Polytec

Nature & Technology: Vibrations Everywhere!

Field of Application

A Aerospace
B Audio & Acoustics
C Automotive
D Data Storage
G General Vibrometry
M MEMS & Microstructures
P Production Testing
S Scientific & Medical
T Structural Testing
U Ultrasonics

Polytec's Vibrometers are Indispensable Tools to Optimize Parts and Goods and to Investigate Natural Dynamic Processes

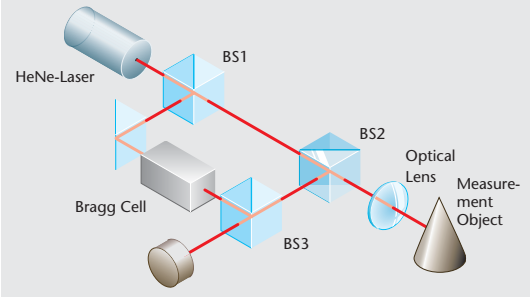
Originally developed to characterize man-made products, technology and systems, non-contact laser-Doppler vibrometry is also exploring measurements that unravel the mysteries of biological structures. Read on to learn more about vibrations in both nature and technical products and processes. Discover how these vibrations are detected and studied using laser vibrometry. Find more interesting applications and Polytec Application Notes on www.polytec.com/applications.

Introduction

The heart beats, wings flap, sounds are sent out and received – life would be much too quiet without vibrations. To investigate vibrating systems in nature requires sensitive and flexible measurements that don't disturb the specimen. Challenging tasks in medicine, biology and many other sciences take advantage of Polytec's universal modular vibrometers, single-box portable devices, or high-end scanning systems.

In the field of industrial research and development, Polytec's vibrometers are used to study objects of very different sizes including large automobile bodies, airplane fuselages, ship engines and buildings as well as tiny silicon micromachines, hard disk drive components and wirebonders. There are numerous other research applications in mechanical and civil engineering.

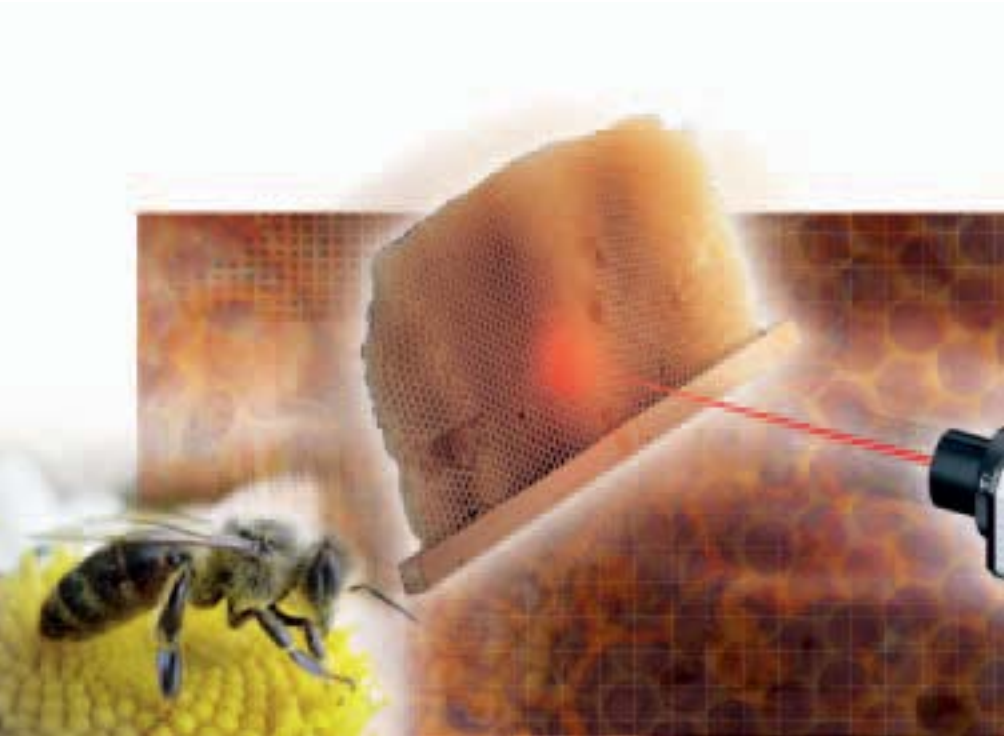
Demanding applications such as measurements on hot running exhausts, rotating surfaces, underwater objects, delicate structures or ultrasonic devices are all made possible by non-contact laser vibrometry.



