Insight *into the Dynamics of the Micro-World*

Micro Motion Analyzer MMA-300

Comprehensive measurement technology to characterize Micro-Electro-Mechanical Systems.

The Microscope Scanning Vibrometer MSV-300 has proved its value for years now in characterizing out-of-plane vibrations of microstructures. The new MMA-300 Micro Motion Analyzer presented here now makes it possible to acquire in-plane motion components also. It is made up of the proven MSV-300 and the new PMA-300 Planar Motion Analyzer for in-plane analysis. This modular approach allows you to upgrade an existing MSV to a Micro Motion Analyzer.

Objective

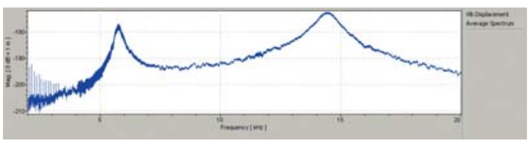
Attaining fast, quality data is the main objective for measurement systems used not only in research and development but also in production. Anyone familiar with laser Doppler vibrometers (MSV-300) is accustomed to receiving the complete frequency spectrum response to broadband excitation in a matter of seconds. Through the scanning process, high density structural measurements can be made and evaluated quickly (up to thousands of points with a speed of > 20 points/s).

However, due to the additional in-plane components found in many MEMS, this option alone is insufficient because the vibrometer only receives vibration information parallel to the direction of the laser beam.

Alternative interferometric image-generating processes such as ESPI or white light interferometry can be used, as used by Polytec for optical topography acquisition in the nanometer range. These methods are undesirable, however, for broadband frequency response measurements. This is because the interferometric process requires an image to be acquired for every phase position and every frequency, making it impossible to rapidly traverse wide frequency ranges.

Measurement Principle

Combining laser Doppler vibrometry and stroboscopic video-microscopy, resonant frequencies of in-plane movement can be detected, verified and evaluated immediately (refer to box "Stroboscopic Video Microscopy" on page 7). The MSV with its picometer resolution does not miss even the tiniest in-plane resonance corresponding to out-of-plane components. Using the live mode of the PMA, you can see at a glance whether there is movement and/or whether there is obvious damage to the component. The live mode thereby shows the movement of the components up to frequencies of 1 MHz in slow motion or at a standstill at a defined phase position.



Spectrum of a broadband excitation (periodic chirp)

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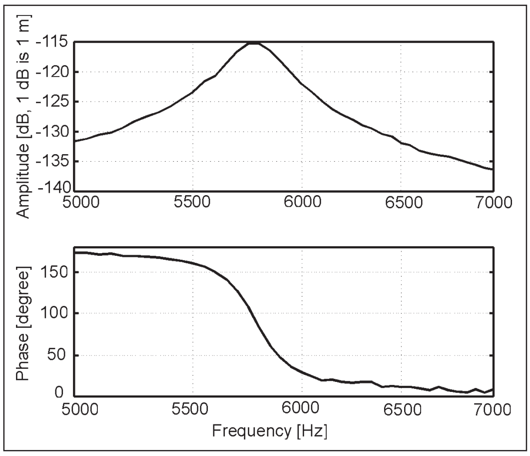


Bode Plot calculated using the PMA-300 to verify the in-plane resonance

An advantage of the combined procedure is that in-plane data are only acquired within the frequency ranges determined using the laser vibrometer. This significantly reduces the sample time that would be otherwise wasted acquiring a vast amount of data. In production control it would be plausible to even dispense entirely with the in-plane measurement if the characteristics of the out-of-plane movement are known.

Why are FFT and image processing combined?

The combination of FFT and image processing measurements offers unique advantages. Without the FFT measurement, the image processing measurements would be required at many frequencies. Particularly for weakly attenuated components (in a vacuum), which show steep resonance peaks, the frequency step between two image processing measurements must be very small. Small step sizes, however, considerably increase the volume of data and measurement time.

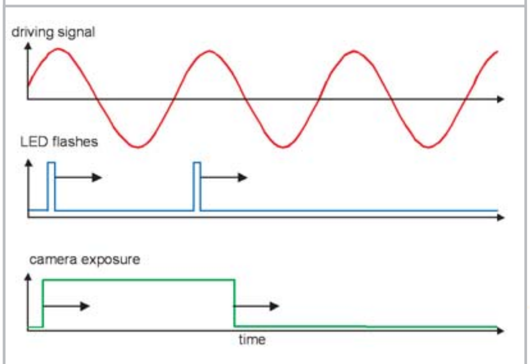
The FFT measurement can be used to identify the resonance peaks. The time needed for a high resolution FFT-measurement is in the order of milliseconds to a few seconds. With random excitation even resonance peaks, which are narrower than the FFT resolution, can be identified. Once the resonance frequencies are known, image processing measurements can be performed with sinusoidal excitation only at these frequencies.

The analysis is carried out according to the Pattern-Matching process, which acquires and tracks the defined pattern in a high-resolution video image (1030x1300 pixels). As a result, all in-plane movement data for the selected area is available for further analysis.

Stroboscopic Video Microscopy

The internal signal generator of the MMA periodically excites the component with a sine or a pulse signal. A so-called "pattern generator" uses an LED to generate ultra-short flashes of light (< 100 ns) synchronously with the phase position of the excitation signal. This means that a high degree of phase accuracy is attained, even with high-frequency excitation. The electronic camera shutter in turn is synchronized with the excitation. This remains open until enough light has been collected to save the image after several periods. The power of the LED generally allows sufficient illumination with only a few flashes.

This procedure guarantees a high degree of measurement accuracy and a visual real-time analysis in live mode.



Principle of stroboscopic video microscopy

SUMMARY

The development of the MMA-300 Micro Motion Analyzer to include PMA inplane analysis now makes it possible to fully characterize MEMS components.

The modular design allows retrospective adaptation of existing MSV-300 systems with the PMA to make it a fully functional MMA-300.

By combining the quick vibrometer process with stroboscopic video microscopy, the time required is minimized while retaining full acquisition of information. The MMA-300 reveals our micro-mechanical worlds.

For more information please send an e-mail to Lm@polytec.de

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