

Holographic projection interferometer with photorefractive recording media

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ABSTRACT

Characteristics of a holographic interferometer with photorefractive media that includes a regime of real time registration of holograms are considered. The interferometer arranges an optical fiber bunch that allows one to use this scheme for delivery of optical information from hard accessible places. Distortions coming from changes of mode structure of the probe fiber bunch during hologram recording are decreased significantly owing to the features of the proposed optical setup and the method of registration.

Keywords: Holographic interferometry, holographic interferometer, fringe contrast, lightguiding bundle, photorefractive hologram registration, photothermoplastic hologram registration

INTRODUCTION

A possibility of construction of interferometer based on multimode lightguiding bundle with photorefractive or photothermoplastic registration is considered in the report. The experimental results that demonstrate a feasible solution of problems arising at the stage of forming and transference of the informative signal.

The urgency of the researches is conditioned by a need of expansion of application area for modern interferometry technique [2]. A maximal efficiency of the interferometry methods of noncontact and nondestructive control and diagnostics of joins and elements of mechanisms is achievable only by mean of fundamental aggregation of those methods with certain technical and technological processes. This requirement immediately constrain the use of holographic interferometer by mean of the principal difficulties implied by necessity of delivery of optical information from the objects placed in areas either out of direct visibility or out of possibility of placing of registering unit of the interferometer. The conceptual design of the interferometer with optical fiber bundle almost entirely overcome mentioned constraints.

In constructing an interferometer intended to acquire an information from hardly accessible places a certain scheme must be found out low-sensible to unavoidable distortions of optical field transferred through the bundle, coming up from its construction and the operating conditions. After passing through the bundle wave front of transferred beam gets a resemblance to being scattered with fine diffuser. Insignificant deformations of the bundle lead to various changes of mode field distribution within the individual fibers. This will result in new wave front configuration of the beam. In this report we consider field distortions from both fixed and disturbed bundle.

The use of photorefractive or photothermoplastic registration is very important by mean of opportunity of real-time observation of changes of the object under test.

EXPERIMENT

The scheme of our holographic interferometry setup based on the lightguiding bundle is shown in Fig.1. The similar schemes were described in [5] and [3]. However in [3] were used a monomode fiber and in [5] only the stationary bundle case was considered. The laser beam from the He-Ne laser **L** expands with the telescope **T** to homogeneously light up the object **C** (a coin). Then the glass plate **Sp₁** takes a portion of power from the beam and directs it to the mirror **M₂** turning the reference beam to the hologram. The rest of the beam gets to the mirror **M₁** turning the illuminating beam to the object **C**. Illuminated object image is projected by the objective **O₁** onto the front face of the fiber bundle **B** (bundle length ~50cm, inlet and outlet aperture ~10mm). The image of the rear face of the bundle is projected by the objective **O₂** onto the screen **Sc**. The holographic registering unit (photothermoplastic cell with poly-N-epoxypropylcarbazole dye doped film sensing element [4]) **H** is situated between the second objective **O₂** and the screen **Sc**. Beam splitter **Sp₂** at the rear face of the bundle is mated with the microscope to control optical field changes within the individual fibers when disturbing the bundle between the two exposures of the interferographic process. The named field change is illustrated in Fig.1.

