High Efficiency Grating Lateral Shear Interferometer

D. A. Thomas and J. C. Wyant
Optical Sciences Center, University of Arizona
Tucson, Arizona 85721

Abstract

The use of dichromated gelatin for holographically recording the component single frequency gratings of a high efficiency grating lateral shear interferometer is described. Interferograms obtained using a grating lateral shear interferometer simultaneously having a diffraction efficiency of 30% in each of two shearing interferograms are presented.

Background and Procedure

Recently, several grating lateral shear interferometers have been described.[1-3] The interferometers offer the advantages of simplicity, often good potential for operation with white light sources, and in some cases variable shear operation. The disadvantage with previously described grating lateral shear interferometers has been low light efficiency. The purpose of this short communication is to describe the use of holographic gratings formed in dichromated gelatin to construct a high-efficiency grating interferometer. The interferometer is of the modified Ronchi type described previously.[1,2] Two identical diffraction gratings are located near the focus of the converging wavefront under study. The grating frequency is chosen so that the angle of diffraction is large enough to avoid overlap of the first-order diffracted cones and the directly transmitted beam. The zero order of the first grating and first order of the second grating (0,+1) and the first order of the first grating and the zero order of the second grating (+1,0) interfere to form one interferogram. Likewise, the (0,0) and (+1,-1) orders interfere to form a second interferogram. The amount of lateral shear in the two interferograms is selected by rotating the two gratings in their own plane in opposite directions.

The potential for recording sinusoidal gratings having diffraction efficiencies of up to 100% in thick (15μm) dichromated gelatin emulsions has already been considered from a theoretical standpoint.[4] Lin[5] has described the physical mechanism by which gratings are recorded in this emulsion and has experimentally obtained gratings having diffraction efficiencies as high as 90%. One of the problems he encountered was that his gelatin samples tended to turn milky in appearance when the exposures were processed. This quality adds considerable noise to the gratings that are recorded in the emulsion, and would make them unusable in a lateral shear interferometer. A process[6] was later devised for preparing dichromated gelatin emulsions from Kodak 649F plates that eliminated this problem.

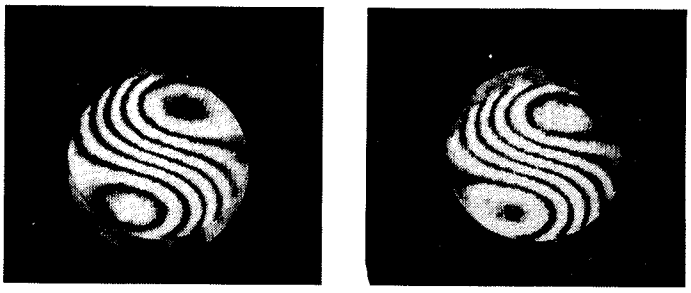
This process was used to prepare the gratings for a lateral shear interferometer. Two plane wavefronts were interfered to give interference fringes having a spatial frequency of about 800ℓ/mm. An exposure of approximately 500mj/cm^2 was empirically found to give the brightest gratings at a wavelength of 0.5145μm. The exposures were made with one beam normal to the emulsion.

Results

The resulting processed exposures were generally quite clear and non-milky. They generally had either low diffraction efficiencies (5-15%) and low noise, or high diffraction efficiencies (75-90%) and high noise. The fact that the brightest gratings were also the noisiest is consistent with Lin's findings. The best exposures had diffraction efficiency values in the 40 to 60% range with acceptably low amounts of noise.

Bright, high contrast lateral shear interferograms were obtained when aberrated wavefronts were focused onto a composite grating formed by pressing two single frequency gratings together. For the best lateral shear interferometer, each grating had a diffraction efficiency of nearly 60%, and the gratings could be rotated with respect to one another to vary the amount of shear. From the sample interferograms shown in Figure 1, it is evident that both the (0,0), (+1,-1), and (0,+1), (+1,0) diffraction orders gave excellent lateral shear interferograms. Note that, as expected for the phase gratings, the two interferograms are 180° out of phase.

Since each pair of diffraction orders gave an efficiency of approximately 30%, 60% of the incident energy can be utilized if both shearing interferograms are used. This efficiency is several times the efficiency of previous grating lateral shear interferometers.[1,2]



(0,0); (+1,-1) orders (0,+1); (+1,0) orders

Fig. 1. Shearing interferograms obtained using dichromated gelatin grating lateral shear interferometer.

References

1. Hariharan, P., W. H. Steel, and J. C. Wyant, "Double Grating Interferometer with Variable Shear," Opt. Comm., *11*, pp. 317-320, July 1974.
2. Rimmer, M. P. and J. C. Wyant, "Evaluation of Large Aberrations Using a Lateral-Shear Interferometer Having Variable Shear," Appl. Opt. *14*, pp. 142-150, January 1975.
3. Chang, B. J., R. Alferness, and E. N. Leith, "Space-Invariant Achromatic Grating Interferometers: Theory," Appl. Opt. *14*, pp. 1592-1600, July 1975.
4. Collier, R. J., C. B. Burckhardt, and L. H. Lin, *Optical Holography*, Academic Press, New York, 1971.
5. Lin, L. H., "Hologram Formation in Hardened Dichromated Gelatin Films," *Applied Optics, 8*, pp. 963-966, May 1969.
6. Chang, Milton, "Dichromated Gelatin of Improved Optical Quality," *Applied Optics, 10*, pp. 2550-2551, November 1971.