Guest Editorial

Precision Surface Metrology

James C. Wyant
Optical Sciences Center
University of Arizona
Tucson, Arizona 85721

During the past two decades there have been many changes in precision surface metrology. The introduction of the laser and the large computer during the 1960s and 1970s produced many changes in testing capabilities and requirements. Several commercial interferometers became available in the 1970s, enabling people who were not necessarily experts in interferometry to use interferometers to produce better optics. Since both buyers and sellers could test optics, the quality of the optics manufactured and sold improved greatly. If a person ordered 1/10 wave optics, he would probably get 1/10 wave or better optics; if he got optics of lower quality, he would know it, and he could prove it and return it.

The big development of the 1980s is the addition of solid-state detector arrays (CCDs) and microprocessors to interferometers. The use of CCDs and microprocessors makes it possible to build direct phase measurement interferometers for a reasonable amount of money. These direct phase measurement interferometers offer better precision and faster data taking; thus several data sets can be averaged to yield better accuracy. While the basic idea for direct phase measurement interferometers is not new, without low-cost detector arrays and microprocessors they would be available only to the large optics houses.

The big push in the next few years is expected to be in the area of software development. The combination of optical analysis and interferometric analysis programs to remove alignment errors is expected to produce testing improvements. Similarly, improvements in the testing of aspheric surfaces is expected.

This issue of *Optical Engineering* contains 12 papers on state-of-the-art topics in precision surface metrology. The first six papers in this group involve special techniques in direct phase measurement interferometry. The first paper, by J. E. Greivenkamp, describes an algorithm for use with both digital heterodyne and fringe scanning interferometers that removes many of the restrictions that previously had applied to the data reduction scheme. In the second paper, J. L. Seligson, C. A. Callari, J. E. Greivenkamp, and J. W. Ward describe an interferometer designed for testing lenses in transmission that gives a repeatability of better than 10^{-3} waves. The third paper, by T. Yatagai and T. Kanou, describes a computer-controlled interference phase measuring technique designed especially for the testing of aspheric surfaces. The next paper, by R. Smythe and R. Moore, presents a clever technique for greatly increasing the speed at which data can be taken using a direct phase measurement interferometer. The fifth paper, by C-C. Huang, describes an interferometer for the measurement of surface roughness that has a measurement sensitivity on the order of 0.1 Å. In the last paper in the series on direct phase measurement interferometry, K. N. Prettyjohns discusses the CCDs that might be used for direct phase measurement interferometry and the techniques for digitizing and interfacing these arrays to microcomputers.

In the seventh paper of this special issue, by B. S. Fritz, an algorithm that utilizes the orthogonal properties of Zernike polynomials is used to provide the absolute calibration of a flat optical surface. The next paper, by P. Glenn, describes a set of orthonormal polynomials for cylindrical optics. These polynomials provide a convenient means of using surface deformation data to separate rigid-body motion from surface errors.

K. H. Womack, in the ninth paper, reports on a family of three phase measurement techniques that are spatial analogs of temporal phase-shift methods. Advantages and disadvantages of these techniques compared to phase-shift methods are given. A second paper by Womack discusses the sampling problem associated with interferogram analysis using the concepts of Fourier analysis.

T. Yatagai, S. Inaba, H. Nakano, and M. Suzuki, in their paper, present a high-speed automatic flatness analyis system using a Fizeau interferometer for checking VLSI wafers. Special hardware is developed for fringe peak detection, fringe thinning, and fringe order selection. The last paper, by J. C. Stover, S. A. Serati, and C. H. Gillespie, describes the operation of a differential scatterometer that takes and stores data under computer control. Various results are discussed, including comparison with the effective rms roughness obtained using a total integrated scatter system.