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General method of designing phase-shifting algorithms for grating lateral shearing interferometry

Key words: Interferometry; Phase measurement; Phase-shifting algorithms

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Motivations

1. The zeroth-order beam and the ±1st-order beams generate complicated interferograms, which increases the difficulty of wavefront restoration and reduces the accuracy of wavefront measurement.

2. It is significant to design special algorithms to suppress the zeroth-order effect and to compensate for the phase-shifting error.

3. Based on the existing grating lateral shearing interferometer, new phase-restoration algorithms have been designed to improve the measurement accuracy of the wavefront of projection lens systems, which is significant in developing new lithography equipment with narrower critical dimension.

Main idea

In this paper, we derive a general expression of a phase-shifting algorithm in a grating lateral shearing interferometer and introduce the corresponding design method.

Methods

1. We derive a general expression of the phase-shifting algorithm in a grating lateral shearing interferometer and introduce the corresponding design method.

2. Based on the expression and method, four phase-shifting algorithms are designed with different phase-shifting errors to obtain high measurement accuracy.

3. A new 13-frame phase-shifting algorithm is designed and simulated with a large zeroth-order effect.

Major results

1. With the same phase-shifting error, the phase-restoration error is smaller as more frames are used.

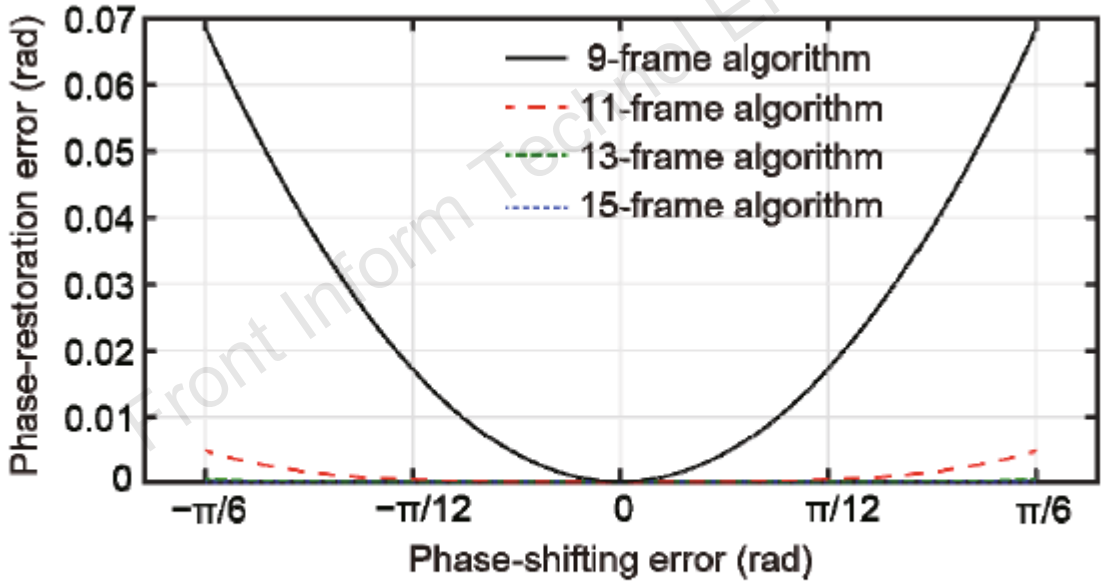

Fig. 2 Phase-restoration error with different algorithms

Major results

2. With the same zeroth-order effect error, the restoration accuracy of the new 13-frame algorithm is higher than that of the 9-frame algorithm. The accuracy difference is remarkable, especially when the zeroth-order effect error is large.

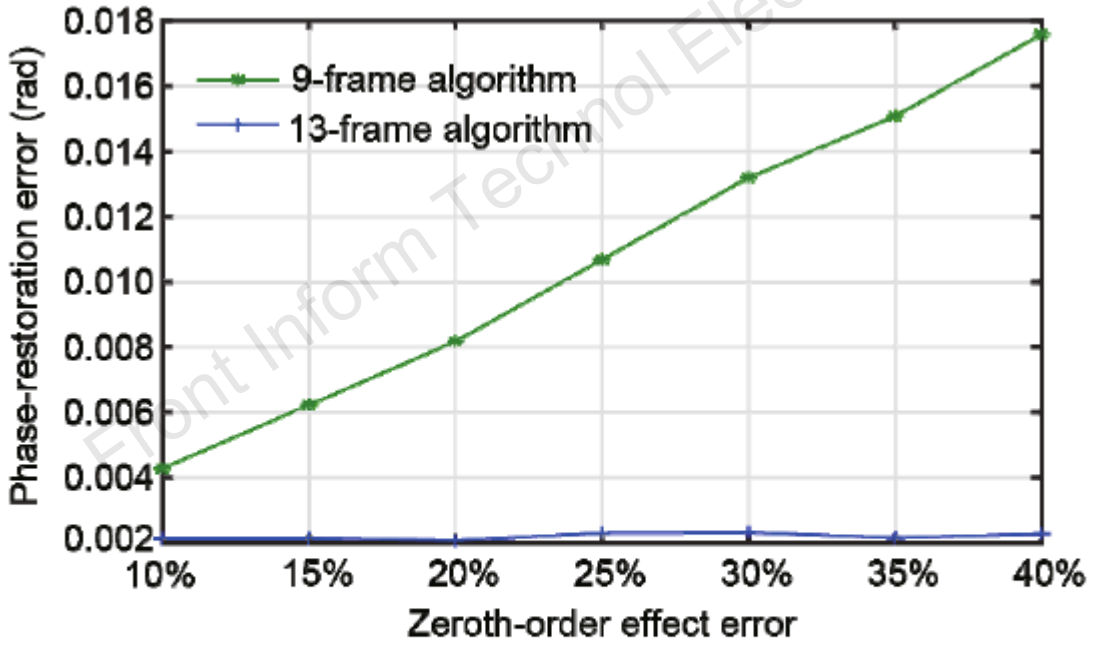

Fig. 4 Restoration root mean square errors of the 9-frame and the new 13-frame algorithms for different zeroth-order effect errors

Conclusions

1. In this paper, we have derived a general expression of a phase-shifting algorithm for a grating lateral shearing interferometer and have offered a detailed design method.

2. The 9-, 11-, 13-, and 15-frame phase-shifting algorithms have been designed with the primary optimization of suppressing the phase-shifting error.

3. The new 13-frame phase-shifting algorithm has been designed with the primary optimization of suppressing the zeroth-order effect.

4. The analysis and simulations showed that the designed phase-shifting algorithms can effectively eliminate the phase-shifting error and zeroth-order effect error for the grating lateral shearing interferometer.