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During this program year, a third generation heterodyne system has been constructed with a demonstrated temporal capability for measuring out-of-plane displacements with a resolution of better than 1/1500 of a fringe (Previous configurations provided resolutions to 1/900 of a fringe or about 3 Angstroms). Pulsed heterodyne holographic interferometry of large amplitude acoustic waves propagating over an aluminum test specimen and interacting with a machined slot defect was successfully demonstrated. This new readout system is extremely flexible in that it incorporates two acousto-optic (Bragg) cells with electronics to permit either frequency shifting for true heterodyning or phase shifting for phase-stepped, quasi-heterodyne holographic interferometry.

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ANNUAL SUMMARY REPORT

for

1 October 1985 through 30 September 1986

for

Contract N00014-82-K-0741

FULL FIELD VISUALIZATION OF PROPAGATING SURFACE ACOUSTIC WAVES

James W. Wagner (Principal Investigator)
Robert E. Green, Jr. (Co-Investigator)

The Johns Hopkins University
34th and Charles Streets
Baltimore, Maryland
21218

The objective of this research effort is to apply optical holographic techniques coupled with electronic processing techniques for providing a several orders of magnitude more sensitive method for full field visualization of low amplitude (order of Angstroms) acoustic waves propagating along the surface of a solid body. The technique being developed for measuring sub-fringe surface displacements is heterodyne holographic interferometry. The holographic recording process is similar to that employed for double pulsed holographic interferometry except that the heterodyne system uses two reference beams to record and readout the hologram. During the recording of the double exposure hologram, one beam is used for the first exposure and the other for the second. On playback, both reference beams are used. Bragg cells inserted in each beam are used to shift the beams at slightly different frequencies causing the fringes to move periodically at the difference frequency of the two beams. The intensity variations are detected at each point on the image using a photomultiplier tube or image dissector camera and compared in phase with a reference signal from a fixed point on the image. The phase difference is measured and recorded for each spot in the image. A 360deg phase difference is equivalent to one fringe displacement observed in a conventional holographic interferogram. Thus, the resolution of the heterodyne system is limited only by the stability of the optical setup, spatial bandwidth of the imaging system, and the accuracy with which phase differences can be measured.

An alternative to true heterodyne holographic interferometry is being considered as well. Quasi-heterodyne (or phase step) holographic interferometry permits video image processing of double-exposure, dual reference beam holograms which are recorded in a manner identical to that used for true heterodyne holographic interferometry. Fringe interpolation is performed by combining three of the holographic interference images which differ only in that the fringe positions on the object are shifted by a known change in optical path length of one of the reference beams relative to the other. This technique is far faster, however, it provides a displacement resolution about one order of magnitude poorer than the true heterodyne technique.

During this program year, a third generation heterodyne system has been constructed with a demonstrated temporal capability for measuring out-of-plane displacements with a resolution of better than $1/1500$ of a fringe (Previous configurations provided resolutions to $1/900$ of a fringe or about 3 Angstroms). Pulsed heterodyne holographic interferometry of large amplitude acoustic waves propagating over an aluminum test specimen and interacting with a machined slot "defect" was successfully demonstrated. This new readout system is extremely flexible in that it incorporates two acousto-optic (Bragg) cells with electronics to permit either frequency shifting for true heterodyning or phase shifting for phase-stepped, quasi-heterodyne holographic interferometry. A manuscript is being prepared which describes the means by which phase shifting may be obtained using acousto-optic cells. The system provides for a small angular separation (0.003 degrees) between the two reconstructing beams to help ensure immunity to environmental effects and provide ease of alignment.

PAPERS SUBMITTED TO REFEREED JOURNALS
(Not Yet Published)

Wagner JW, High resolution holographic techniques for
visualization of surface acoustic waves, Submitted
for publication, Materials Evaluation.

PAPERS PUBLISHED IN REFEREED JOURNALS

Phillips LC, Kelly RG, Wagner JW, Moran PJ, An investigation of the volume change associated with discharge of lithium/iodine batteries via holographic interferometric techniques, J Electrochem Soc, 133(1) 1-5, January 1986.

Wagner JW, Sensitivity and nonlinearity of optical path difference measurements using triple-exposure heterodyne holographic interferometry, Applied Optics 25(18), 15 September 1986.

Wagner JW, Gardner DJ, Phase stable automatic gain control for heterodyne holographic interferometry, Accepted for publication, Review Sci Instr (July 1986).

BOOKS (AND SECTIONS THEREOF) SUBMITTED FOR PUBLICATION

N/A

BOOKS (AND SECTIONS THEREOF) PUBLISHED

N/A

PATENTS FILED

N/A

PATENTS GRANTED

N/A

INVITED PRESENTATIONS AT TOPICAL OR
SCIENTIFIC/TECHNICAL SOCIETY CONFERENCES

"High Speed Heterodyne Holographic Interferometry" Gordon
Research Conference on Nondestructive Evaluation,
Meriden, N.H., August 18-22, 1986.

"Examples of holographic versus state-of-the-art in the
medical device industry, in Holographic
Nondestructive Testing(NDT)"- Status and
Comparison with Conventional Methods: Critical
Review of Technology (SPIE Proceedings Vol. 604),
(Las Angeles, CA) January 1986.

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N/A

GRADUATE STUDENTS SUPPORTED UNDER
CONTRACT FOR YEAR ENDING 30 SEPTEMBER 1986

Louis C. Phillips- 5th year graduate student. Expected
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