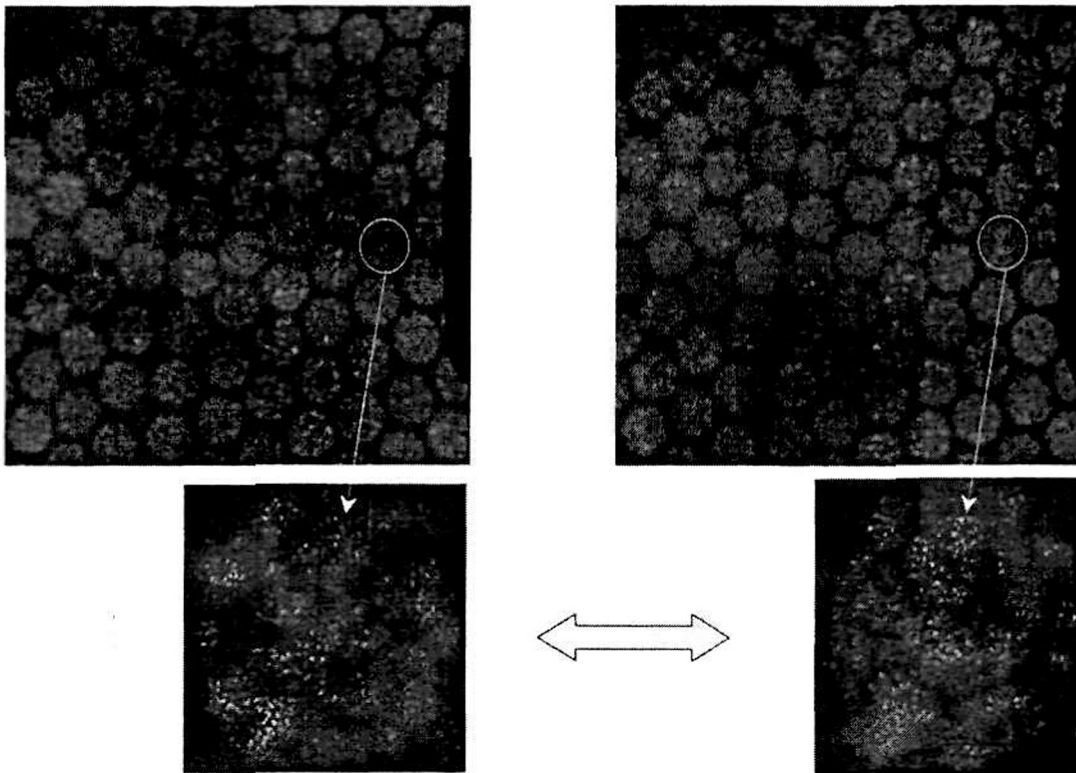


Fig.1 Optical field change within the individual fiber due to bundle disturbance

At the first stage of our work we obtain a holographic interferogram of the object without the bundle to have a reference to compare to. We take the first exposure then turn the object with a micro lead screw and then take the second exposure.

At the second stage we obtain a holographic interferogram of the object with the immovable bundle [5]. The same actions as at the first stage but with the bundle in the scheme (see Fig.2).

At last at the third stage we obtain a holographic interferogram of the object with the disturbed bundle. The disturbance (light jog) of the bundle occurs between the exposures together with the object state change.

