Instantaneous phase-shift, point-diffraction interferometer.

James E. Millerd, Neal J. Brock, John B. Hayes and James C. Wyant
4D Technology Corporation, 3280 E. Hemisphere Loop, Suite 112, Tucson AZ 85706
(520) 294-5600, (520) 294-5601 fax, james.millerd@4dtechnology.com

Abstract: We demonstrate a phase-shift, point diffraction interferometer that achieves high accuracy and is capable of measuring a single pulse of light. Results of measuring transient phenomena and numerical apertures as high as NA 0.8 are presented. The operational limits and accuracies of the technique are discussed.

OCIS codes: (1205050, 120.3180)

Summary

Wavefront measurement is important in the manufacture of telescope optical components and for measuring system performance. The utilization of active optical components, such as deformable mirrors and arrays, requires fast measurement and feedback to the control actuators. Point diffraction interferometry is a simple, self-referencing configuration to measure the wavefront quality of low temporal coherence optical beams. Significant research has been devoted to adapting phase-shift interferometric techniques to common path interferometry to enable high precision wavefront measurements. Several methods have been proposed and have demonstrated accuracies better than one fortieth of a wave. These systems all involve a relatively slow temporal phase-shifting process that is incompatible with measuring single, short pulses of light and are sensitive to mechanical vibration. In addition, the retardation and splitting elements are optically thick and add aberration to the measurement, which must be subtracted through calibration. Finally, these techniques have been restricted to low numerical aperture beams because of feature size limitations in the phase-plate.

In this paper we present a method that accomplishes high-resolution phase-shift interferometry with a self-referencing point diffraction plate where all the phase-shifted data is acquired simultaneously. This has the advantage of allowing the measurement of single optical pulses, which can freeze out vibrations and capture transient events. The heart of the technique utilizes a finite-aperture conducting grid structure as a polarizing point diffraction plate. The plate generates a synthetic reference beam that is orthogonally polarized to the transmitted test beam. The plate has very high polarization contrast (>500:1), works over an extremely broad angular range, and is only 100 nanometers thick. The unique features of the polarizing element make the technique amenable to measuring strongly convergent light from high numerical aperture optics without the need to use a point reference source to calibrate the system. The high-level design of the system is shown in Figure 1 along with measured data of transient air-flow and a high-numerical aperture lens. In the paper we present the theory of operation and measurements from a prototype system.