Precision control for ten decades cross-scale subnanometer positioning and measuring machines

E. Manske

Institute of Process Measurement and Sensor Technology, Technische Universität Ilmenau, 98684 Ilmenau, Germany

eberhard.manske@tu-ilmenau.de

Abstract

Nanometrology is undisputedly an enabler for the acquisition of new knowledge in the nanoworld and at the same time for the implementation of nanotechnology in real applications. More and more, the limits of physics and technology are being put to the test. In particular, alternative nanotechnologies will not make decisive progress without high-precision nanoinstrumentation.

In recent years, the TU Ilmenau has succeeded in developing a nanopositioning and nanomeasuring machine NPMM-200 for a measuring range of 200 mm x 200 mm x 20 mm with a resolution of 20 pm. This means a relative resolution of 10 decades. The enormous accuracy is only made possible by the consistent application of error-minimum measurement principles, highly accurate interferometric measurement technology in combination with highly developed measurement signal processing, comprehensive error correction algorithms and high-precision control. The high performance could be demonstrated as an example in step height measurements with a reproducibility of only 20 pm. The achieved resolution of 10^{-10} also presents new challenges for the frequency stability of the He-Ne lasers used. Here, the approach of direct coupling of the lasers to a phase-stabilized optical frequency comb synchronized with an atomic clock is pursued. Thus, laser stability of $2.4*10^{-12}$ was be achieved. This immense frequency stability is now transmitted by direct coupling of the He-Ne laser to the NPMM-200 via single-mode fiber optics for ultra-precise length measurements (Figure 1). This talk introduces the latest solutions for realization of high-precision positioning and measuring machines.

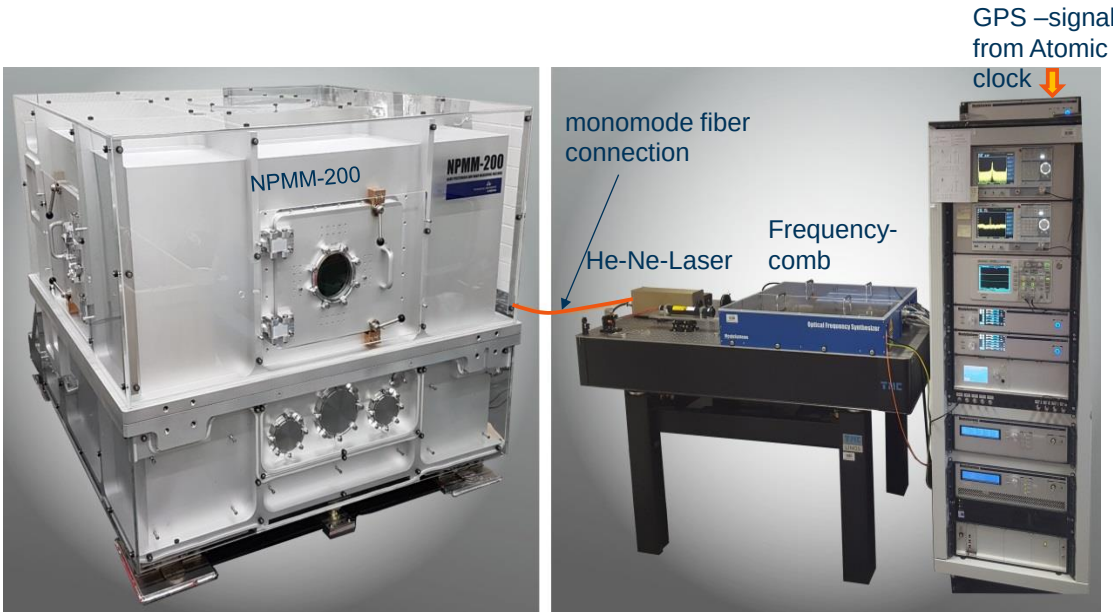

Figure 1: NPMM-200 coupled to an atomic clock stabilized He-Ne laser