高精度激光测振仪

通常，微机械系统应尽量避免机械振动，因为振动会导致微结构精度降低，会增加机械疲劳，从而导致整个系统的故障。相反，对于传感器和扬声器等设备则依靠振动来实现其功能，因此在需求的频率范围内拥有良好的响应对设备性能很重要。

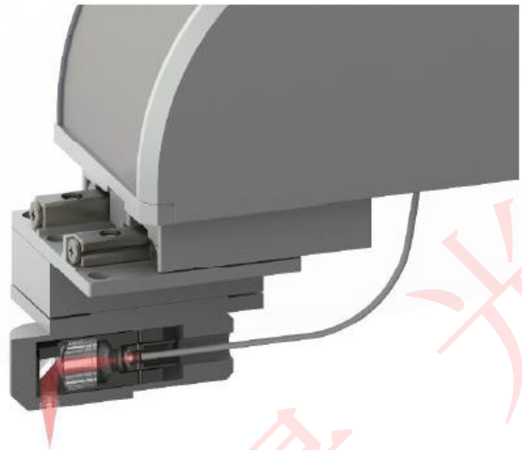
为了研究微观样品在不同位置的振动，传统设备通常在显微系统中采用可见激光用振镜扫描光束，虽然这种方法拥有很高的横向分辨率，但是由于显微系统中视场范围和分辨率成反比，所以几毫米的样品无法在高分辨率的情况下成像。由于目前 MEMS 市场的快速增长，对高成像分辨率的振动计的需求日益增加，此外由于 MEMS 通常是封装好的产品，这对传统的振动测量系统具有极大的挑战性。

为了解决满足日益增长的市场需求和解决传统振动计的问题，我们推出了高精度振动测量仪，该系统可实现百万像素成像，并在图像的每个像素都可以获得图像信息。该系统采用新颖的集成迈克尔逊干涉仪的红外物镜与高精度位移台结合，因此成像范围只受平台移动范围的限制。

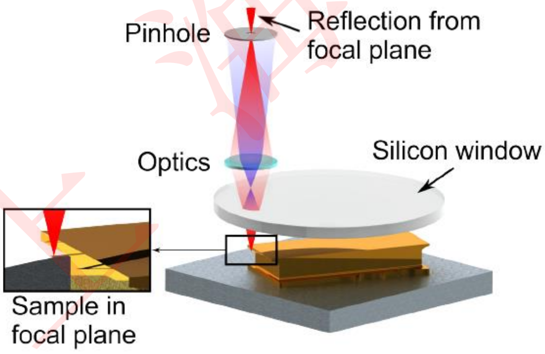
该设备主要由控制器，探头，振动台等几部分构成。

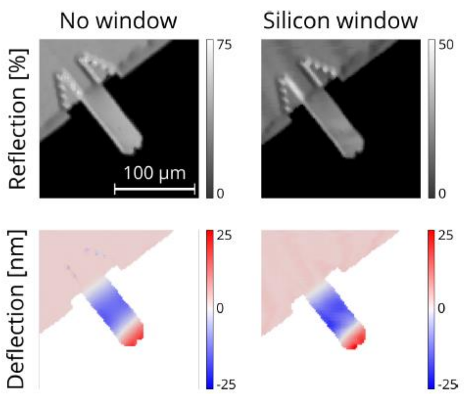
该设备探头部分主要包含集成了迈克尔逊干涉光路的红外物镜和三维位移平台组成，该

物镜安装在三维位移平台，平台可提供 20mm 的行程，全行程重复精度可达 30nm。从而该测振仪的视野要远远大于振镜扫描范围。物镜结合了微型迈克尔逊干涉仪和高分辨率成像光学，通过一个单模光纤耦合到控制器中。因为成像光路和迈克尔逊干涉仪为相同光路，因为设备结构非常紧凑，横向分辨率最高可达 2μm。



