The off-axis aspheric mirror testing based on the fringe reflection technique

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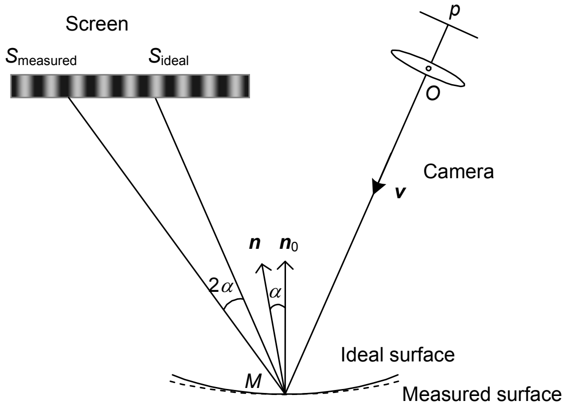

Principle schematic of the measurement setup

Overview: Generally, manufacture of off aspheric surfaces is divided into three stages: milling stage, fine grinding and rough polishing stage, and fine polishing stage. During the rough polishing, the scale of the shape error is large and the interferometer cannot be used for testing due to its limited dynamic range. FRT (fringe reflection technique) is a non-contact profilometry for the measurement of specular optical surfaces. In this paper, FRT is used for the off-axis aspheric surface measurement during the manufacture stage of the beginning of polish with its advantage of large dynamic range and high sensitivity. The basic principle is to project sinusoidal fringe patterns onto a screen located remotely from the surface under test, and the reflected fringe patterns via the surface are captured by the digital camera. The recorded pattern image by the CCD will be distorted and the distortion depends on the reflecting surface. The surface slope variation of the surface can be calculated accurately according to distortions of the patterns and the surface error map is integrated from the slope errors. This method is able to achieve high dynamic range slope measurement by using computer-controlled large displays as light source without requiring specially designed null optics. Also, this technique is completely incoherent which avoids the coherent noise in interferometry test. To reach the high accuracy of measurement, the system calibration is required. Here, the optical CMM, which is a modified CMM using a point source microscope (PSM) as the probing arm, is used for the calibration. The screen pixel position and shape bending are calibrated by the optical CMM. The CCD pinhole position and the ray direction of each camera pixel are calibrated by the optical CMM and pattern images. In the test, the measurement system coordinate and ray trace model are build using the laser tracker, and then the calibration results of the camera calibration and screen calibration are introduced into the Zemax model to establish a virtual null test model and the ideal screen pixel point position can be got by ray tracing. The measurement screen pixel point position is obtained by phase-shifting technique. The slope error of the surface is calculated and final results are got by integration. The measurement results of a SiC off-axis mirror by both the presented method and the CMM are compared. The difference is below 0.5 μm RMS. The feasibility is verified and this method can be used to guide the manufacture of off-axis aspheric surface during the beginning of the polish.

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