10.1117/2.1201102.003555

In situ surface-roughness measuring topographer

Robert E. Parks

A novel surface-roughness profiler directly measures the finish of large optics and does not need any vibration isolation.

Measuring surface roughness or finish is one of the more difficult measurements of large mirrors or lenses. In general, the measurand is too large to place on the stage of a surface-roughness measuring device, so that an indirect measurement must be made using replicas. In addition, the long mechanical path between interference objective and sample on traditional microscope-based profilers makes them prone to vibrations caused by environmental noise, which disturbs temporal phase-shifting measurements.

With our new MicroFinish Topographer (MFT), the entire unit is kinematically supported directly on the surface that needs to be measured using three nylon balls. The short, stiff mechanical-support loop between the three balls and the interference objective means that measurements can be made directly, without the need for replicas or vibration-isolation equipment. Any environmental noise couples in phase to both the device and the surface, so there is no net displacement between them, and phase-shifting measurements are unaffected.

The MFT consists of a point-source microscope[1,2] we developed that incorporates a Mirau interference objective, a piezoelectric transducer (PZT) to phase shift the objective, and 4D Technology 4Sight software to drive the PZT and analyze the interference pattern. The basic MFT is no different than other temporal phase-shifting roughness-measuring interferometers, except for its symmetric, short-coupled, stiff mechanical-support structure (see Figure 1), rather than the vibration-prone stages of most other similar devices.

Because the MFT can be set directly on the surface that needs to be measured, there is no need for replicas. The latter have several drawbacks: they are time-consuming to make (requiring skill and time to cure), lead to indirect measurements with potential loss of fidelity, and the silicon replica material leaves a residue that is difficult to remove and can lead to poor coating adhesion.

Test results have shown that the MFT gives the same roughness values as more traditional roughness devices—and have a 0.05nm repeatability on samples with 1nm rms finish—even though it does not have to be vibration isolated. In fact, the unit can be slid on the test surface (see Figure 2) without the fringes moving from the field of view. The 4Sight software makes it easy to 'fluff' out the fringes and set focus for maximum contrast, yielding the highest-quality data.

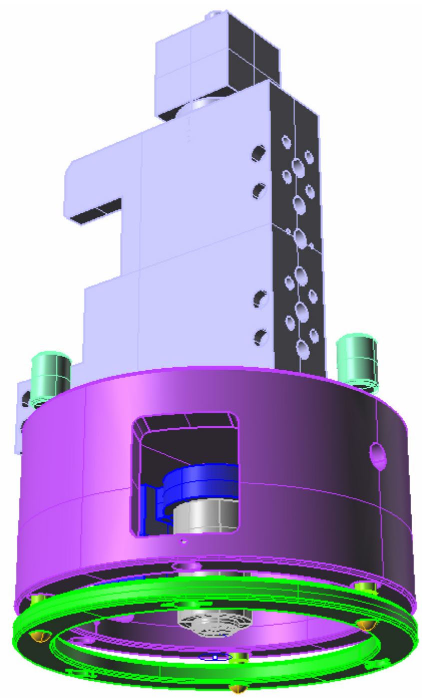

Figure 1. *The MicroFinish Topographer (MFT) showing the point-source microscope (gray) and the short-coupled support (purple), connected—by adjusting screws—to the ring (green) with three balls that sit on the measurand.*

As in all optical devices, users are looking for universal solutions. Can the MFT be used on samples smaller than the 120mm-diameter support ring? The answer is "Yes," with a simple stand

Continued on next page

10.1117/2.1201102.003555

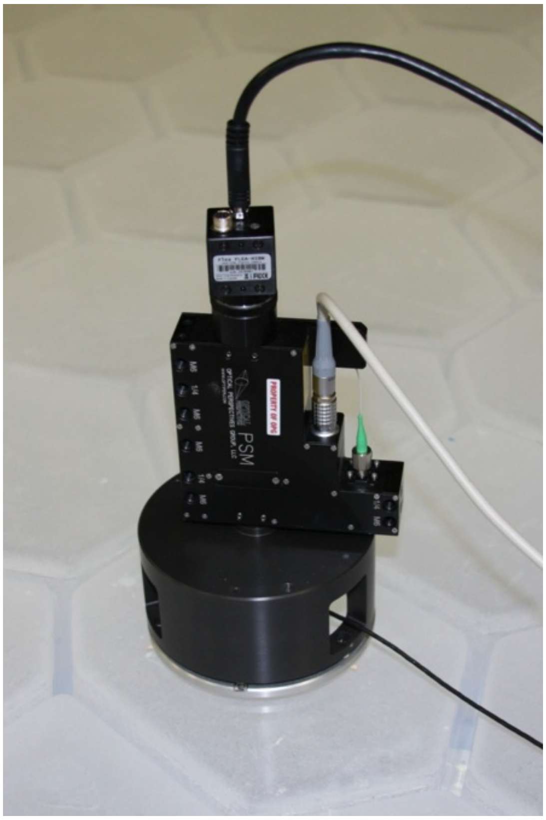

Figure 2. *The MFT measuring the test surface of an 8.4m-diameter mirror. (Credit: John Davis, Steward Observatory Mirror Laboratory, University of Arizona.)*

to hold the objective pointing up and a support plate with a series of three balls of increasing diameters. This allows placement of samples as small as 10mm diameter directly over the objective. Again, no vibration isolation is needed because the sample and microscope move together. A further advantage is that sample after sample of the same curvature can be tested without having to readjust the fringes. This dramatically speeds up roughness measurements of similar samples.

In summary, we have shown that the MFT is a solution to direct measurements of surface roughness of large and small samples, without the need for replicas or vibration-isolation hardware. It is the same basic, time-tested roughness-measurement method packaged in a way to minimize the effect of the environment. Our next steps involve moving the software onto a laptop computer and use a USB amplifier for the PZT, thus making the whole unit completely portable.

Author Information

Robert E. Parks
Optical Perspectives Group LLC
Tucson, AZ

Robert Parks has been working in optical fabrication and testing since his first jobs at Eastman Kodak Company and Itek Corp. In 1976, he became manager of the optics shop at the Optical Sciences Center of the University of Arizona, and in 1992, he launched Optical Perspectives Group LLC.

References

1. Robert E. Parks, *Versatile autostigmatic microscope*, **Proc. SPIE 6289**, p. 62890J, 2006. doi:10.1117/12.682100
2. Robert E. Parks, *Lens centering using the Point Source Microscope*, **Proc. SPIE 6676**, p. 667603, 2007. doi:10.1117/12.726837