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Publication date:
2017

Document Version
Publisher's PDF, also known as Version of record

Citation (APA):
Loaldi, D., Calaon, M., Quagliotti, D., Baruffi, F., Parenti, P., Tosello, G., & Annoni, M. (2017). Laser confocal microscope noise evaluation on injection compression moulded (ICM) transparent polymer Fresnel lenses. Poster session presented at 17th euspen International Conference & Exhibition, Hannover, Germany.

European Society for Precision Engineering and Nanotechnology (euspen), 17th International Conference, Hannover (Germany), 29th May – 2nd June 2017

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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 © Lext). 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 or not of a dark environment.

The noise evaluation is performed by comparing 'on-sample' noise with the one calculated on an optical flat. Noise is investigated by means of established methods, i.e. subtraction and averaging methods. Afterwards, the lowest-noise analysis is structured following a 2^3 full factorial experimental planning, whose factors are measuring working distance, objective magnification and room lighting. The result confirms a strong difference of noise, using the considered objectives. The most interesting result is that the performance of SO 50x objective is better than LWD 100x.

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 [1] ⇔ 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 [2] ⇔
  - Averaging method
  - Subtraction method
- Compared measuring optical set-up on ⇔
  - Magnification
  - Working Distance
  - Environmental lighting conditions
- Specimen employed for analysis (Figure 1)
  - ICM Fresnel lens in Cyclo-Olephin 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

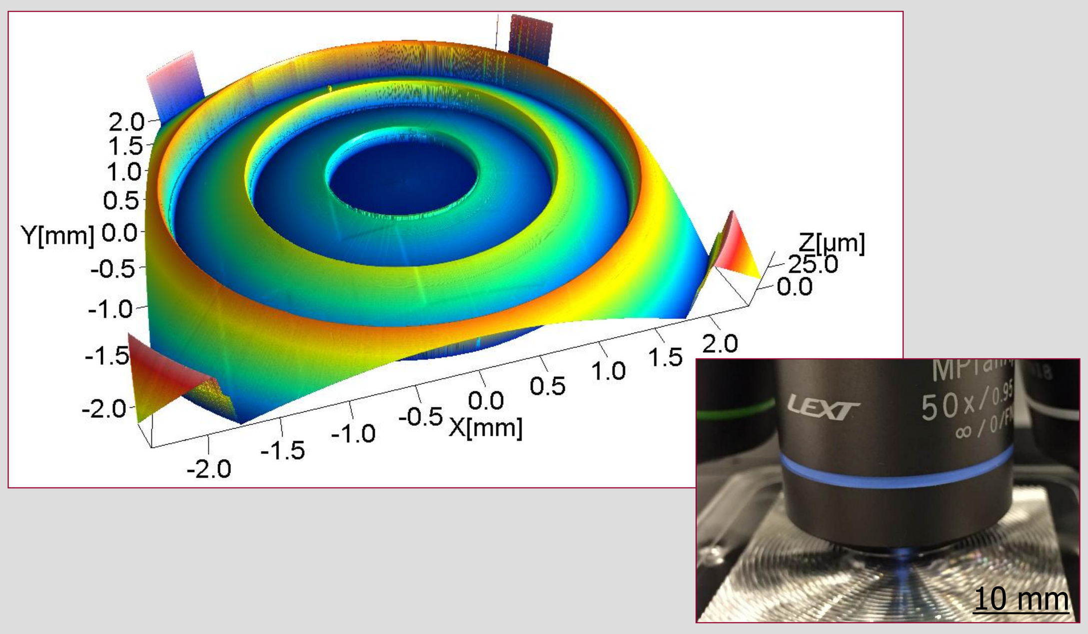

Fig. 1: Measuring roughness in the central region of the Fresnel lens and 3D acquisition with a 5x magnification objective

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
  - Room Illumination ⇒ ON, DARK
- 10 repeated measurements for each set-up
- Measuring conditions
  - ⇒ Image dimensions 258x258 µm²
  - ⇒ 4096x4096 points per image

