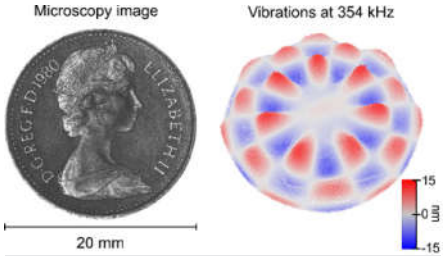
Megapixel Modal Analysis of Small Samples with SmarAct's Scanning Vibrometer

Vibration measurements at up to one megapixel can be performed with SmarAct's scanning vibrometer, the solution for the modal analysis at high spatial and temporal resolution for samples such as MEMS, sensors and actuators.

- Contactless measurement of vibrations with a resolution of under 1 pm
- Up to 10 MHz sample rate to investigate vibrations up to 2.5 MHz
- Confocal optical design with an IR measurement laser
- Measurements possible through semi-transparent enclosures of plastic, glass and silicon
- Integrated confocal microscope with an optical resolution down to 2 µm
- Microscopy images are intrinsically aligned with vibration measurements
- Turn-key instrument complete with shaker stage and software



*Higher order bending modes can result in complex vibrational patterns. For a full modal analysis, the measurement laser of the **PICO**SCALE Vibrometer is scanned over the sample to record microscopy and vibration images simultaneously.*

1 Innovative Sensor Head

- Integrated Michelson interferometer
- Confocal optical design
- Various microscope objectives available

2 Closed-Loop 3D Positioning System

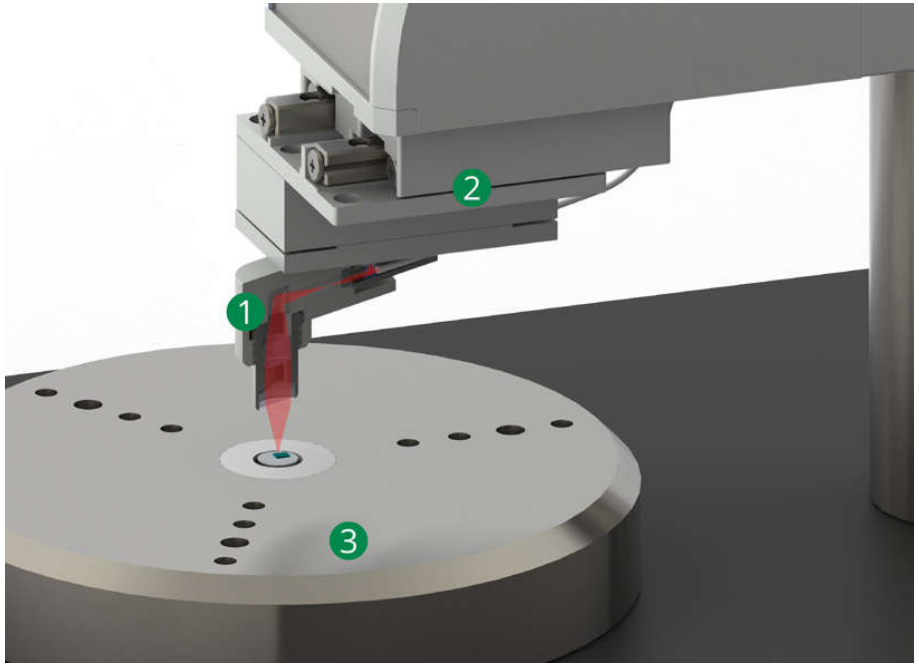
- Closed-loop piezo positioners with nm resolution
- Scan range of 20 mm
- Highly reproducible positioning of laser beam
- Easy integration in custom setups through 1" post mount
- UHV compatible upon request

3 Shaker Stage

- Mechanical excitation of samples by a fast piezo-based shaker stage
- High bandwidth of more than 1.5 MHz

Controller

- Class 1 laser coupled to the sensor head with fiber optics
- Configurable lock-in amplifier for the direct imaging of bending modes
- Vibration data can be processed in the time or frequency domain
- Outputs available for the electrical excitation of samples
- Synchronization with external function generators through trigger output



