Technical Report Synopsis:

Freeform Correction Polishing for Optics with Semi-kinematic Mounting

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1 ABSTRACT

In this report a synopsis of a published paper is presented. In the paper entitled "Freeform Correction Polishing for Optics with Semi-Kinematic Mounting", the author explains how the deformation of a semi-kinematic mounting that consists of three small contact areas, can be quantified, and predictable. The authors also show how this predictable deformation can be compensated, and corrected by polishing the test piece. Comparison of simulation, and experimental results are presented.

2 INTRODUCTION

Besides the error that an optical element could have, the mounting, and assembling of an optical system would introduce deformations that will be the main contributors of the system aberration. These aberrations will be non-symmetric.

The authors state that the form error of lens with 150mm in diameter varies from 0.1 λ to 0.15 λ with semi-kinematic mounting assembly due to self-weight deformation. The shape and magnitude of this deformation are stable and repeatable.

The method proposed in this paper consists of combining Finite Element Method (FEM), stitching metrology, and freeform correction polishing to pre-compensate the lens deformation of semi-kinematic mounting.

3 DESIGN AND SIMULATION OF LENS ASSEMBLY WITH SEMI-KINEMATIC MOUNTING

In this section the authors explain the design and simulation of the lens assembly with a semi-kinematic mounting. The optical module consists in a barrel, a ring, a retainer, and a lens.

The lens diameter is 150 mm, thickness of 18.1 mm, R_1=516.66mm and R_2=480.16mm of first and second surface, and it is fabricated using Nikon NIFS series synthetic silica glass, which mechanical properties are listed in Table 1.

Table 1. Mechanical Properties of Nikon NIFS Series Synthetic Silica Glass.

Density	2.2 g/cm^3
Knoop Hardness (100 g load)	590-620 kg/mm^2
Young's Modulus	73 GPa
Shear Modulus	31 GPa
Poisson's Ratio	0.16
Bending Strength	67 MPa

The barrel and ring are designed with grooves in such a way that the contact areas of the ring lie in contact areas with the barrel at the same orientation. The three contact areas are separated 120 degree from each other on barrel and ring. When the ring screwed in to fix the lens, the contact forces would be counteracted, with this condition they obtain reproducibility test of lens measurement. The material used to fabricate the ring, barrel, and retainer is aluminum 6061T6 alloy.

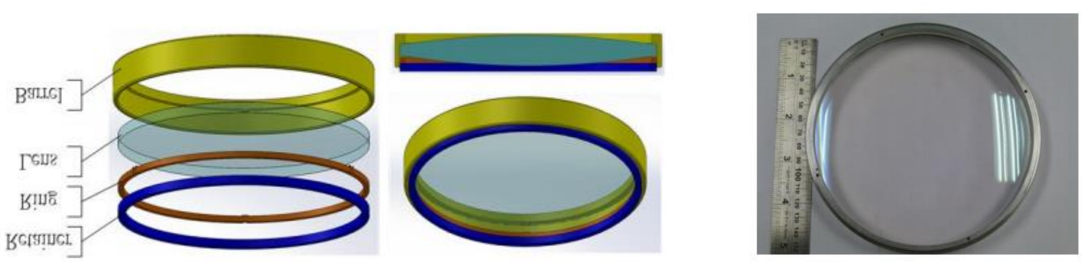

Figure 1. (a) Optical Module Simulation. (b) Optical Module.

The lens surface deformation due to the semi-kinematic mount, and induced by self-weight was found using ANSYS. In the simulation model the authors used one third of the lens to decrease computing time, and get finer meshes. The boundary conditions consist on 3 friction lens supports at B on lens surface, the self-weight was applied in Z-axis, as is shown in Fig (2a). After running ANSYS simulation, the deformations found are shown in Fig (2b).

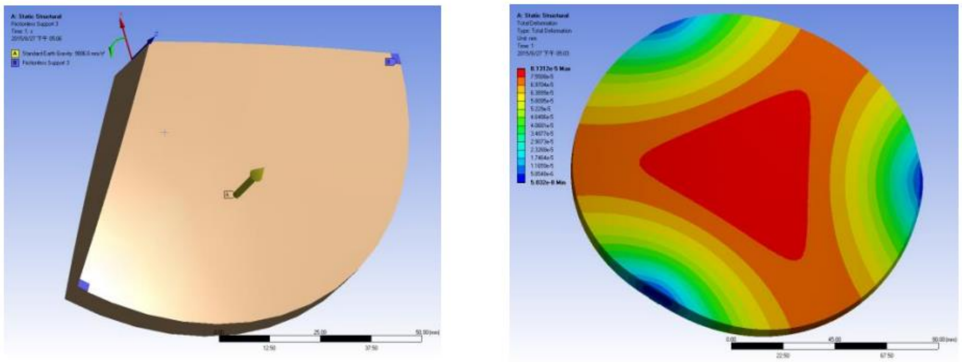

Figure 2. (a) Simulation Boundary Conditions. (b) Lens deformation from Simulation.

After obtaining the deformation, the next step is fitting the data to Zernike terms to describe the deformation as a freeform surface. The chart below shows the contribution of the principal aberrations. The more significant aberration were astigmatism, spherical, and trefoil due to lens self-weight deformation with semi kinematic mounting. The primary contributor was trefoil aberration.