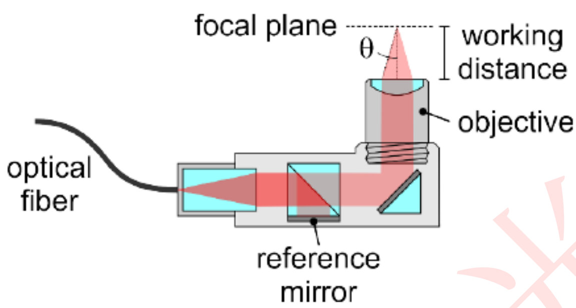
由于探头是通过单模光纤与控制器相连的，因此该光纤与小孔有相同的功能和成像光路组成了共聚焦成像系统。因此只有在焦平面反射的光才会被探测到，通过光纤进入控制器。共焦系统拥有很多优点，例如，可以透过窗口，滤掉反射层对测试的影响；该系统使用的是 1550 的激光，因此可以穿透对可见光不透明的材料，例如硅，可用于封装在硅中的传感器件的测量（如下图所示）。





样品的振动可以由系统的振动台激励也可以由电信号产生，在图像的每个像素点都可获得样品的振动信息，为了达到这个目的，在物镜的前段装有微型迈克尔逊干涉仪，分束器将光束分为

参考光和探测光，参考光通过固定的镜子返回，探测光则聚焦到样品上。反射的光束在分束器出发生干涉并通过光纤传输到光电探测器上。当样品沿轴向有位移时，光程将会发生变化，这将导致干涉的变化从而计算出位移的变化。因此可以通过在频域中绘制位移数据来分析振动也可以通过锁相放大器直接实时成像。

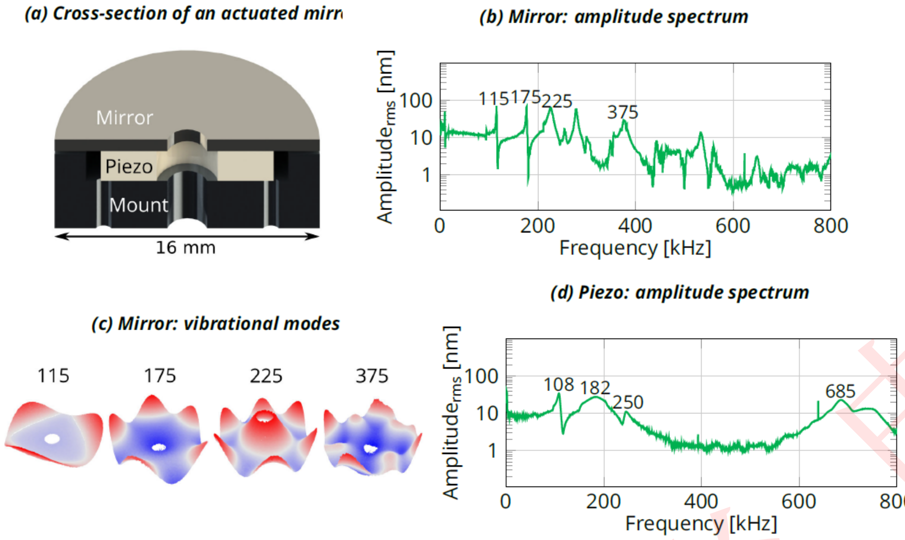


产品参数：

Vibration Resolution in Single Point Mode [pm]	< 1
Vibration Resolution in Imaging Mode [nm]	0.1
Frequency Range [MHz]	Up to 2.5
Optical Lateral Resolution [µm]	2 ... 7
Working Distance [mm]	1.5 ... 10
Maximum Image Size [mm]	20 x 20
Minimum Pixel Size [µm]	1
Maximum Number of Pixels	1000 x 1000
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
Scanning 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	Stainless Steel 8 x 1.5 cm (Ø x H), weight 0.5 kg

APPLICATION NOTE:

1）解析超快快反镜的动态响应（ACTUATED MIRROR）



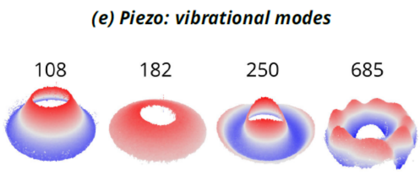
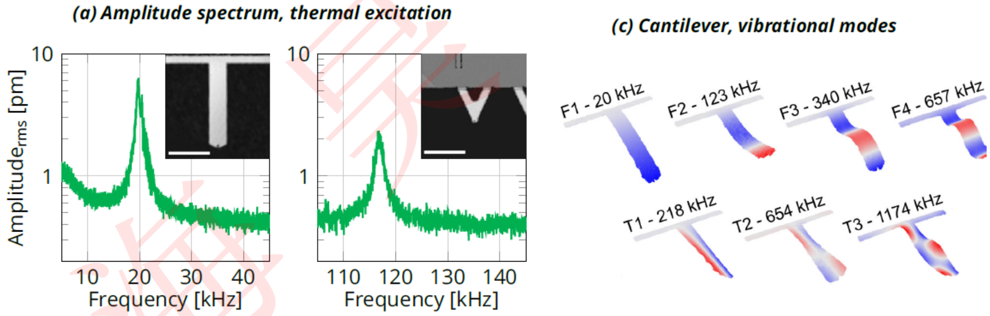


Figure 3. ***(a)*** *A piezoelectric ring stack is sandwiched between a mirror and a titanium mount.* ***(b)*** *and* ***(d)*** *show the amplitude spectra recorded on the mirror and piezoelectric ring stack, respectively.* ***(c)*** *and* ***(e)*** *show the corresponding vibrational modes (the shown displacements are tens of nm)*

2）悬臂梁性能表征



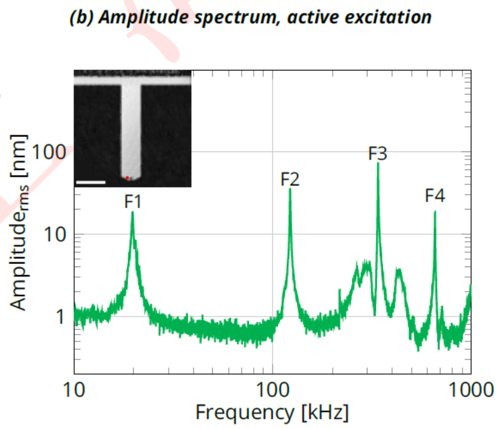


Figure 4. ***(a)*** *Measurements of the thermal vibrations of two cantilevers with different geometries (insets, scale bars: 100 μm). The left cantilever has a spring constant of 0.05 N/m and the right a spring constant of 0.6 N/m. Vibrations were measured at the free ends of the respective cantilevers. The FFT graph shows their resonance peaks with an amplitude of just a few pm.* ***(b)*** *An FFT of the recorded displacements while exciting the cantilever, the multiple resonance peaks suggest different bending modes. The inset microscopy image shows the measurement position on the cantilever (red dot, scale bar: 60 μm).* ***(c)*** *The 3D renderings show the corresponding flexural bending modes at the indicated frequencies (F1 to F4). In addition, the first three torsional modes are shown. The latter frequencies were obtained by measuring the cantilever displacements at the side of the cantilever (not shown).*

3）探究智能手机扬声器非音谐振

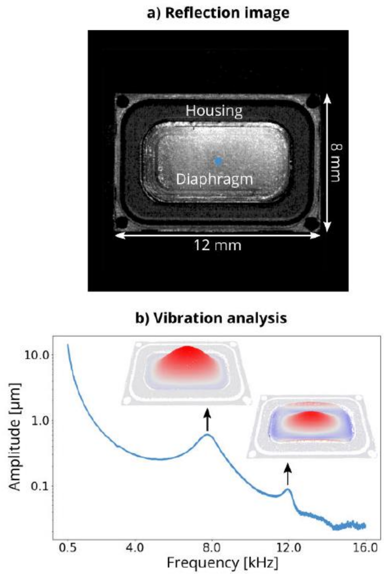


Figure 1. Investigation of Loudspeaker 1. ***a)*** *The reflection image displays the unprotected diaphragm surrounded by its metal housing.* ***a)*** *Local measurement of the amplitude spectrum at the blue dot in the reflection image shows two resonant peaks at 7.5 kHz and 12 kHz. Insets: Deflection images of the vibrational modes at these respective excitation frequencies.*