Software

The **PICO**SCALE *Vibrometer* is delivered with two programs that can be operated in parallel:

- Intuitive operation of the vibrometer with the Control software
- Extensive data analysis with the View software

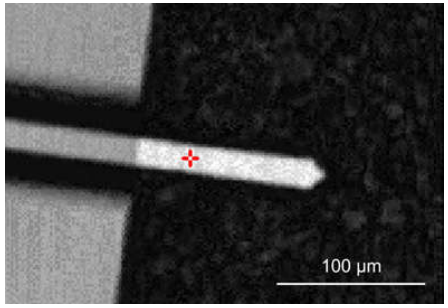
Key Specifications		
Vibrometry	Resolution[1] [pm]	< 1
	Bandwidth[2] [MHz]	2.5
Microscopy	Optical Lateral Resolution[3] [µm]	2 - 7
	Optical Axial Resolution[3] [µm]	7 - 90
	Working Distance[3] [mm]	1.5 - 10
	Maximum Image Size [mm]	20 x 20
	Minimum Pixel Size [µm]	1
	Maximum Number of Pixels	1000 x 1000
Dimensions	Controller	2 units of each 33 x 27 x 7.2 cm (W x L x H), combined weight 7.6 kg
	Scanning Stage	5.5 x 11.0 x 7.5 cm (W x L x H), weight 0.25 kg
	Instrument Mount	Granite stone 15 x 20 x 4 cm (W x L x H) with stainless steel post 2.5 x 15 cm (Ø x H), combined weight 4.3 kg
	Shaker Stage	8 x 1.5 cm (Ø x H), weight 0.5 kg

[1] When analyzing displacements in the frequency domain

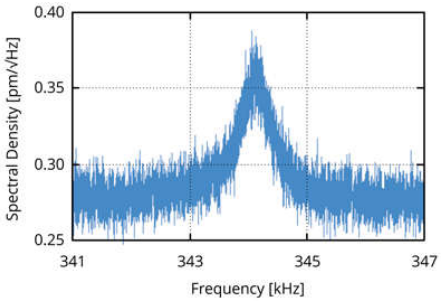
[2] Sampling rate is 10 MHz
[3] Depending on the selected sensor head

*The **PICO**SCALE Interferometer is used in an experiment to precisely measure the oscillation amplitude of a mechanical oscillator. We operate the system at temperatures from -50 to 0 degree Celsius and study friction of samples. The sub-Angstrom noise level of the interferometer and its convenient output in combination with a third party Phase-Locked Loop eventually enabled the acquisition of very precise AFM images.*
+++ A. Niguès
+++ Laboratoire de Physique de l'École Normale Supérieure (UMR CNRS 8550), Paris, France

Single Point Measurements

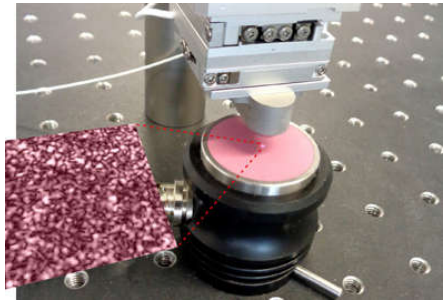


- Measuring out-of-plane vibrations with interferometry
- Easy selection of measurement points with integrated optical microscope
- High resolution and bandwidth

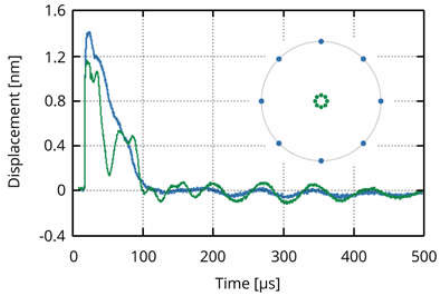


The amplitude spectrum of a micro cantilever was measured at the indicated position. Although the cantilever was not actively excited, the high resolution of the interferometric measurements still allows to detect the thermal fluctuations, in this case 0.36 pm at 344 kHz.

