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Laser confocal microscope noise evaluation on injection compression moulded (ICM) transparent polymer Fresnel lenses

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Abstract

The evaluation of an adequate and robust measuring strategy, for roughness assessment of polymer Fresnel lenses is put under assessment. An ‘on-sample’ measurement noise, is evaluated using a laser confocal microscope (OLYMPUS © Leitz). Secondly, the lowest-noise roughness measuring procedure, on an injection compression moulded (ICM) Fresnel lens, is defined. A set of two different objectives is considered, i.e. a standard series (SO), against a long working distance one (LWD); two different magnifications objectives, 50x and 100x and the use not of a dark environment.

Laser confocal microscope lowest noise optical set-up

- Objective ⇒ Evaluate the best optical set-up to ensure lowest noise measuring routine for an injection compression moulded (ICM) transparent polymer Fresnel lens
- Increase quality of results ⇒ Absence of distortions
- Increase measuring speed ⇒ Find sufficient accuracy
- Avoid small working distance possible collisions ⇒ Assess long measuring vertical step
- Laser confocal microscope ⇒ Suitable for industrial manufacturing application
- Flexible working conditions
- Coherent laser source of 510 nm
- Noise evaluation ⇒ Averaging method
- Reduction method
- Compared measuring optical set-up ⇒ Magnification, Working Distance, Environmental lighting conditions
- Specimen employed for analysis (Figure 1)
  - ICM Fresnel lens in Cyclo-Olefin Polymer material
  - Central circle ⇒ 1.496 μm
  - Slope on center ⇒ < 1°
  - Horizontal pitch ⇒ 748.9 μm
- Experiments performed to achieve optimal instrument set up using a metrological approach

Experimental conditions for noise evaluation

- Design of Experiments (DOE) technique applied
- 3-factor/2-level full factorial design (Table 1)
- ⇒ resulting in a total of 8 different scan settings
- Objective series ⇒ Standard Objectives (SO), Long Working Distance (LWD)
- Objective Magnification ⇒ 50x, 100x
- 10 repeated measurements for each set-up
- Measuring conditions
  - ⇒ image dimensions 258x258 μm²
  - ⇒ 4096x4096 points per image

Conclusion

This study shows the possibility to evaluate measurement noise directly ‘on-sample’ when the specimen surface roughness Sq, and the noise evaluation, have similar values. This is validated evaluating the same Sq and Sq noise of 10 nm on sample and on an optical flat. The lowest-noise measuring strategy is identified in the cases of maximum AN, in absence of measurement disturbances. Moreover noise estimation with 50x SO results lower than 100x LWD objectives, in the first case 10 nm against 15 nm.

References


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Table 2: Noise evaluation in terms of Sqqmax compared on optical flat and Fresnel lens

Table 1: 3-factor/2-level full factorial DOE

Fig. 1: Measuring roughness in the central region of the Fresnel lens and 3D acquisition with a 5x magnification objective

Fig. 2: DOE results of noise evaluation (Sqqmax) on Fresnel lens for the different experimental conditions

Validation of an “on-sample” noise evaluation procedure

- Optical Flat
  - Averaging: 9.7
  - Subtraction: 9.7
- Fresnel Lens
  - Averaging: 8.1
  - Subtraction: 6.9

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