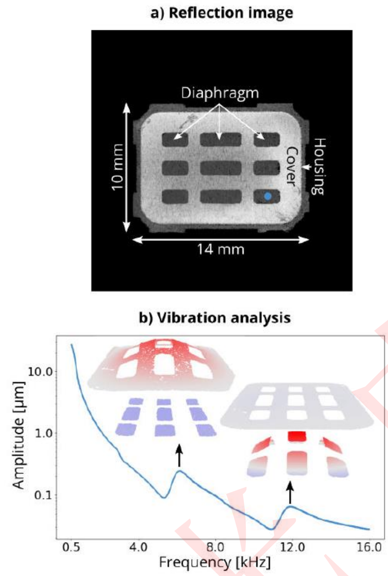


Figure 2. Investigation of Loudspeaker 2. ***a)*** *The reflection image displays the diaphragm through the apertures of the highly reflective metal cover.* ***b)*** *Local measurement of the vibrations at the blue dot in the reflection image shows two resonant peaks at 6 kHz and 11.5 kHz. Insets: Deflection images of the vibrational modes at these respective excitation frequencies.*

4）透过硅封装测量 MEMS 的振动

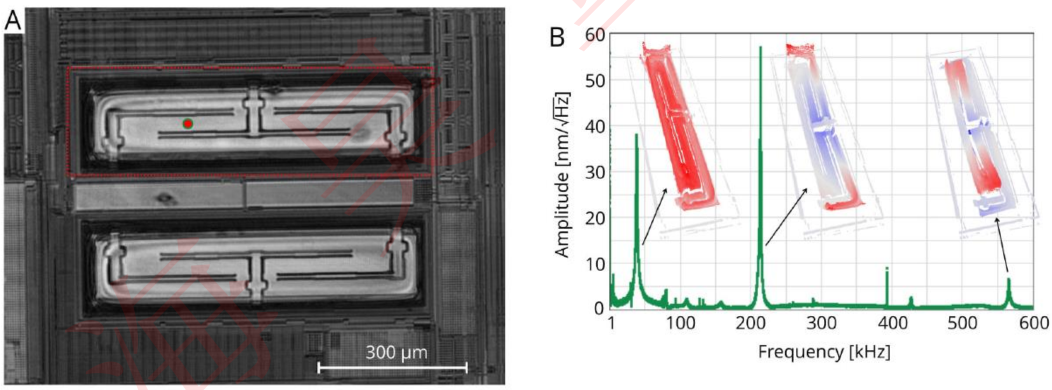
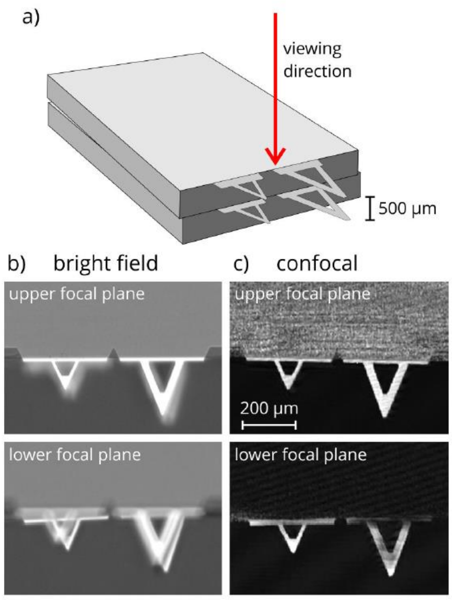


Figure 2. Modal analysis of the motion sensor through a silicon window. A) The vibrations were first measured at the indicated point. B) The amplitude spectral density plot shows multiple resonance peaks. At the indicated peaks a modal analysis was performed of the part of the structure that is indicated by the red box in A). The inset figures show a 3D rendering of the motion of the structure.

5）利用共聚焦测量窗口下悬梁振动性能



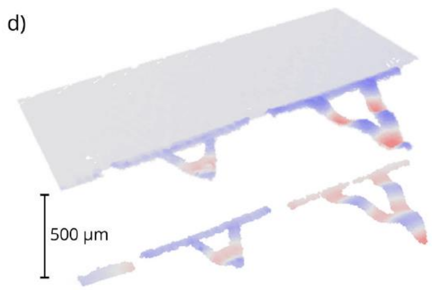


Figure 3. Measuring vibrations of multi-layered samples. ***a)*** *Schematic of the experiment. Two AFM cantilever chips were positioned on top of each other such that the view of the lower cantilevers is blocked by the upper ones.* ***b)*** *Imaging of both layers by bright field microscopy does not produce clear images of each layer.* ***c)*** *Confocal imaging reveals clear images of both layers. The image taken at the lower focal plane shows some variation in intensity caused by the presence of the upper cantilevers in the path of the laser.* ***d)*** *Vibrations measured of each layer.*