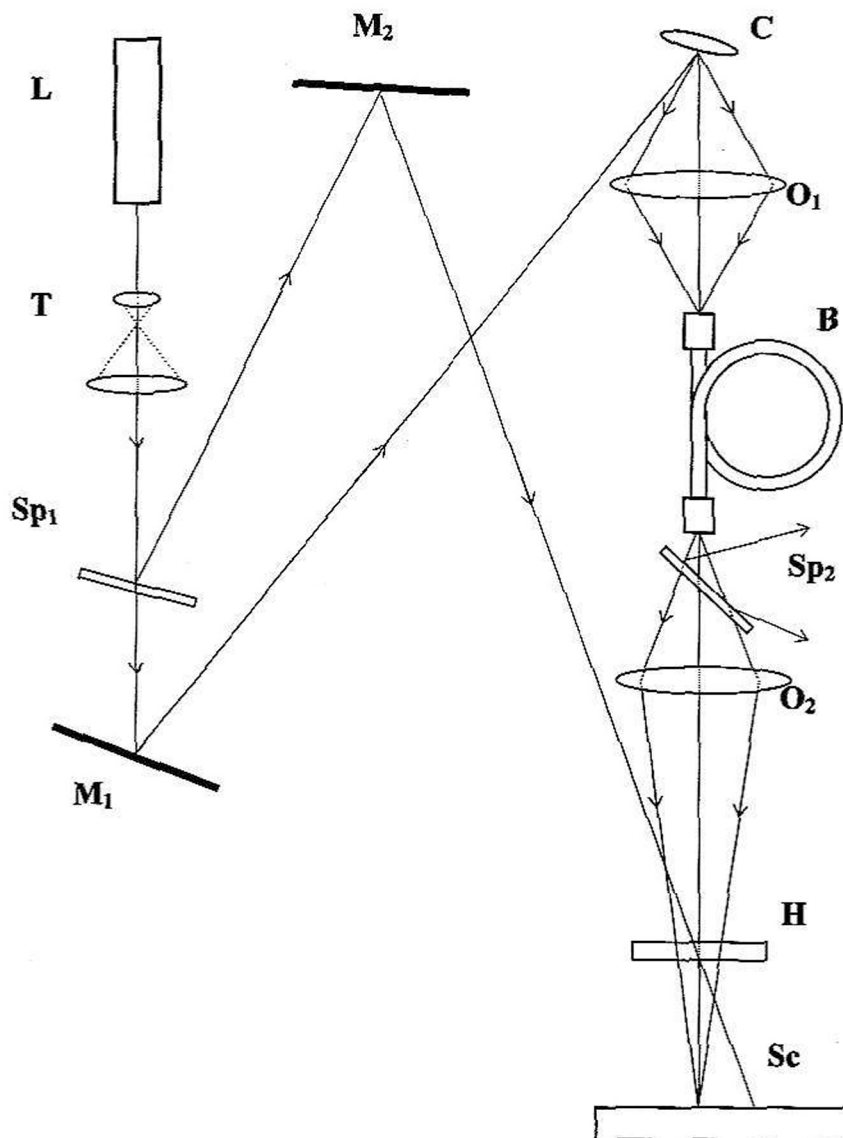


Fig.2. The setup scheme.

RESULTS AND DISCUSSION

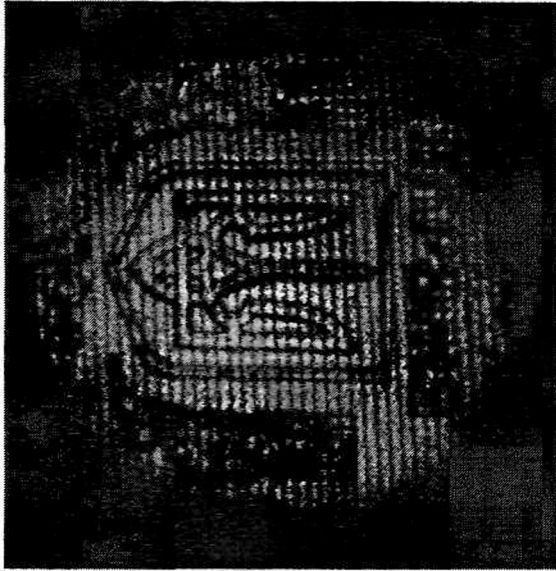
The results of the experiments on obtaining interferogram of the object are illustrated in Fig.3, Fig.4, Fig.5 and Fig.6 correspondingly without a bundle, with immovable bundle, with disturbed bundle and original image transferred through the bundle without interference (for comparison). In the a) parts of the figures the obtained interferogram images are shown. And in the b) parts the plots of normalized intensity averaged along the interference fringes (in Fig.6 averaging along the fringes of Fig.5). One can see from the figures that the fringe contrast V decreases with complication of operating conditions, but even in the last case (with disturbance) it is not zero and the interference pattern is observed.

The influence of the bundle on the process of interferogram obtaining may be considered confining to the model of the bundle as a set of point retransmitters which repeat the amplitude of the optical field in the transferred point but add some value to the phase. Added phase is different for the individual retransmitters but it is constant while the bundle is undisturbed. So the effect of the bundle appears in adding a random phase noise to the image of the object and in some way is likely to the effect of a matte glass. When obtaining an interferogram with immovable bundle the images of the object during the two exposures contain the same phase noise which is thus self-compensated at the stage of interference of reconstructed wave fronts and does not affect the interference pattern formation [5],[1].

If the bundle is unstable there is two ways for it to affect the obtaining the interferogram that depend on the operating conditions. In the first case (semi-stable) the bundle is stable during both exposures but it is unstable between the exposures (heating, cooling, longtime deformations). In the other case (unstable) it is unstable even during exposures (vibration, shaking).

