

A novel multi-axis position sensor is validated to nanometre accuracy and demonstrates picometre/nanoradian potential

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Abstract

Anemos has developed a novel Multi-dimensional Absolute Position Sensors (MAPS) system [1]. MAPS consists of a specially patterned and photolithographically defined reference scale, a camera, and computer image processing that decodes relative position of camera to scale on four to six axes simultaneously from each video frame. MAPS uses low-cost standard optics.

The MAPS system was tested experimentally against two orthogonal optical interferometers (OIs) using the NPL Stage Testing Rig [2]; see figure 1. The optical interferometer measurements are directly traceable to the SI metre. MAPS and the OIs simultaneously measured the XY displacement of a two-axis servo controlled nanopositioning stage. A planar (4-axis) MAPS system with a 1 megapixel camera and 5 μm -grid reference scale was verified to 5 nm maximum XY error against OI readings. Attempting to improve on this, a second experiment with a 12 megapixel CMOS image sensor and full 6 degree of freedom decoding yielded similar results.

However, when MAPS, OI, and stage position were correlated across much finer steps, MAPS demonstrated repeatability and noise below 100 pm, implying discrepancies between the MAPS and OI positions were likely stage induced Abbe errors, servo-mechanical, and other OI/MAPS-extrinsic factors. Finally, using yaw as a proxy for XY sensitivity where XY axis vibration could be nulled, a measured noise of approximately 20 nrad suggests MAPS resolves better than 10 pm of XY motion with just a square-millimetre field of view. This million-to-one grid interpolation sensitivity is in line with Anemos simulations.

[1] Aras R, MULTI-AXIS POSITION SENSING SYSTEM, UK patent number GB2576164.

[2] Yacoot A, *et al.* 2019 Design and performance of a test rig for evaluation of nanopositioning stages *Meas. Sci. Technol.* **30** 035002 (10pp)

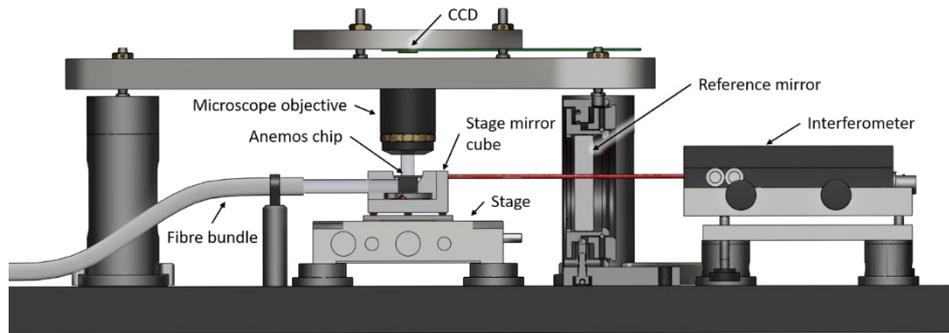


Figure 1. A side view of the experimental setup showing the key components. The y axis interferometer components have been omitted for clarity. The x axis reference mirror mount is shown in cross section to show the mirror position within.