Experimental conditions			Objective properties	
Objective series	**Objective Magnification**	**Room Illumination**	*Numerical Aperture* A_N	*Working Distance* WD / mm
SO	50x	ON	0.95	0.35
SO	50x	DARK	0.95	0.35
SO	100x	ON	0.95	0.35
SO	100x	DARK	0.95	0.35
LWD	50x	ON	0.5	10.60
LWD	50x	DARK	0.5	10.60
LWD	100x	ON	0.8	3.40
LWD	100x	DARK	0.8	3.40

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

Validation of an "on-sample" noise evaluation procedure

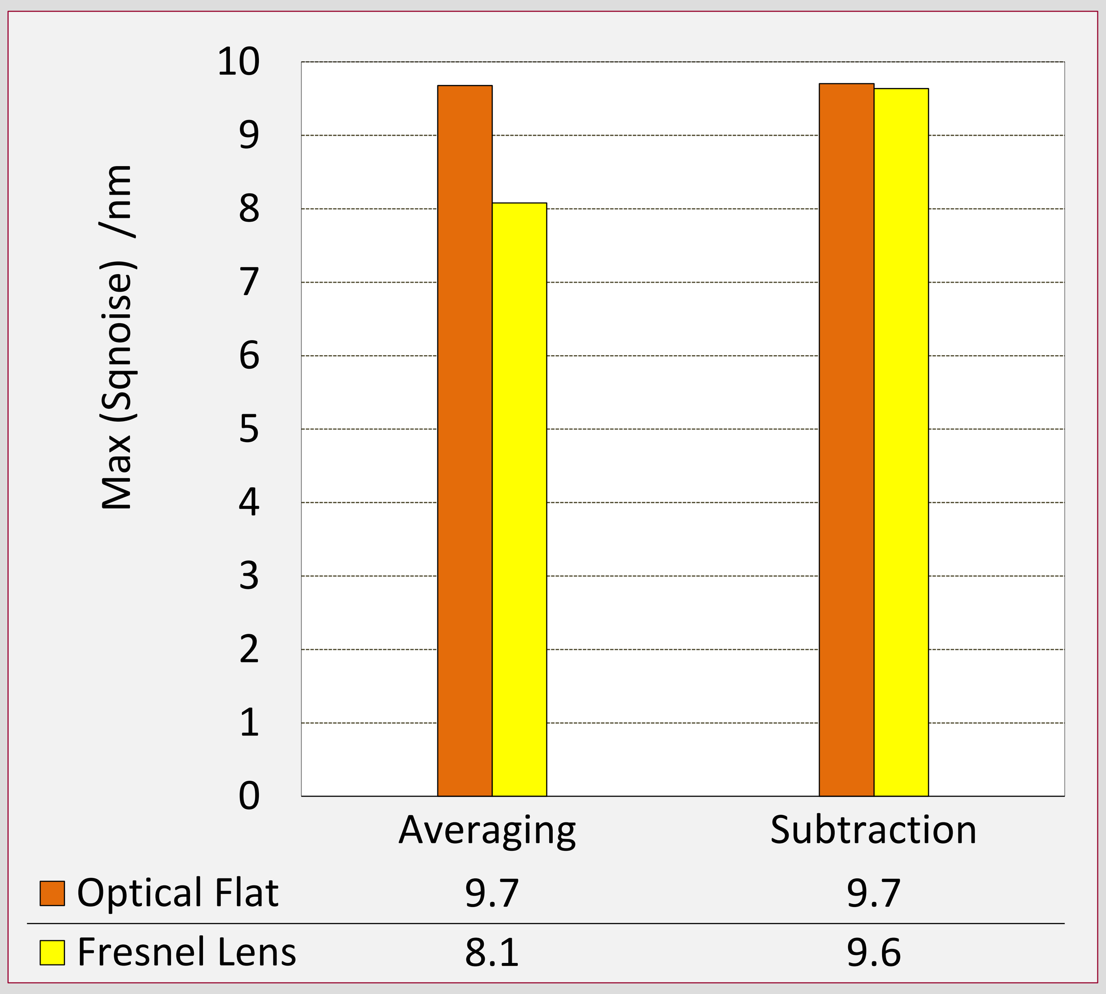

Table 2: Noise evaluation in terms of Sq_{noise} compared on optical flat and Fresnel lens

