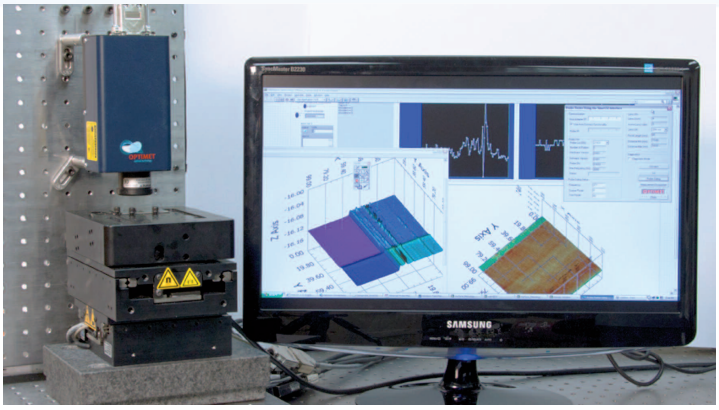
The Best of Both Worlds: Building a high performance non-contact optical surface metrology system with Newport Motion and Optimet Sensors



Micro/nanotechnologies continue to expand across a broad spectrum of fields from biomedical engineering to high-precision manufacturing. Many of these applications require highly engineered surfaces (i.e. applied coatings, mechanical patterning) with careful process control and verification using 3-D non-contact optical metrology tools. With the recent acquisition of Optimet, a member of the Ophir Optronics group, Newport now has extensive capability to provide hardware for customizable high-performance 3-D surface metrology systems that are versatile enough to perform multiple functions.

Surface Metrology System

To demonstrate the potential for highly capable 3-D measurement tools using Newport Motion and Optimet Sensors, we have built a 3-D non-contact optical surface profiler. The system was built using the Optimet NanoConoprobe, XM Linear Stages, VP-5ZA Vertical Stage and XPS-C4 Universal Motion Controller. The NanoConoprobe and XPS both communicate via TCP/IP, networked over an Ethernet bridge connected to a control computer. The control software was developed in-house using the extensive driver libraries of the XPS and driver library of the Nanoconoprobe and was prepared in LabVIEW V10.0.

The Technology

The NanoConoprobe was used to take surface height measurements. The sensor works on a non-contact optical measurement principle known as conoscopic holography, which is an interferometric measurement technique. With interchangeable objectives, the sensor has adjustable measurement resolution, down to the nanometer scale. The working range, pending on the objective lens used, is available from 1mm (with 25mm objective lens) up to 9mm (with 75mm objective lens) with Z resolution of 0.01% of the working range. The NanoConoprobe can also work with microscope objective lenses (10X or 20X). The minimum lateral resolution is 1 micron. Depending on the objective lens used, the sensor is capable of angular measurement ranges of 3-20 degrees.

The sensor can perform measurement on glass, liquids and specular surfaces. The NanoConoprobe can be tuned for optimal signal based on various materials under measurement (for diffuse materials, see the Conoprobe).

The XM Series Ultra Precision Linear Stages were used for sample positioning. These stages feature a non-contact direct drive system capable of minimum incremental motion of 10 nm with travel ranges exceeding 300mm. A sub-nm high precision glass-scale encoder provides position feedback with excellent repeatability. Ultra-quiet anti-creep crossed roller bearings provide ripple free motion and excellent pitch-yaw characteristics critical for robust, repeatable surface measurements observed. The FMS Series of All Steel Construction Linear Stages are purpose engineered for surface metrology applications and are also highly recommended for use in multi-axs surface metrology applications with Optimet Sensors.

The VP-5ZA Precision Vertical Stage was used for fine sample positioning along the optical axis, which was critical for measurement on samples with various substrate thicknesses. Once the sample was positioned to the mid-range of the working distance of the objective, the measurement was taken at a fixed height, as all profiled samples were within working range of the lens used. The stage provides 4.8 mm of travel with minimum incremental motion of 60 nm, and integrated linear encoder with feedback resolution of 20 nm.

The 3-D Non-Contact Optical Measurement

The surface metrology demonstration system was used to profile multiple samples. A sampling of profiled surfaces include: chrome on glass photomasks and broadband metallic mirrors on Pyrex substrates as well as other optical surfaces. Measurements were taken via a raster scan technique with a 5 micron step size (corresponding to the spot size of the 25mm objective). The software was used to drive the measurement, verify measurement points achieved the proper signal-to-noise ratio, provide active current scan profile cross section and reconstructs the surface via 3D Surface Mesh Plot, once scanning was complete. Surface characteristics observed were consistent and highly reproducible from scan to scan.

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Summary

Both the XM and FMS Linear stages, which were designed for high straightness and flatness, are excellent solutions to build high-precision 3D Surface Measurement tools using Conoprobe and NanoConoprobe sensors. With the extensive offering of Newport Motion products and capability of Optimet sensors, there are many potential solutions for non-contact surface measurement on both specular and diffuse surfaces.

The combination of Newport Motion with Optimet Sensors also offers expansion of standard capability. For example, integrated rotation stages can overcome angular working range limitations of the NanoConoprobe to profile non-flat surface geometries. Sequential rotational scanning with selective logic applied to Signal to Noise measurements of the sensor allow a complete, accurate and high resolution measurement of curved surface profiles. Samples with depths exceeding the working range capability of the selected objective can also be overcome by using an integrated z-axis stage. With a sequential scanning methodology surface measurements can be layered across a broad range of surface heights to provide an accurate, high resolution measurement.

For additional information, please contact Newport sales and applications engineers at tech@newport.com.

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