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SURFACE ROUGHNESS MEASUREMENTS

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Introduction

The Optics Division is currently in the research phase of producing grazing-incidence mirrors to be used in x-ray detector applications. The traditional method of construction involves labor-intensive glass grinding. This also culminates in a relatively heavy mirror. For lower resolution applications, the mirrors may be of a replicated design which involves milling a mandrel as a negative of the final shape and electroplating the cylindrical mirror onto it. The mirror is then separated from the mandrel by cooling. The mandrel will shrink more than the "shell" (mirror) allowing it to be pulled from the mandrel. Ulmer[2] describes this technique and its variations in more detail. To date, several mirrors have been tested at MSFC by the Optical Fabrication Branch by focusing x-ray energy onto a detector with limited success. Little is known about the surface roughness of the actual mirror. Hence, the attempt to gather data on these surfaces. The test involves profiling the surface of a sample, replicating the surface as described above, and then profiling the replicated surface.

Results

The sample chosen for this test is a silicon carbide disk 1.5" in diameter. We measured the surface with a TopoMetrix scanning force microscope (SFM) and a WYCO TOPO 3-D. The TopoMetrix has a stylus which contacts the surface while the WYCO is a non-contact interfereometric-type profiler. Both are described quite well by Bennett[1]. The technology used in the WYCO is well-known while the SFM is a relative new-comer to the industry. The initial measurements made with the SFM were of known "standards" and were within 5% of the published values. However, the height distances on these standards were on the order of 1 k angstroms and the sample was reported by Jean Bennett of Michelson Laboratory and Darrell Englehaupt of The University of Alabama at Huntsville to have an RMS roughness[1] of approximately 1 angstrom. It was quickly realized that the SFM will require critical noise isolation in order to make measurements in the sub-nanometer range. The WYCO with a 20 X objective lens yields a measurement area of approximately 0.5 mm on a side. An "absolute" measuring technique was employed which involves taking a measurement and removing tilt from the sample (with software), translating a distance laterally, and repeating the measurement then obtaining the difference. The 0.940 angstroms measured is comparable to the value mentioned earlier.

At the time of this writing, the replication process is not completed. Measurements on the replicated surface compared to the previous measurements will yield valuable information which will aid in refining the replication process.

Reccomendations

Due to the noise problems encountered with the scanning force microscope, the instrument must be relocated to an area more conducive to its operation. Specifically, acoustic noise seems to be its greatest nemesis.

References

1. Bennett, J., and Mattsson, L., Introduction to Surface Roughness and Scattering, Optical Society of America, Washington, D.C., 1989.

2.Ulmer, M., et al, "Electroformed grazing incidence x-ray mirrors for a mirror array telescope," Applied Optics, Vol. 26, pp.3852-3857, 1987.