Characterizing Ultrasonic Transducers

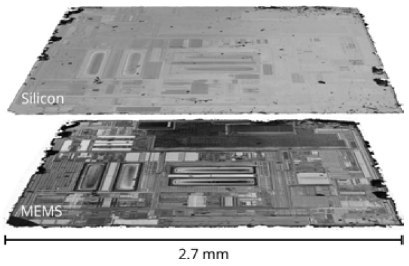


- Measuring sub-nm motion at multiple predefined points
- Sample excitation with external arbitrary waveform generator

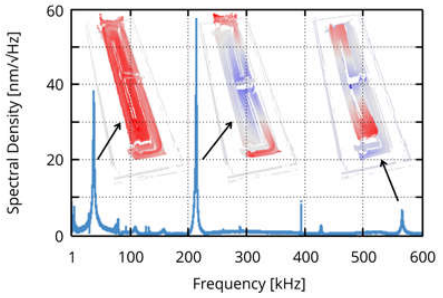


Measuring motion at a circular array of points on the surface of an ultrasonic transducer. The graphs show the averaged response from all measurements performed at 1.3 mm (green) and 10 mm (blue) from the transducer center. We thank Vallen Systeme GmbH for their support with this application example.

Measuring MEMS through Silicon

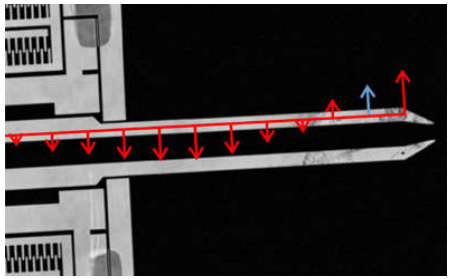


- Selective imaging of layers with infrared confocal microscopy
- Measuring through semi-transparent materials such as glass and silicon
- Semi-transparent structures themselves can still be measured when in focus

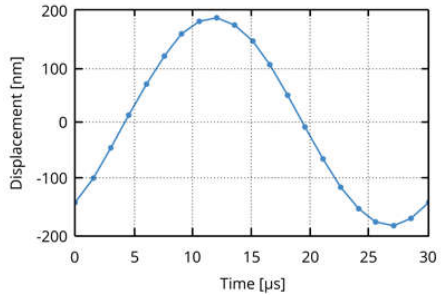


Measuring vibrations of MEMS through a packaging of silicon is made possible by confocal imaging with an IR light source. We thank InvenSense, a TDK Group Company, for their support with this application example.

Imaging Lateral Vibrations



- In-plane motion is imaged by recording a sequence of microscopy images that span exactly one vibration cycle (conceptually similar to stroboscopic imaging)
- In plane vibrations down to 10 nm can be extracted through optical flow algorithms



Lateral vibrations are measured by recording a sequence of microscopy images. Of any moving part within the images the motion can be quantified with a tracking routine. Although this method is based on microscopy, and not on interferometry, the resolution is not limited by optical diffraction and can be as good as a few nm.

Measurement and Rental Services

Measurement Services

- Simplify your development process by outsourcing specific measurement tasks
- Results are reported according to established or customer defined standards.
- Benefit from our long-standing expertise in displacement and vibration measurements
- Get faster approval for measurement services as opposed to an investment in technology

Rental Services

- **PICO**SCALE Interferometers and Vibrometers can be rented on a weekly or monthly basis
- Direct support from SmarAct's application engineers
- Benefit from the latest equipment
- Evaluate the impact of new measurement capabilities prior to an investment decision

Take the next step

Our measurement and rental services can help to optimize your development process but also to solve a one-off problem that limits the performance of your product. Please contact us to discuss your requirements and plan a pilot study today.

Typical Customer Applications

Characterizing vibrational modes with laser scanning vibrometry.

- MEMS
- Wire bonds
- Voice coil motors
- Ultrasonic transducers
- Micro-loudspeakers
- Hearing aids
- Acoustofluidic devices
- Noise source identification for microscopy (AFM, EM)

Multi-dimensional analysis of motion at unsurpassed resolution by parallel interferometric displacement measurements.

- Calibration and validation of positioning and motion systems
- Repeatability and accuracy
- Thermal stability
- Tip/tilt of target during translation
- Radial run-out of a rotating system