example when considering the influence of damping.
- The ability to measure high frequencies: In principle there is no frequency limitation. Currently the highest mechanical vibration frequency that can be measured is 1.2 GHz.

### Instruments

Depending on the application, various measuring instruments are available. Single-point vibrometers permit measurement of the amplitude at one point and are used in the verification of specified characteristics (amplitude, frequency). They vary in terms of bandwidth and the direction of the measurement (in-plane, out-of-plane or all three components, 3-D).

Scanning vibrometers are used to measure complete deflection shapes dependent on the frequency. Due to the surface-based measurement principle, the data obtained are suitable for the validation of FE calculations. Out-of-plane systems (PSV-400) and three-dimensional measuring systems are available for this purpose, and their measurement data can also be used to calculate the dynamic stress and strain distributions.

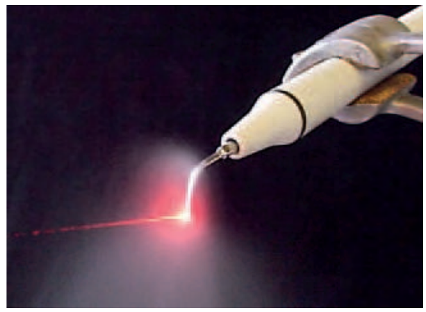
### Summary

Laser vibrometry is ideally suited as a tool for the verification of FE simulations both for invasive and diagnostic medical ultrasonics instruments. Thanks to its linearity well into the high MHz range and the complete lack of feedback effects, coupled with high lateral resolution, this technology is suitable for nearly all structural dynamic tasks. Calculation methods derived from the basic technology for sound field visualization and for fatigue strength (strain/stress) add further applications.

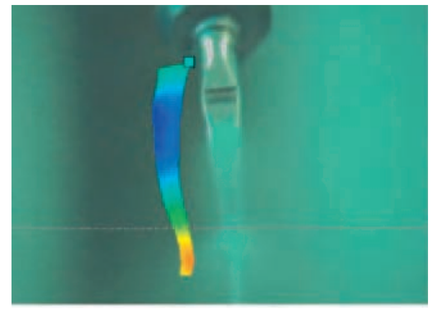
Consequently laser Doppler vibrometry is a tool suited to the development of efficient, reliable and effective instruments for the doctor and surgeon.

Please download the full article as Polytec Application Note VIB-U-01 on **www.polytec.com/applications.**

### Example: Dental Scaler Instrument

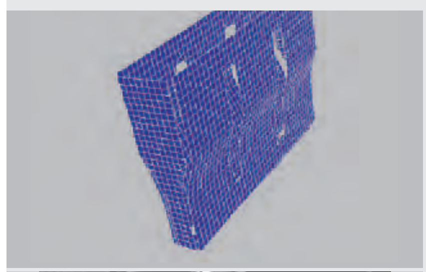


**The laser of the scanning vibrometer measures the surface of a dental ultrasonic scaler.**



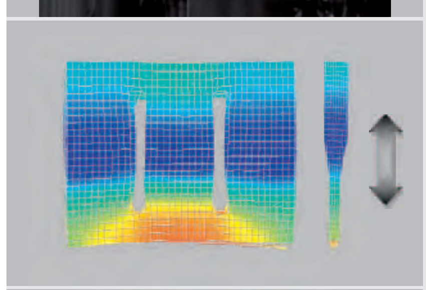
**Snapshot of the 3-D animation, together with the video image of the scaler tip.**

## Method Toolbox: Integration of 3-D Measurement Grids

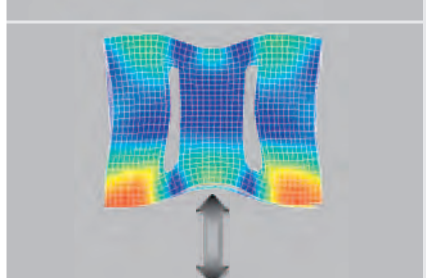


**The measurement mesh of an ultrasonic tool tip in this case is determined by precise geometry measurement using triangulation of the three PSV-3D laser beams.**

