APPLICATION NOTE

Dynamic Characterization of a MEMS Membrane Resonator by Digital Holographic Microscopy

Microelectromechanical Systems (MEMS) are devices typically made up of components less than a few hundred micrometers in size and are capable of a wide range of abilities. As these devices continue to decrease in size, and grow in complexity and occurrence, there is an increased need for precise and quick electrical and mechanical interactions for testing and characterization.

In this application note, the device under test is a MEMS resonator consisting of a circular silicon membrane with a thickness of 1 µm, electrothermal actuators, a resonating cavity, and electrical contacts with side lengths of 200 µm. The device is to be characterized with Digital Holographic Microscopy (DHM) to determine its resonant frequencies and image the deformation of the membrane. DHM technology uses real-time digital reconstructions of phase information to provide vertical resolution on the nanometer scale, and intensity images, as in conventional optical microscopy [1]. Since the device under study is already packaged, wires are bonded to the electrical pads. Testing and characterization must be carried out by contacting the electrical pads directly to ensure the measurements are independent of the other components and devices of the system.

To overcome the challenges of approaching and contacting the electrical pads without damage to the wire bonds, two miBot™ micromanipulators from Imina Technologies were used. The nanometer positioning resolution over their four degrees of freedom was ideal for this operation since it minimized most of the risk of incorrect maneuvers. Moreover, due to the length of the miBot arm being extremely short (<2 cm), the vibration of probes is nonexistent at this scale.

Imaging and dynamic characterizing was performed using a DHM™ R2100 Digital Holographic Microscope from Lyncée Tec. The two miBot micromanipulators fitted with tungsten probes were placed on a miBase and connected to a DHM stroboscopic module [Figure 1]. The miBase was simply placed on the DHM manual X-Y positioning stage and the miBot manipulators were slid into coarse position by hand [Figure 2]. The micromanipulators were then operated through the intuitive miBot Remote Control (MRC) software, using a control pad, and accurately contacted the electrical

In collaboration with:
Lyncée Tec SA, Lausanne, Switzerland
www.lynceetec.ch

Imina Technologies products in use:
- miBot^{TM} BT-11 micromanipulator
- miBase BS-42 stage
- syDrive SD-10 piezoelectric controller

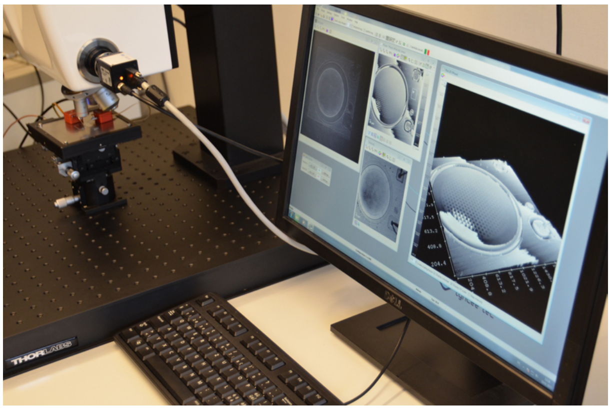

Figure 1. Experimental setup of the miBots and miBase mounted on a manual X-Y positioning stage under the DHM.

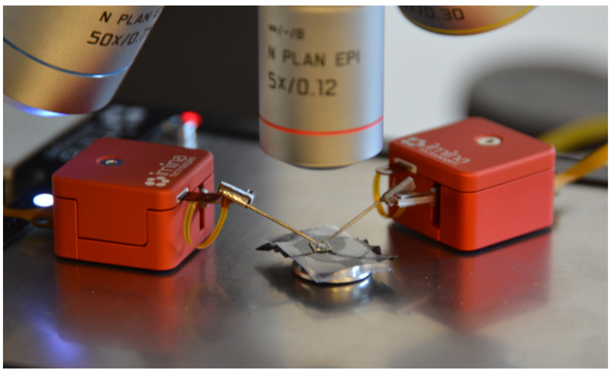

Figure 2. The miBot micromanipulators in contact with the MEMS resonator

pads within seconds [Figure 3]. A 10 V_{peak} sinusoidal signal was swept from 1 to 200 kHz and phase data was observed in order to determine the frequencies at which the largest membrane displacements are present [Figure 4].