At the heart of every Polytec vibrometer system is the laser Doppler vibrometer – a very precise optical transducer used for determining the vibration velocity and displacement at a point by sensing the frequency shift and phase variation of back scattered laser light from a moving surface.
To learn more about laser Doppler vibrometry, please visit **www.polytec.com/vib-university**

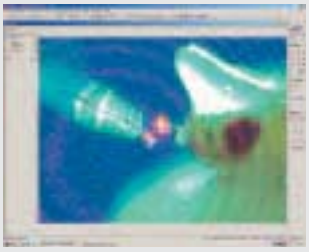
Polytec GmbH
Optical Measurement Systems
Application Note
VIB-G-05

June 2006



Measurement of honeycomb vibrations generated by dancing bees

Drosophila head and laser spot focused onto its antenna sound receiver



Biology

For numerous living species on our planet there are corresponding biological applications of laser vibrometry. One of the most prominent is insect communication. Some insect sounds are quite loud, such as the singing of the cicada; while others are supersonic and can't be heard. Some insects are so small that their songs are transmitted mainly through a plant rather than air. Entomologists use vibrometers to record this unheard noise for later study. Consider honeycomb vibrations in beehives; these signals can only be measured with highly sophisticated equipment. Other bio applications include measuring communication between elephants, fruit ripeness, spider web motion, and the hearing mechanism in frogs and fruit flies.
www.polytec.com/research

Laser vibrometer measurements of the vibration patterns of dental ultrasonic scaling equipment

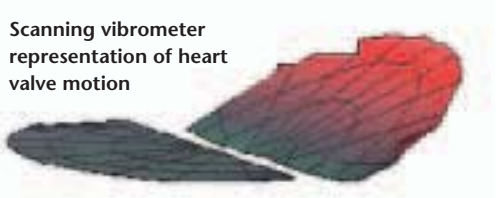
Laser Audiometer providing full ear diagnostics within a couple of seconds

Medical and Health Care

Laser vibrometry can assist with eardrum diagnostics and research on the middle and inner ear. In addition, vibrometers have been used for vibration measurements on artificial heart valves, mechanical properties of tendons, analysis of vibrations while bone drilling or medical laser ablation, and detection of bone crack propagation.

Medical, safety and health care devices like tooth brushes, dental scalers and respirators have been investigated using Polytec vibrometers. The vibrometer can also function as a non-contact polygraph detector recording artery pulse waves and respiratory activity, or as a remote voice detector as a part of a multi-media surveillance system.
www.polytec.com/research

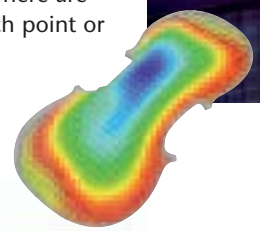
Scanning vibrometer representation of heart valve motion



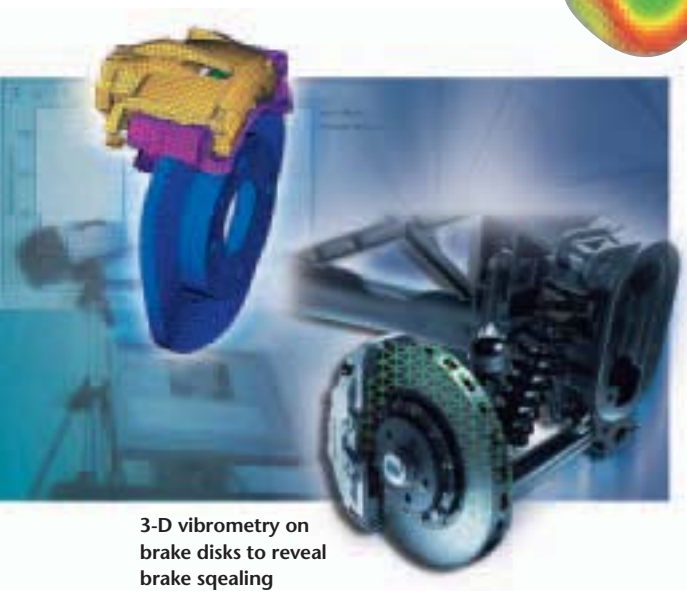
Acoustics

Musical instruments generate wonderful, inspiring sounds through their vibrations. Polytec vibrometers can help us understand how this happens with early work already done on violins, cembalos and dulcimers. Vibrometers are also indispensable tools for loudspeaker design identifying diaphragm resonances that are deleterious to the sound quality. Vibrometer measurements provide an experimental basis for sophisticated acoustic investigations like structural-acoustic response (sound field) predictions, acoustic imaging and anti-sound research. Acoustics are also increasingly important in product design. The focus is on how and where are undesired noises generated and at which point or location can countermeasures be taken.