**Alternatively the mesh can be imported from the FE program into the measuring system and then aligned with the measurement object using a number of reference points.**



**Example of a desired deflection shape: The deflection shape measured at 20 kHz largely corresponds to the vibration necessary for the desired process (arrow direction). The movement is fairly uniform over the whole length of the active surface.**



**Example of an undesired deflection shape: At a somewhat higher frequency, another mode occurs in the foreground, which superimposes a bending eigenmode on the active movement. This means that unsatisfactory results can be expected.**

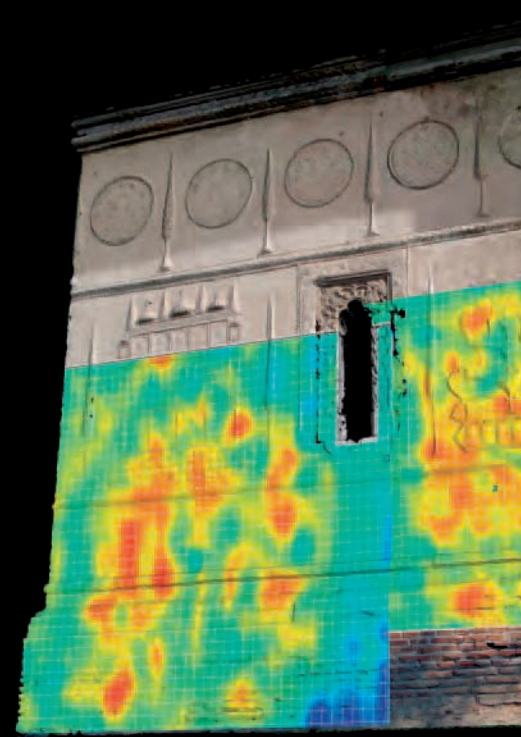


Fig. 4: Overlapped vibration map on textured digital model of the south wall of the Fundenii Doamnei church (1699), Bucharest.

# Employ ART and Enjoy Art

## Scanning Vibrometry for Non-destructive Testing of Artwork

**One of the most fascinating fields of activity for a scientist or an engineer is cultural heritage investigation and conservation. For many years it has been known and largely accepted that restoration is no longer only an art, it is also based on and influenced by ART (Advanced Research Techniques).**

### Non-contact Methods for Artwork Investigation

Due to some special features, optoelectronics is often claimed to assist and support laboratory investigations, and more importantly on-site investigations. There are possibilities to identify a material's composition and to map the distribution of various materials over a large surface. One of the most non-invasive techniques that does not stress fragile and precious surfaces (paintings, documents, murals etc.) is Laser-Induced Fluorescence (LIF), a non-destructive remote spectroscopy method. Laser-Induced Breakdown Spectroscopy (LIBS) also remotely delivers very accurate information about material composition. Information about thermal emissivity, top layers covered by black encrustations, and possible infiltration routes into historical walls are easily extracted from thermograms. These days there are many analytical methodologies and techniques to determine an artwork's chemical composition, but less attention has been paid on structural diagnostics instrumentation.

### Remote Acquisition vs. Traditional Diagnostics

For example, determining the multilayer structure of a large mural could be carried out in the time-consuming traditional way, which is by repeatedly tapping point by point and relying on the expertise of the restorer and on their good hearing. Obviously, this typical diagnostic process is accomplished mainly through manual and visual inspection and the results vary from restorer to restorer.

The basic idea behind employing laser Doppler vibrometry is to substitute human senses and contact sensors with measurement systems capable of remote acquisition. On-site set-ups are quite compact, easily managed and ergonomic (fig. 1). The laser Doppler vibrometer set-up is based on acoustic excitation by a loudspeaker system. In many cases the surfaces are very slightly vibrated by mechanical and acoustical actuators, while a laser Doppler vibrometer scans the objects measuring surface velocity, producing 2-D or 3-D maps.

### Example – Painted Canvas

Think for example of a wooden wall of a historic church covered by ancient painted canvas (fig. 2) with hidden detached areas. These defects can be easily spotted by laser Doppler vibrometry as regions where velocity is higher than in neighboring areas (fig. 3). The results can be used to determine subsequent repair or conservation measures.