Lowest noise measuring set-up

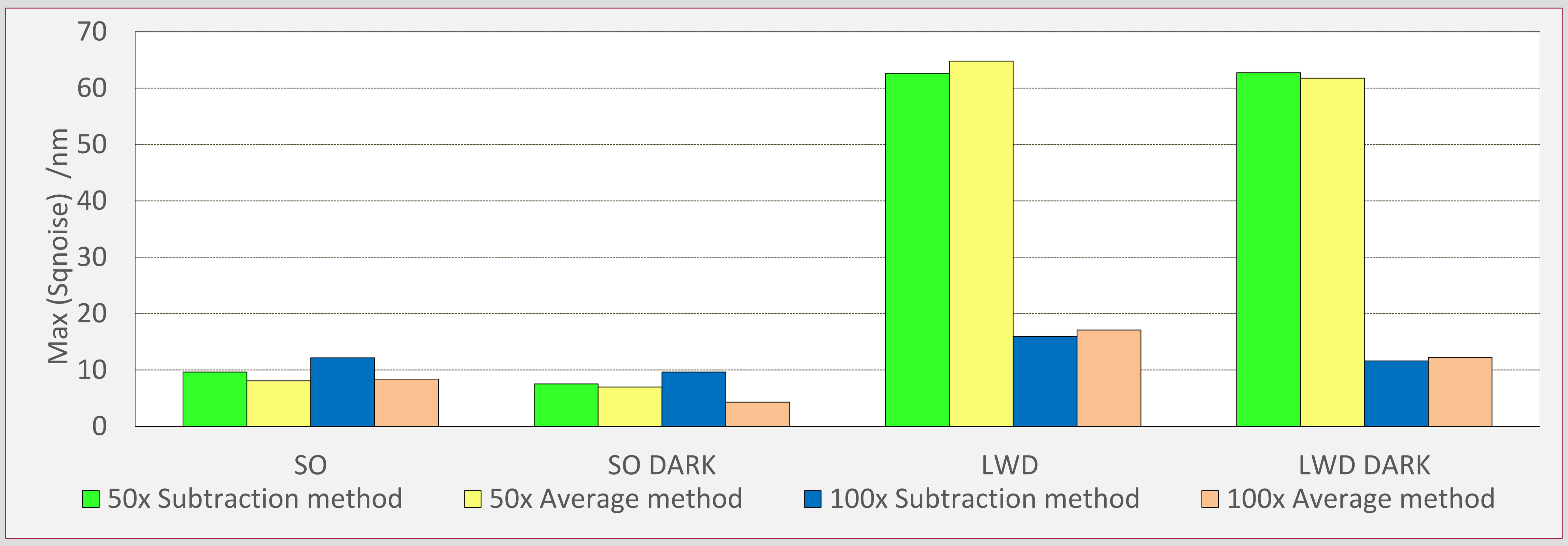

Fig. 2: DOE results of noise evaluation (Sq_{noise}) on Fresnel lens for the different experimental conditions

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 Sqnoise 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.

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Acknowledgements

This research work was undertaken in the context of ***MICROMAN*** project ("Process Fingerprint for Zero-defect Net-shape MICROMANufacturing", http://www.microman.mek.dtu.dk/). MICROMAN is a Marie Skłodowska-Curie European Training Network supported by Horizon 2020, the EU Framework Programme for Research and Innovation (Project ID: 674801). The Department of Mechanical Engineering at the Technical University of Denmark and the Department of Mechanical Engineering at Politecnico di Milano (Italy) are thanked for supporting the collaboration between the two institutions in the project "*Technological Signature in Precision Injection Compression Moulding of Polymer Fresnel Lenses*".

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HORIZON 2020