Sound field measurement using PSV Scanning Vibrometer (photo courtesy: Bosch)



Operational deflection shape of a violin



3-D vibrometry on brake disks to reveal brake sqealing

3-D scanning measurement of structural dynamics of a car body

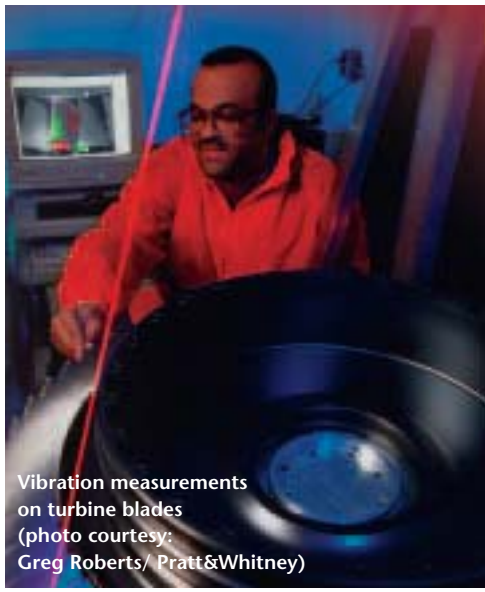
Valve train measurement using High Speed Vibrometer (photo courtesy: Porsche)

Automotive Development

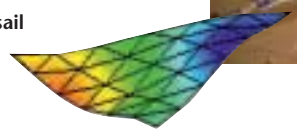
To certify that a new part meets noise and vibration specifications, automotive engineers favor testing instruments that are easy to set up and operate, and that can exchange data with existing CAE equipment and software. Polytec's laser vibrometers are widely used both for structural dynamics measurements in the R&D labs and for quality control purposes in the production process. Laser vibrometry gives the opportunity to optimize dynamic automotive FE models by matching the parameters derived from vibration measurements on prototypes to the FE model. Scanning vibrometers provide time saving measurements without mass loading regardless whether on large areas, hot components, rotating parts, light weight surfaces, or at high frequencies.
www.polytec.com/automotive

Aerospace Industry

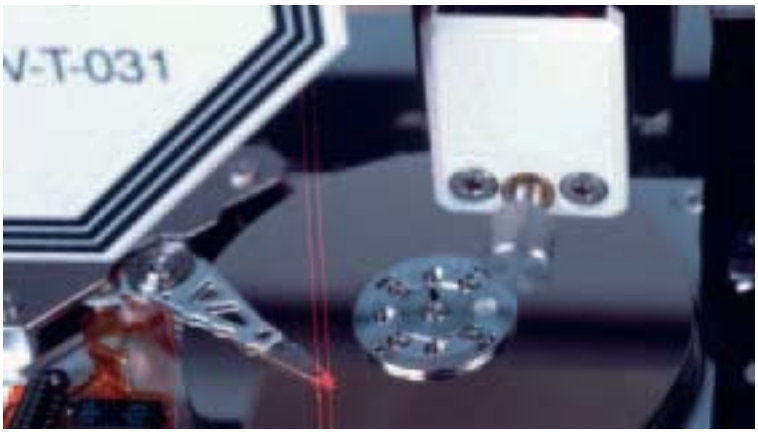
In the aerospace industry there are undesired vibrations of parts and bodies that must be eliminated. Typical aerospace applications include design verification, characterizing airframe components for production and quality control, and evaluating aging aircraft structures for maintenance and repair. Measurements on aircraft wings, turbine blades and space structures can be performed for modal analysis and subsequent FEM validation. Polytec's scanning vibrometer is also the ideal tool for measuring surfaces of large aerospace objects difficult to reach with contact methods.
www.polytec.com/aerospace



Vibration measurements on turbine blades (photo courtesy: Greg Roberts/ Pratt&Whitney)



Modal tests for validation of a solar sail design (photos courtesy: NASA)



