The 3rd GMSI International Symposium, Tokyo, Japan, 2011, 135

Multi-probe scanning system comprising three laser interferometers and one autocollimator for measuring multiple motion errors of X-Y table in micro-coordinate measuring machine

Ping Yang[1], Tomohiko Takamura[1], Satoru Takahashi[1], Kiyoshi Takamasua[1],
Osamu Sato[2]; Sonko Osawa[2], Toshiyuki Takatsuji[2]
[1] Department of Precision Engineering, The University of Tokyo
[2] National Metrology Institute of Japan, National Institute of Advanced Industrial Science and Technology
yangping@nanolab.t.u-tokyo.ac.jp

Today, with the development of microsystem technologies, demands for three-dimensional (3D) metrologies for microsystem components have increased. High-accuracy micro-coordinate measuring machines (micro-CMMs) have been developed to satisfy these demands. A high-precision micro-CMM (M-CMM) is currently under development at the National Metrology Institute of Japan in the National Institute of Advanced Industrial Science and Technology (AIST), in collaboration with the University of Tokyo. In order to evaluate the motion accuracy of each stage of the M-CMM, we described a multi-probe scanning system comprising three laser interferometers and one autocollimator to measure multiple motion errors and a flat reference bar mirror profile with nanometer accuracy. The laser interferometers probe the surface of the flat bar mirror that is fixed on top of a scanning stage, while the autocollimator simultaneously measures the yaw error of the scanning stage. The flat bar mirror profile and horizontal straightness motion error are reconstructed by an application of simultaneous linear equation and least-squares methods. Measurement uncertainties of the flat bar mirror profile were numerically evaluated for different installation distances between the laser interferometers. The average measurement uncertainty was found to be only 10 nm with installation distances of 10 and 21 mm between the first and second, and first and third interferometers, respectively. To validate the simulation results, a prototype system was built using an X-Y linear stage driven by a stepper motor with steps of 1 mm along the X direction. Experiments were conducted with fixed interferometers distances of 10 and 21 mm, as in the simulation, on a flat bar mirror with a profile known to an accuracy of 632.8 nm. The average value of twice the standard deviation (95%) of the profile calculated over ten experiments was approximately 10 nm. Other results from the experiment showed that the system can also measure the yaw and horizontal straightness motion errors successfully at a high horizontal resolution. Comparison of our measured data with the results measured by ZYGO's interferometer system showed agreement to within approximately 10 nm. (Fig. 1)

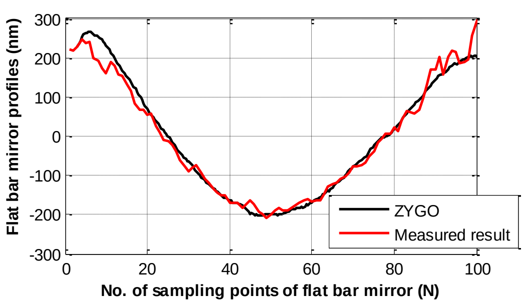

Fig. 1 Comparison of average flat bar mirror profile with profile measured by ZYGO's interferometer system