In semi-stable process the effect of the bundle appears in that the interference pattern function contains a term of type of $\cos(\Phi + \varphi_2 - \varphi_1)$, where Φ is the phase function describing the object state change, φ_1 and φ_2 are the functions of phase noise at the first and the second exposures correspondingly. As we see more than one interference fringe the amplitude of Φ function is 2π . So it is obvious that while the amplitude of $\varphi_2 - \varphi_1$ function is less than 2π the bundle instability leads only to fringe contrast decreasing but not to disappearing of fringes.

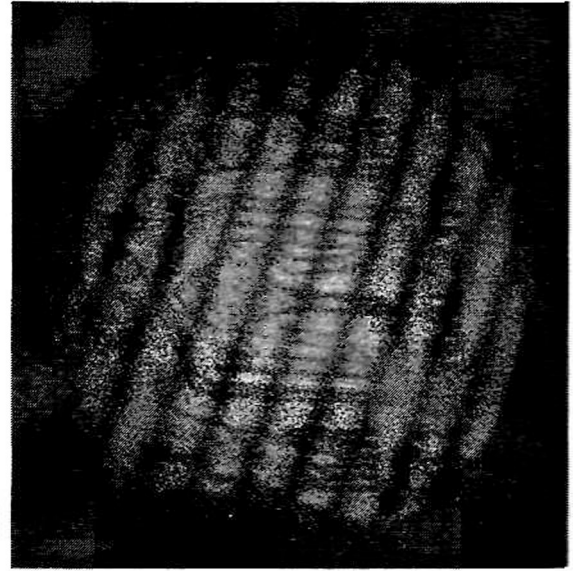
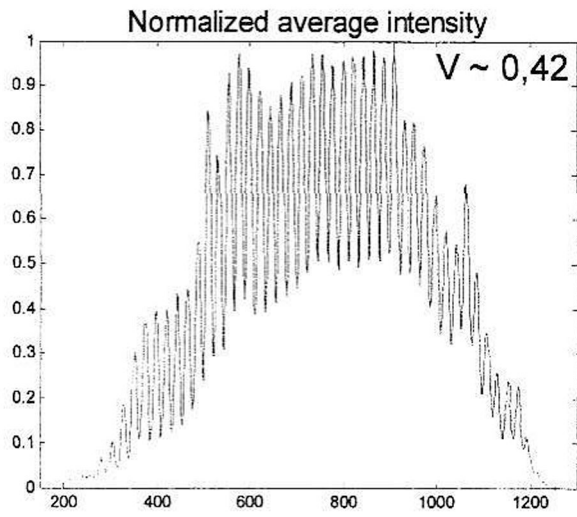
In unstable process in addition to factor mentioned above one more factor comes to play. If the bundle is changing during the exposition the interference pattern on the hologram is being unstable. That results in decrease of diffraction efficiency of the hologram from this exposure. So either the hologram might not be recorded at all or the two reconstructed images might be of different intensities that yet decrease fringe contrast.



a)

Fig.3.
No bundle

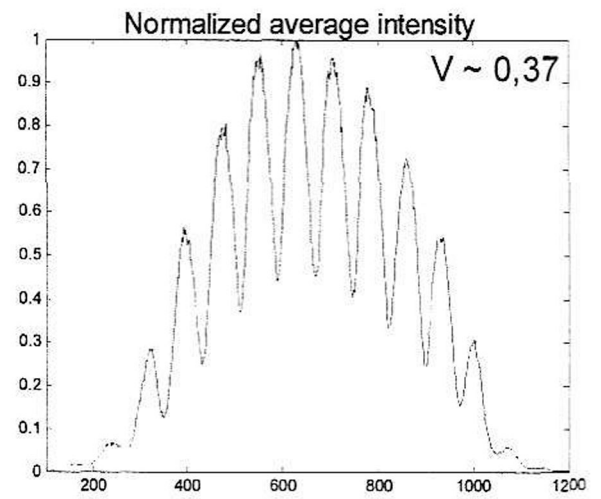
b)



a)