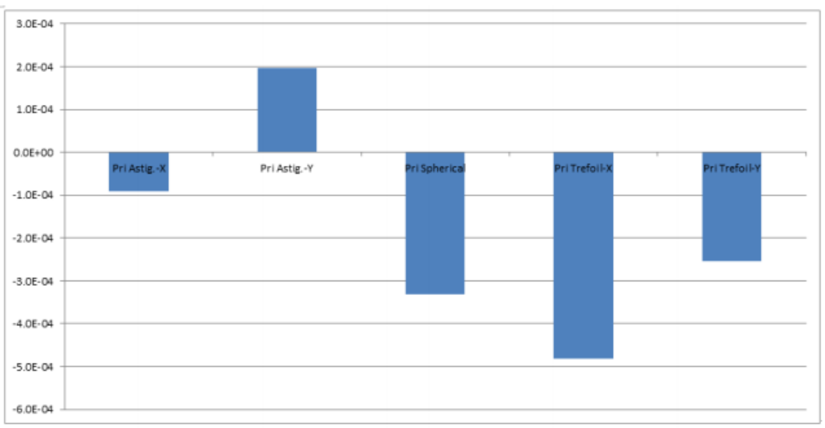

Figure 3. Contribution of low order Zernike terms.

4 Metrology of Lens Deformation with Semi-Kinematic Mounting

In this section, the authors explain how they tested the lens. The technique used to test the lens was interferometry with stitching function (ASI). ASI acquires sub aperture form figures and stitches each other to get a complete surface form error. They used ASI with 6 inch F/5.4 transmission sphere to measure the form error of the surface 2 (radius of curvature 480.16 mm). In order to measure a 143 mm clear aperture of the surface, they used 14 sub apertures and they tilted the lens up to 5 degrees when acquiring marginal sub apertures. They found good repeatability, and that the maximum deviation of 3 tests is less than 1/50λ.

To compare the simulation results and the experimental results, they subtracted the formal error of the lens, from the error using the semi-kinematic mounting.

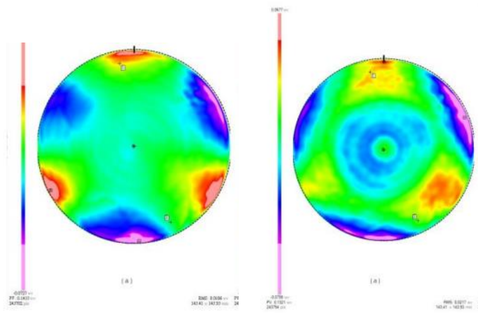

Figure 4. (a) Deformation of semi kinematic mounting by ASI measurement. (b) Surface form error of the assembled lens.

5 FREEFORM CORRECTION POLISHING

After describing the surface deformation as a freeform surface, they used Magnetorheological finishing (MRF) to correct the assembled form error of the lens and the trefoil aberration due to the mount. The polishing parameters were C10+ MR fluid and D50 mm polishing head were used to spot test. The peak removal rate (PRR) of spot was 2.507 μm/min. The initial errors of map are 83.6 nm in PV and 13.7 nm in RMS as shown in Figure 4(b). The freeform correction polishing is carried out by using the QED Q-flex 300 MRF machine. The total polishing time was around 1.5 hours.

The corrected errors were 26.1 nm in PV and 3.4 nm in RMS. The results from the last test using ASI are shown in Fig (5).

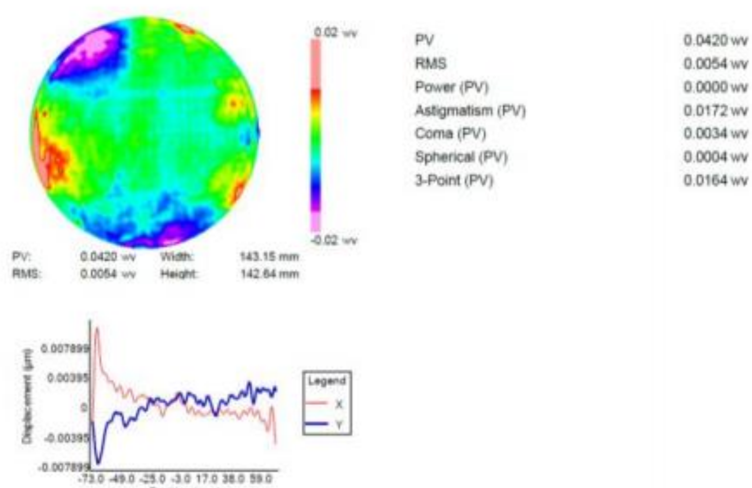

Figure 5. Result of freeform correction polishing.

6 CONCLUSIONS

In this paper the authors showed how after characterizing the deformations of a lens assembly with a semi-kinematic mounting, they were able to reduce the surface error by polishing the lens. The differences were found by two methods: Finite Element Modeling (using ANSYS software), and experimental testing (using an interferometer with stitching function). By fitting the differences to 37 Zernike terms, they were able to describe the data as a freeform surface. Using a Magnetorheological finishing technique to polish lens, they compensated the lens deformation achieving a surface form error of the assemble lens module of 0.042λ in PV.

7 REFERENCES

[1] Huang, Chien-Yao, et al. "Freeform correction polishing for optics with semi-kinematic mounting." SPIE Optifab. International Society for Optics and Photonics, 2015.

[2] http://www.edmundoptics.com/downloads/mrf.pdf