### Example – Stucco Decoration

Painted stucco is not only an ancient form of decoration, but also a precious artistic and historic “memory”. As a building material, stucco is well appreciated all over the world and has been used throughout almost all ages. Being quite durable, attractive, and weather-resistant, it was used even for entire wall surfaces.
Its enemies are high temperature gradients and shocks. Any incipient detachments have to be identified and repaired. In historical reconstructions, laser vibrometers can identify structural resonance frequencies thus providing a complete characterization of these defects.

**Fig.1: Members of the INOE group working on-site. About 300 m² of the building’s walls were evaluated, with measurement points every 10 to 15 cm, in less than 2 days.**

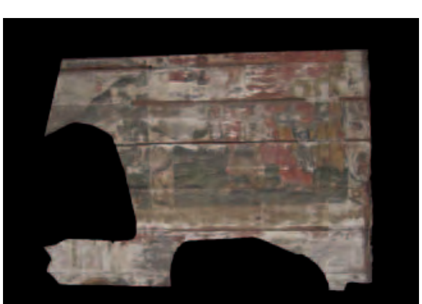


**Fig. 2: Detail of painted canvas on a wooden wall in a church in Bucharest.**

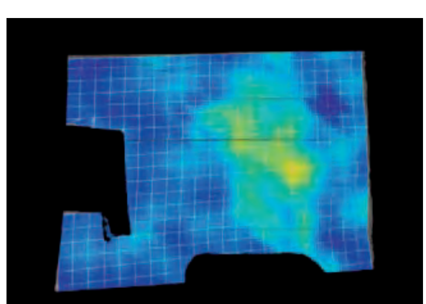


**Fig. 3: Vibration map of painted canvas.**

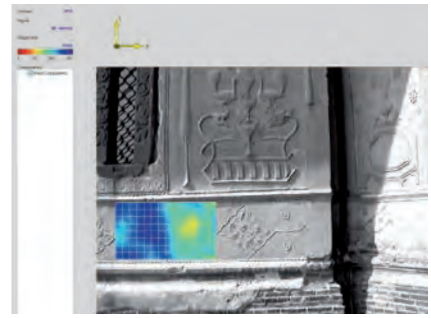


**Fig. 5: Detail of complex multilayer diagnostic report.**

This holds true as well for massive structures. Fig. 4 and fig. 5 show vibrations maps that pinpoint detachments with various dimensions on large walls of the Fundenii Doamnei church (1699), a beautiful and interesting historic monument in Bucharest, its outside entirely covered by stucco.

### Conclusion and Outlook

The range of laser Doppler vibrometry applications have been successfully tested and recommended for different types of movable or decorative artworks such as frescoes, icons, mosaics, ceramics, inlaid wood and easel paintings. Laser Doppler vibrometry is so far the most impressive investigation technique for restorers and conservationists who are dealing with multilayer structures with possible hidden detachments, delaminations and fragile top surfaces. A succinct list of the advantages of this technique includes limited intrusiveness, the non-contact, remote measurement principle, ample frequency response, high sensitivity, transportability, and easy data management.

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# New Non-contact LSV-2000 Length and Velocity Sensor

**The LSV-2000 Laser Surface Velocimeter, the latest member of Polytec's compact instrument class, determines the direction of motion (forward or reverse), and also recognizes standstill conditions (v=0). The direct, non-contact measurement of product length and speed, coupled with the high precision, reliability and consistency of the LSV-2000 enables users to fully optimize the production process and thus save costs. www.velocimeter.us**

The new LSV-2000 measures reliably on almost any solid surface, whether controlling processes utilizing carbon steel, shiny aluminum or oily sheets; producing round wire and cable; or manufacturing paper, cardboard or tissue.

