Application Note: Motion & Sensing 10

Displacement Measurement on a Water Surface

Tracking Water Surface Movements with the M12/F40 Sensor Head

Thomas Ch. Hirschmann
attocube systems AG, Eglfinger Weg 2, 85540 Haar, Germany

Introduction

Measuring displacements on a large variety of materials with nanometer accuracy – as well as vibrations with amplitudes of a few picometer – is very challenging, as it is exceeding the capabilities of most commercially available measurement techniques. A unique feature of our system is the ability to accommodate advanced applications, for example in very constrained spaces and under extreme environmental conditions. We developed sensor heads with a diameter smaller than 1 millimeter and suitable for temperatures up to 250 °C. In the following Application Note, we present measurement results on a liquid surface performed with attocube's Industrial Displacement Sensor (IDS), demonstrating the flexibility of our interferometer system.

The interferometric sensor IDS3010 enables displacement measurements down to the picometer regime. The broad sensor head portfolio has been optimized for measurements on various surfaces and target materials such as glass, plastic, ceramics, silicon, copper, steel, aluminum, silver, gold or even water. Working distances and angular tolerances depend on the surface reflectivity as well as which sensor head is used. Using a standard target, such as a retroreflector, the possible working distance starts immediately after the sensor head and can exceed a range of 30 meters.

The ability to measure the surface movements of liquids opens the possibilities to realize unique applications in various scientific and industrial areas. For example, vibration measurements of hydraulic systems, detecting the liquid level in falling film reactors or analyses of liquid levels in a hydrostatic leveling system [1].

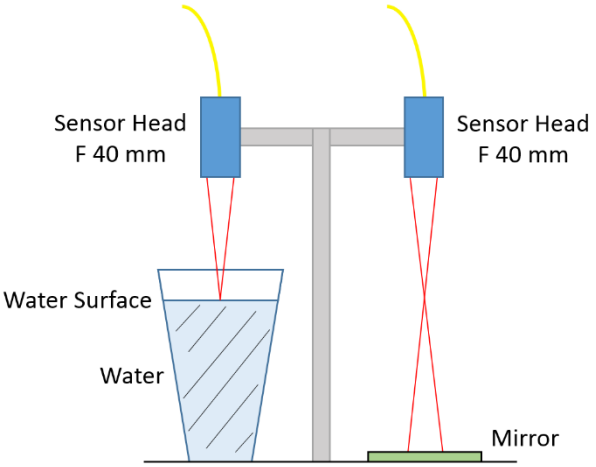

Figure 1: Sketch of the experimental setup to perform simultaneous displacement measurements on the surface of water and on a mirror.

Setup

The illustration in Figure 1 shows the schematic setup for the displacement measurements carried out on a water surface. The experimental setup included two focused sensor heads with a focal length of 40 mm (M12/F40) fixed on an optical table, a cup of water, and an aluminum mirror. We focused on the water surface and were able to achieve a working range of a few millimeter with angular tolerances of a few tenths of a degree.

Measurement Results

Figure 2 shows the results of the displacement measurement. One can see that for the first 0.714 seconds the water surface (blue curve) is only slightly wavering with 11.6 Hz in comparison to the stable position measurement of the mirror (red curve). Hitting the optical table between the two targets with a hammer, the water surface oscillates with a maximum deflection of approximately ± 20 µm. The zoom highlights that the two measurement arms show similar behaviors in the high frequency range for the first milliseconds after the excitation.

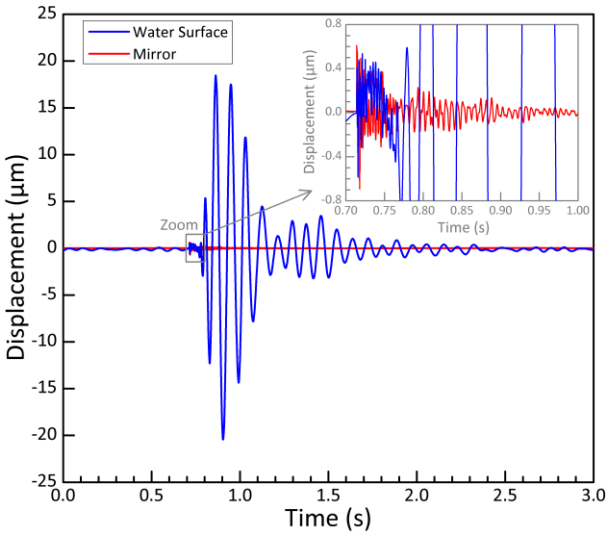

Figure 2: The blue curve shows the water surface and sensor head movements and the red curve represents the displacements measured on the side of the mirror after hitting the optical table with a hammer.

Conclusion

This experiment demonstrates the ability of the interferometer sensor to track water surface movements.

References

[1] Meier E., Limpach P., Geiger, Ingensand H., Steiger A., Licht H. and Zwyssig R. 2010 Journal of Applied Geodesy 4 2 91-102.