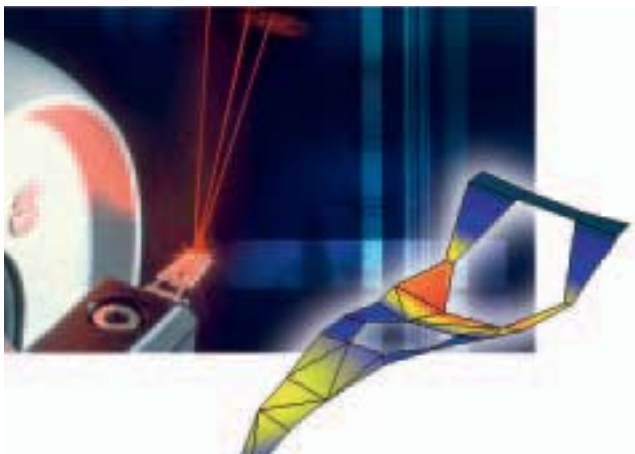
Determination of stable flying heights for a hard disk read/write head

Data Storage

In designing hard disk drives, one of the challenges is to understand how mechanical interactions affect positioning. Methods accompanying design, optimization and quality control have to be fast but highly sensitive and precise. When verifying a new drive design, fast testing time is paramount. Laser-Doppler vibrometers have been effectively used for many years in design of data storage media. Disk and tape drives and their components encompass a wide range of dynamic applications.
www.polytec.com/datastorage

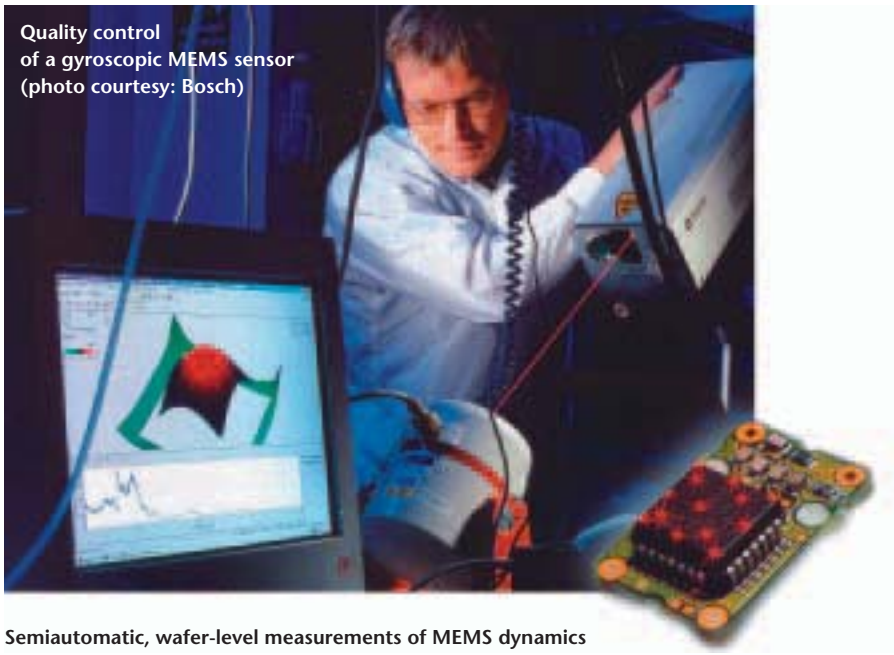
Noise investigation in hard disk spindle motors using scanning vibrometry

3-D vibration measurements for modal test on a disk drive suspension



MEMS and Microstructures

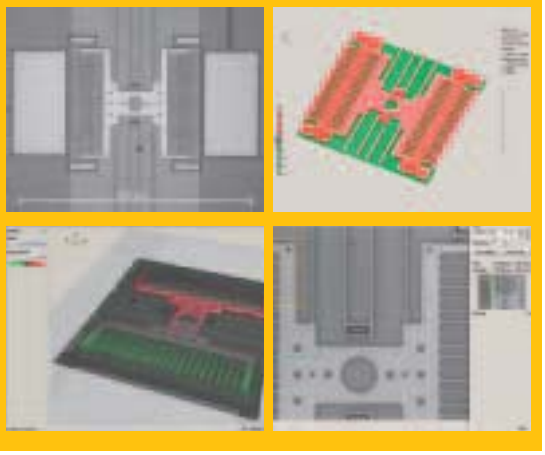
MEMS (Micro-Electro-Mechanical Systems) find numerous applications in the automotive, medical, bio-chemical and aeronautic industry. As a consequence there is a huge demand for standardized MEMS testing for both packaged and unpackaged devices (single die and wafer-level testing). Polytec's instrumentation for micro motion analysis enables the systematic testing of the dynamic mechanical response to important electrical and physical inputs, as well as the dynamic investigation of other microscopic structures ranging from natural objects to semiconductor components.
www.polytec.com/microstructures