The new optical system design offers depths of field and velocity ranges that are independent of the sensor standoff distance. This leads to significantly more application possibilities, especially for sensors with short standoff distances. For example, in the event of varying material thicknesses or varying pipe diameters, a shorter standoff distance, with the new, larger depth of field, may well meet the process requirements, rather than using a sensor with a long standoff distance. Thanks to its compact design the LSV-2000 is perfectly suited for use in small spaces, such as in C-Frame Thickness Gauges for rolling mills or scanning systems in paper mills and film processing lines. In addition, the LSV-2000 offers accessories for use in hostile environments. Air wipes, water-cooled plates and rugged, fully water-cooled housings are some of the accessories available for applications in dirty, dusty or high temperature process areas.

When used as a footage counter, Laser Surface Velocimeters allow users to reliably reduce process scrap through accurate and precise length measurements, enabling process optimization to ensure a fast ROI. Likewise, accurate and repeatable measurement of material speed at two points (differential speed measurements) enables users to reliably measure and control process parameters for achieving specified material properties and quality, as is the case in applications such as mass flow, elongation, stretch and draw.

**Fig. 1 (left): LSV installation at the melt shop of TMK-Ipsco Koppel Steel.**

**Fig. 2 (right): Polytec LSV laser measuring system for cut-to-length control in a corrugator.**

### A Broad Range of Applications

- Speed measurement
- Slippage detection and speed synchronization
- Coil length measurement
- Speed calibration

- Part length measurement for goods in pieces
- Cut-to-length control
- Encoder calibration
- Spool length
- Ink-jet marker control
- Speed balancing
- Speed and length measurements in hot environments

## Non-contact Velocity Measurement in the Corrugated Board Industry Compared to Conventional Methods

The aim of this study was to improve the dimensional stability of the sheet lengths at the cross cutter of a corrugator. The laser measuring system was used instead of an encoder wheel in the cross cutter control (fig. 2). The cut sheets were then remeasured manually. Continuously changing plant velocities represent the greatest challenge for the measuring systems. The LSV instrument from Polytec achieved the best results – no deviations of greater than ±1 mm were measured under all operating conditions. This high absolute accuracy and repeatability of the laser measuring system cannot be achieved with the conventional idler encoder and feed roller encoder.

Source: S.K. Musielak, Velocity measurement in the corrugated board industry – contact-free velocity measurement in comparison with conventional measurement methods. Sensor Magazin 2/2011, S. 8-11 (in German).

## Improving Cut Length Tolerance and Long Term Consistency in Continuous Casters with Laser Velocimeters

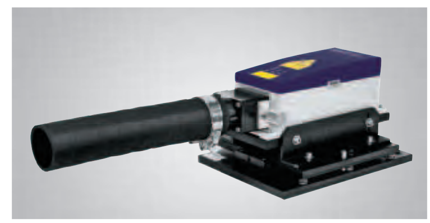
The melt shop of TMK-Ipsco Koppel Steel in Koppel, PA has a 4 strand billet caster producing rounds in the range of 5.5 and 6.5 inch diameter for seamless tube products (fig. 1). In May of 2010, TMK-Ipsco Koppel installed 4 Polytec LSV laser velocimeters on the 4 strand caster with a standoff distance of 1500 mm, a depth of field of 150 mm and a watercooled housing with air wipe. Previously, an evaluation had been conducted by installing a single LSV laser velocimeter resulting in cut length tolerances approaching ±1.0 inch – a significant improvement upon the existing contact wheel, which from experience provided cut length tolerances with variation up to ±4 inches. Introduction of these laser systems has since resulted in a significant reduction in safety factors, improved process repeatability and has eliminated the need for continued process calibration and correction factors for each strand. In addition, little to no maintenance is required.

Source: P. M. Nawfel, Improving Cut Length Tolerance and Long Term Consistency In Continuous Casters with Laser Velocimeters. AIST Iron & Steel Technology Conference and Exposition, 2–5 May 2010, Indianapolis, Ind., USA.

