Positioning and Measuring at the Nanometric Level Over Macroscopic Distances

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This talk will cover progress on one of three stages under development at UNC Charlotte. It is the Sub Atomic Measuring Machine (SAMM) which is being modified to provide picometer resolution with a 25 mm x 25 mm x,y range and a z range of 100 micrometers.[1] A special AFM, developed by MIT, is being integrated with the stage and a transfer standard is being built for error mapping.[2]

This stage is both magnetically suspended and driven using Halbach linear motors that provide lateral and vertical forces.[3,4] Four such motors are attached to a platen which is neutrally buoyant in silicone oil for damping. Attached to this platen is a Zerodur sample chamber with a sample pocket for the three lapped and plated surfaces that are targets for the stage's interferometers (for x, y and yaw) and three capacitance gages (for z, pitch and roll). These six sensors are referenced to a kinematically mounted metrology frame, also made of Zerodur. The metrology frame supports an atomic force microscope designed and built at MIT. The whole machine is in a sealed aluminum case filled with helium. Inside the case is a refractometer in a Mach-Zehnder configuration. Pressure and temperature are also measured.

The laser system for the machine consists of two lasers, one for the refractometer and one for the interferometers, both in sealed pressure cavities and frequency offset locked to an iodine stabilized He-Ne laser. They have a stability of approximately 1 part in 10^{10}. The heterodyne interferometers have electronic resolution of 8 pm over the 25 mm travel ranges, but in the helium atmosphere show approximately 15 pm "noise."

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[1] J.L. Overcash, R.J. Hocken, C.G. Stroup, Jr., Noise Reduction and Disturbance Rejection at the Sub-Nanometer Level, Proceedings of the American Society for Precision Engineering, 2009 Annual Meeting, Monterey, California.

[2] D. Amin-Shahidi, D.L. Ljubicic, J.L. Overcash, R.J. Hocken, D.L. Trumper, High-Accuracy Atomic Force Microscope for Dimensional Metrology (II), Proceedings of the American Society for Precision Engineering, 2009 Annual Meeting, Monterey, California.

[3] M.L. Holmes, Analysis and Design of a Long Range Scanning Stage, Ph.D. Dissertation, UNC Charlotte, 1998.

[4] R.J. Hocken, D.L. Trumper, and C.H. Wang, "Dynamics and Control of the UNCC/MIT Sub-Atomic Measuring Machine," CIRP, 50/1, pg. 373, 2001.

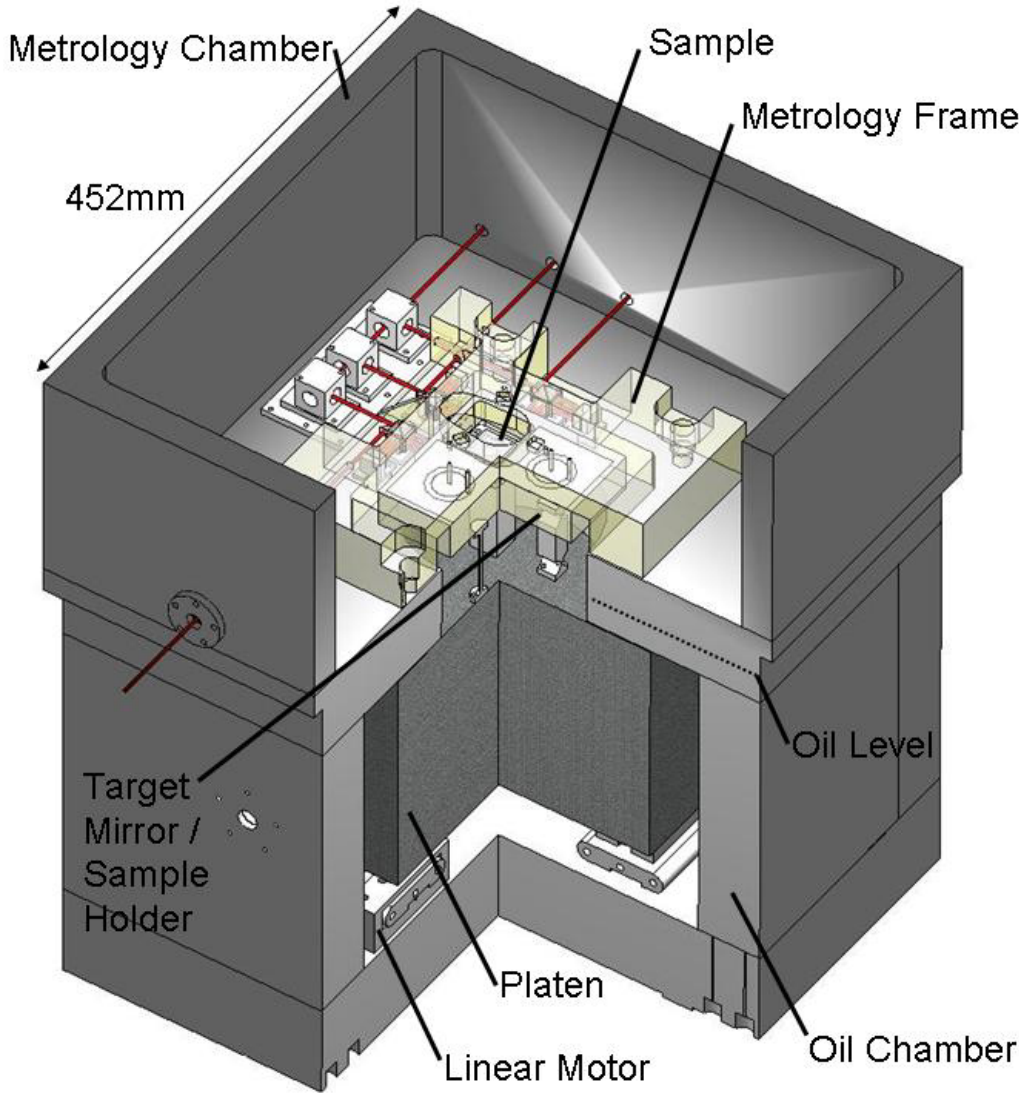

Figure 1: Solid model of the Sub-Atomic Measuring Machine. Parts shown in yellow are Zerodur and consist of the sample chamber and the metrology base.