Quality control
of a gyroscopic MEMS sensor
(photo courtesy: Bosch)

Semiautomatic, wafer-level measurements of MEMS dynamics

Combined measurement of surface topography, out-of-plane and in-plane vibration on a MEMS comb drive using the Polytec Micro System Analyzer



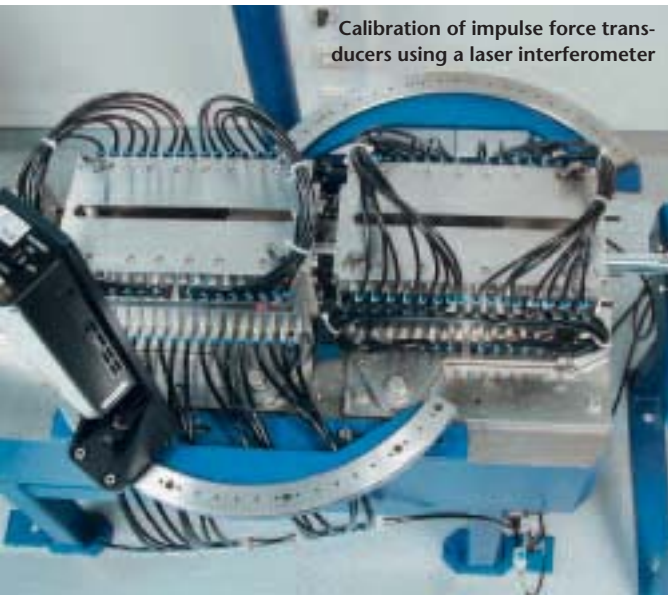
Vibration measurement on a cable-stayed bridge

Materials Research, Mechanical and Civil Engineering

Laser vibrometry is an ideal tool for the measurement of structural dynamics and for non-destructive flaw detection (fracture, delamination, fatigue) in all kinds of materials, parts and components. For instance, vibrometry can be used for non-destructive testing and for the investigation of ultrasonic wire bonding.

Regarding buildings and industrial plants, there are many applications for in-the-field structural health monitoring on wind turbines, building vibration and displacement, and cable-stayed bridges to prevent bridge resonance failure. Geological applications include detection of land mines, rock failures and earthquake-induced defects in concrete.

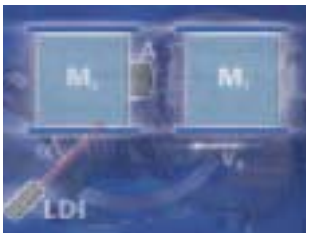
Non-destructive testing of delamination in a composite material



Calibration of impulse force transducers using a laser interferometer

Metrology and Calibration

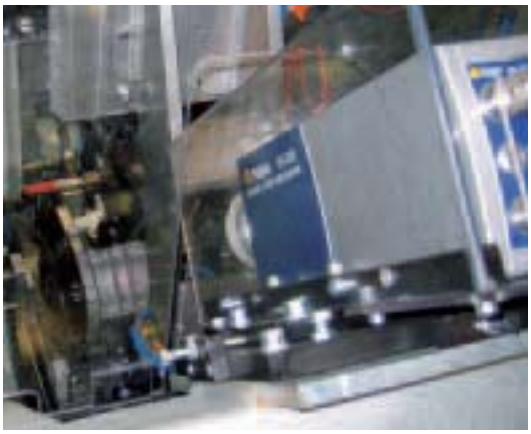
Primary calibration of vibration transducers by laser Interferometry has the unique advantage that measurements of surface acceleration, velocity or displacement are made with a precision that is traceable directly to the wavelength of laser light. Also, laser vibrometric velocity measurements offer the possibility to perform traceable impulse calibrations of transducers subjected to known impulse loads.



Production Testing

The optimization of products and processes plays an important role in a company's economic success. In industrial production, process and quality control relies on fast, automated and rugged measurement instrumentation. For both 100% quality control of manufactured products and on-line monitoring in continuous production, Polytec provides interferometric sensors that optically measure vibration, but also velocity, length and surface integrity. In addition, they offer many specific advantages for industrial production applications such as precise results without contact, a flexible retrofitting and continuous operation under industrial conditions with low maintenance.

www.polytec.com/industrial



Automated 100% quality assurance of vehicle components (photo courtesy: P. Marpe, TRW Automotive)

Semiautomatic test station based on a Compact Laser Vibrometer for quality control of medical devices

Automatic vibration analysis for crack testing of cam rings

Please find more interesting applications and Polytec Application Notes on **www.polytec.com/applications**

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