Fig.4.
No disturbance

b)

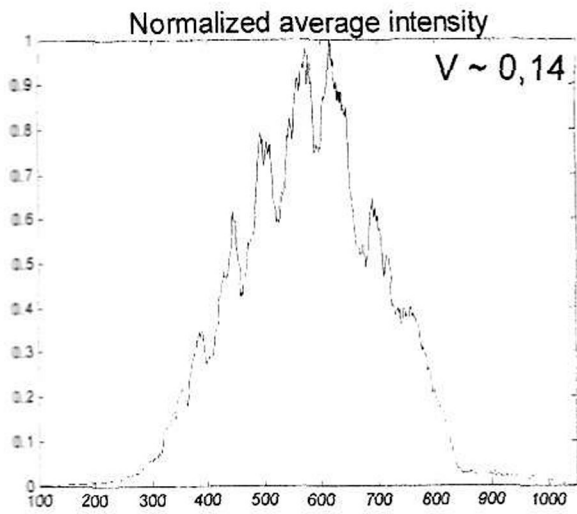




a)

Fig.5.
With disturbance

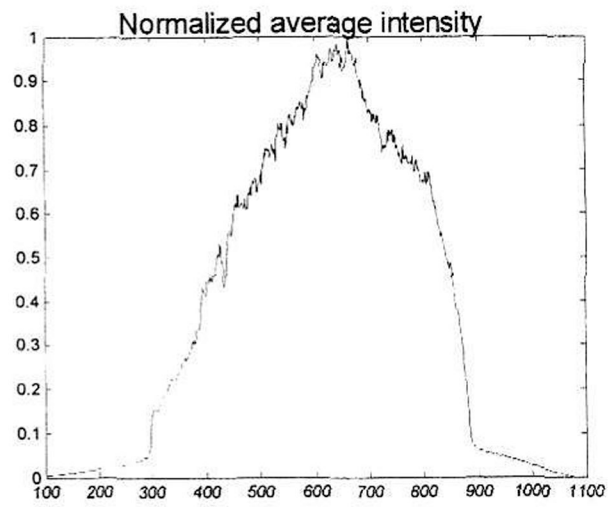
b)



a)

Fig.6.
Original image

b)



CONCLUSION

In this work we succeeded in obtaining a holographic interferogram under the condition of use of unstable lightguiding bundle. Initially we assumed the process to be semi-stable. However we can not exclude the bundle to be unstable during the second exposure because of possible residual vibrations after the disturbance. Nevertheless we obtained the interferogram with non-zero fringe contrast. This means the opportunity of practical appliance of methods of holographic interferometry for non-contact and nondestructive control in hardly accessible places under non-stationary within some ranges operating conditions. The ways to reduce the sensitivity of the process to instability might be found in involving impulse holography and shortening the time interval between the exposures or, if it is not appropriate, in use of bundle of higher quality. If under all expected disturbances the amplitudes of the functions φ_i don't exceed some value φ_{\max} then the amplitude of the function $\varphi_2 - \varphi_1$ doesn't exceed $2\varphi_{\max}$. As soon as $\varphi_{\max} < \pi$ we always can obtain an interferogram with non-zero fringe contrast in semi-stable process. We proceeds with the researches on finding other physical methods of reducing the sensitivity of the process to non-stationary operating conditions.

REFERENCES

1. Kogelnik H., Pennington K.S. "Holographic imaging through inhomogeneous medium.", Journ. Opt. Soc. Amer., 58, 273, 1968
2. Charles M Vest. "Holographic interferometry.", Moscow, "Mir", 1982
3. Gilbert J.A., Dudderar T.D., Schultz M.E., Boehnlein A.J. "The monomode fiber—a new tool for holographic interferometry", Experimental Mechanics, 23(6), 190, 1983.
4. Kuvshinskij N.G., Davidenko N.A., Komko V.M. "Physics of amorphous molecular semiconductors" Kyev, "Lybid", 1994
5. Zolochevkaja O.V., Gnatovskij K.A. "A holographic interferometer on the basis of multimode lightguiding bundles" proceedings SPIE vol. 2648, 694-697, 1995