In a second step, to observe the deformation due to an applied force on the silicon membrane, a miBot manipulator was then moved from the electrical pad and positioned over the membrane. By adjusting the speed and step size of the miBot arm, the probe was slowly lowered onto the membrane and the out-of-plane deformation was characterized with DHM [Figure 5].

CONCLUSIONS

Imina Technologies miBot micromanipulators proved to be extremely well suited for this MEMS application, where both a precise and flexible positioning of probes was required. In addition, along with the miBase, they form a very portable and easy to use microprobing solution that can be integrated into virtually any setup, and ready to use in less than 10 min. Furthermore, the fact that miBots are not mechanically tied to the stage provides them with an unparalleled freedom to move. This allowed us to effortlessly change the function of one of the miBots during the experiment from injecting an electrical signal to applying a mechanical deformation on the thin silicon membrane of the MEMS, saving time by not having to alter the setup.

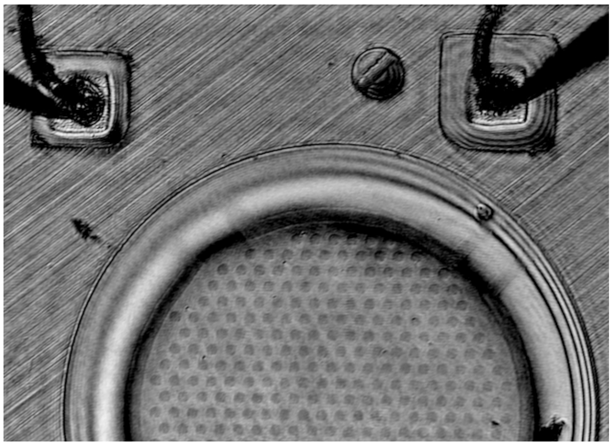

Figure 3. The miBot probes in contact with the electrical pads of the MEMS resonator. Carefully positioned as to not damage the wire bonds.

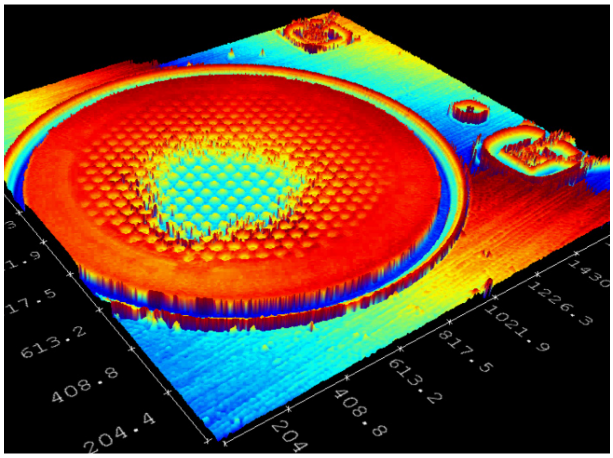

Figure 4. DHM 3D phase plot of the actuating MEMS resonator at 60 kHz. Displayed units are in μm.

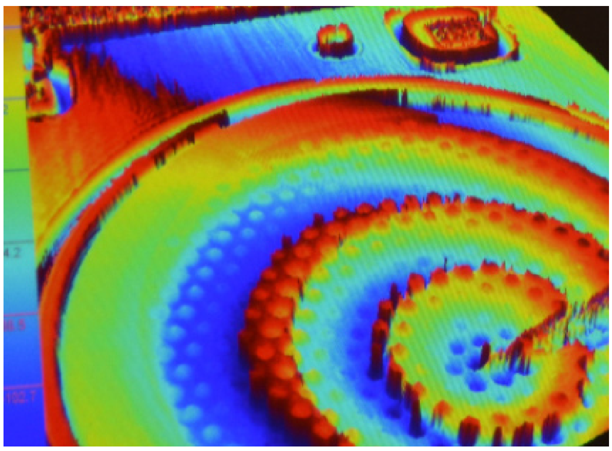

Figure 5. 3D phase plot of a miBot probe mechanically deforming the silicon membrane. The "ripples" are an interference effect of partial refection off the back of the cavity due to the transparency of the silicon membrane.

Imina Technologies SA
Route de Montheron 8b, 1053 Cugy (VD), Switzerland
www.imina.ch