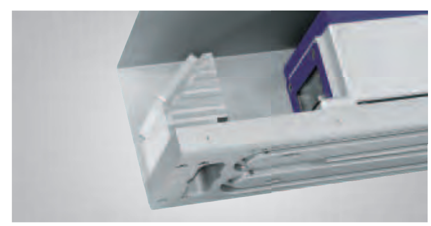
More Info: **www.velocimeter.us, www.velocimeter.co.uk**

## LSV Accessories – a Complete Solution for Your Measurement Task

**LSV-A-110 Connection Box**

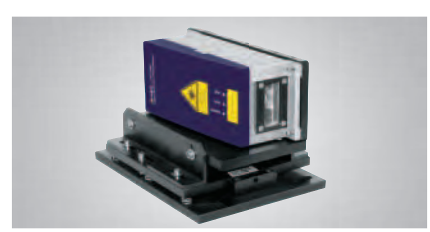


**LSV-A-120 Air Wipe with quick-exchange window**



**LSV-A-124 C-Frame Accessory Kit**

**LSV-A-122 Cooling Plate**



**LSV-A-130 Mounting Platform**

**LSV-A-121 Cooled Protective Housing**

# Trade Shows and Conferences

| | | | |
|---|---|---|---|
| Jan | 29 – Feb 02, 2012 | MEMS 2012 | Paris, France |
| Jan | 30 – Feb 02, 2012 | IMAC XXX Conference and Exposition on Structural Dynamics | Jacksonville, FL, USA |
| Feb | 15 – 17, 2012 | Convertech Japan | Tokyo, Japan |
| Mar | 06, 2012 | Instrumentation, Analysis & Testing Exhibition | Silverstone, UK |
| Mar | 06 – 08, 2012 | Automotive Testing Expo India | Chennai, India |
| Mar | 11 – 15, 2012 | Smart Structures and Materials/NDE | San Diego, CA, USA |
| Mar | 26 – 30, 2012 | TUBE 2012 | Düsseldorf, Germany |
| Apr | 11 – 13, 2012 | FilmTech Japan | Tokyo, Japan |
| Apr | 17 – 20, 2012 | Analytica | Munich, Germany |
| Apr | 23 – 27, 2012 | Hannover Messe | Hannover, Germany |
| Apr | 25 – 27, 2012 | APACT Advances in Process Analytics and Control Technology | Newcastle, UK |
| May | 07 – 10, 2012 | AISTech Iron & Steel Technology Conference | Atlanta, GA, USA |
| May | 08 – 10, 2012 | Spacecraft Technology Expo 2012 | Los Angeles, CA, USA |
| May | 16 – 18, 2012 | Japan Automotive Engineering Exposition | Yokohama, Japan |
| May | 21 – 24, 2012 | 2012 IEEE Int'l Frequency Control Symposium | Baltimore, MD, USA |
| May | 22 – 23, 2012 | WAI Operations Summit & Wire Expo 2012 | Dallas, TX, USA |
| May | 22 – 24, 2012 | 15th Int'l Conference on Low Frequency Noise and Vibration and its Control | Stratford-upon-Avon, UK |

# Polytec Web Academy

| | | |
|---|---|---|
| Feb | 07, 2012 | An Introduction to Non-Contact Vibration Measurement |
| Feb | 08, 2012 | Characterize, Analyze and Validate Surface Metrology with Innovative, High Precision, Optical Surface Profiling Systems |
| Feb | 09, 2012 | RSV-150 Long Distance Vibrometer |
| Mar | 06, 2012 | Improving Performance of MEMS Designs Using Dynamic Characterization |
| Apr | 10, 2012 | An Introduction to Non-Contact Vibration Measurement |
| Apr | 11, 2012 | An Intro to Scanning Laser Vibrometry for Non-Contact Vibration Measurement |
| Apr | 12, 2012 | Characterization at Ultrasonic Frequencies Using Laser Vibrometry |
| May | 01, 2012 | An Introduction to Non-Contact Vibration Measurement |
| May | 02, 2012 | Non-contact Methods for Aerospace Structural Analysis and NDT |

For more information visit: **http://polytec.webex.com**.

## New Multimedia:

# All About Laser Surface Velocimetry

Polytec's LSV laser length & speed sensors are used in a wide variety of industries. A new LSV video provides an overview of the technology, markets and applications, as well as the benefits compared to traditional contact speed & length measuring techniques. To learn more, read the new article "Laser surface velocimeter" on Wikipedia, or view and download the video at **www.polytec.com/video**.

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