6）真空环境下测量悬梁真空

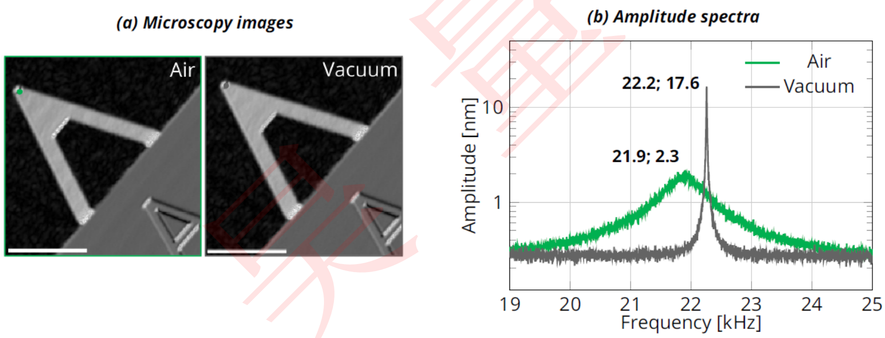


Figure 1. Vibrometry measurements in air and in vacuum. The AFM cantilever was measured in a scanning electron microscopy chamber, either at 1.0 × 103 mbar (ambient air pressure) and 3.6 × 10−3 mbar (vacuum pressure). First, microscopy images were recorded. (a) Confocal reflection images in air and in vacuum. The dot shows the position of the measurement laser for the recording of the thermal vibrations. (b) The amplitude spectra in air and in vacuum. The curve in vacuum is much sharper and shows an higher resonance frequency as in air.

7）利用振动计测量超声环能器

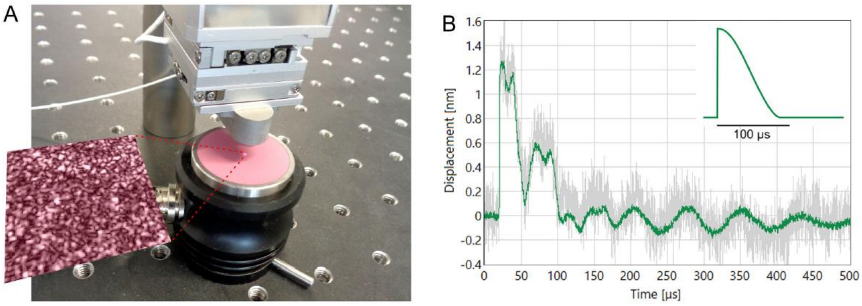


Figure 1. Measuring motion with interferometry. A) A commercially available transducer was placed under the scanning head of the vibrometer. The bright spot of the pilot laser in the middle of the pink ceramic disc indicates the measurement position. Inset: 200 x 200µm microscopy image showing the detailed structure of the ceramic surface. B) Average from 2000 displacement measurements (green curve), sampled at 10MHz. Details of less than 0.1 nm can be easily distinguished including the reverberation after the pulse end at ▯ 100 µs. Average from 50 measurements (gray), many details are still buried in noise. Inset: Electrical excitation pulse

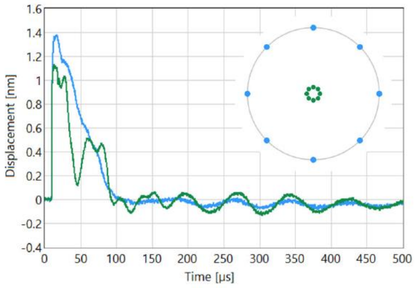


Figure 2. Measuring motion at different positions. *Inset: 16 measurement positions located on 2 concentric circles with radii of 1.3 and 10 mm, respectively. The graphs show the averaged response from all measurements performed at 1.3 mm (green) and 10 mm (blue) from the transducer centre.*