VOL. 9, NO. 2 MAY 1998

SPIE's International Technical Group Newsletter

Holography

HOLOGRAPHYONLINE

info-holo@spie.org

Here's an easy way to reach your colleagues around the world—instantly. SPIE's **Holography Listserv** is an automated e-mail server that connects you to a network of engineers, scientists, vendors, entrepreneurs, and service providers.

SPIE's Holography Listserv has its roots in the well-established and active Holography Technical Group, and is yet another way to use SPIE's technical resources.

To join the Holography Listserv, send an e-mail message to `info-holo-request@spie.org` with the words `subscribe info-holo` in the message body.

For detailed instructions, as well as information about other online SPIE services, such as Abstracts Online, Employment Services, and Technical Programs Online, send a message to `info-spie-request@spie.org` with the word `help` in the message body.

SPIE The International Society for Optical Engineering

Holography

This newsletter is published semi-annually by SPIE—The International Society for Optical Engineering for its International Technical Group on Holography.

Technical Group Chair	Michael Klug	*Managing Editor*	Linda DeLano
Technical Editor	Sunny Bains	*Advertising Sales*	Roy Overstreet

Articles in this newsletter do not necessarily constitute endorsement or the opinions of the editors or SPIE. Advertising and copy are subject to acceptance by the editors.

SPIE is an international technical society dedicated to advancing engineering, scientific, and commercial applications of optical, photonic, imaging, electronic, and optoelectronic technologies. Its members are engineers, scientists, and users interested in the development and reduction to practice of these technologies. SPIE provides the means for communicating new developments and applications information to the engineering, scientific, and user communities through its publications, symposia, education programs, and online electronic information services.

SPIE—The International Society for Optical Engineering, P.O. Box 10, Bellingham, WA 98227-0010 USA. Phone: (1) 360/676-3290. Fax: (1) 360/647-1445.

European Office: Contact SPIE International Headquarters.

In Japan: c/o O.T.O. Research Corp., Takeuchi Bldg. 1-34-12 Takatanobaba, Shinjuku-ku, Tokyo 160, Japan. Phone: (81 3) 3208-7821. Fax: (81 3) 3200-2889. E-mail: otoresco@gol.com

In Russia/FSU: 12, Mokhovaja str., 121019, Moscow, Russia. Phone/Fax: (095) 202-1079. E-mail: edmund@spierus.msk.su.

Want it published? Submit work, information, or announcements for publication in future issues of this newsletter to Sunny Bains at sunny@spie.org or at the address above. Full submissions guidelines are available at http://www.sunnybains.com/newslet.html. All materials are subject to approval and may be edited. Please include the name and e-mail address of someone who can answer technical questions. Calendar listings should be sent at least eight months prior to the event.

Characterization of bleached holograms

Optimization of the processing of bleached silver halide holograms is not an easy task because the processing consists of two consecutive steps, the developing and the bleaching. Since both processes are nonlinear, it is difficult to determine the influence of the processing on the quality of the hologram quantitatively.

As for amplitude holograms, in early holography the density/exposure or amplitude transmittance/exposure functions were used for the evaluation of the imaging properties of nonlinearly recorded holograms. Some authors derived other characteristics from the above functions. Pennington and Harper[1] proposed the use of optical density difference against average optical density function to characterize the recording of silver halide absorption holograms. Lin[2] introduced the use of the square root of the diffraction efficiency against bias exposure and fringe visibility curves (Lin-curves) of plane wave holograms.

To characterize bleached holograms, Lin-curves were usually used, or the diffraction efficiency was related to the average optical density before bleaching. Van Renesse and Bouts[3] related the square root of the diffraction efficiency of the phase grating to the effective electrical polarizability of the silver salt molecules. Ward and L. Solymar[4] used the refractive index modulation versus optical density modulation characteristics. However, the direct measurement of the refractive index modulation across the hologram by interference microscopy can be applied only for gratings of relatively low spatial frequency.

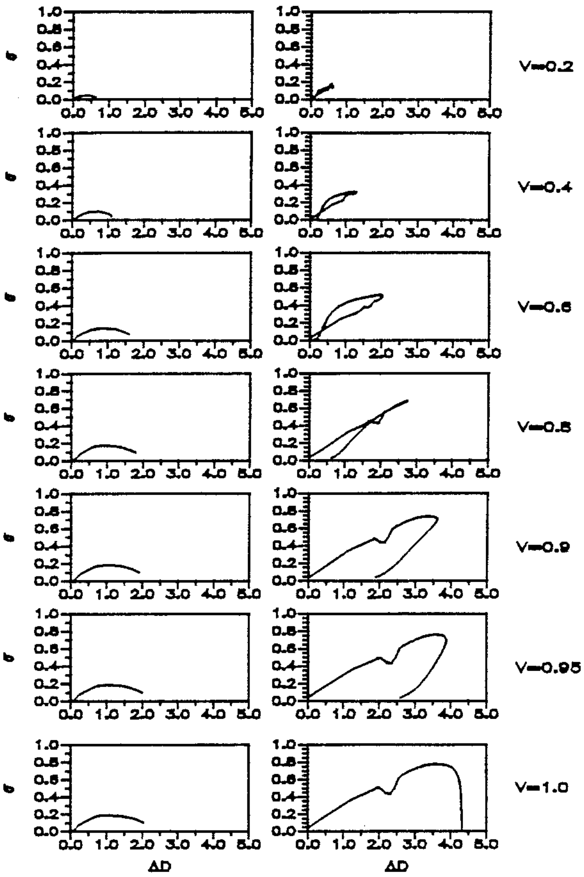

Figure 1. Square root of the diffraction efficiency of absorption (left column of graphs) and phase (right column) holograms as a function of the amplitude of the modulation of the optical density created at the development step. Fringe visibility is indicated right of each row.

We characterized the processing of bleached silver halide holograms in another way. The square root of the diffraction efficiency (σ) of the bleached hologram was directly related to the amplitude of the optical density modulation obtained at the development step.

Agfa 8E75HD was chosen as recording material, AAC as developer and R9 as (solvent-type) bleach. Pairs of plane wave holograms at $\lambda = 632.8$ nm with an interbeam angle of 45°, at seven values of fringe visibility, namely at $V = 0.2$, 0.4, 0.6, 0.8, 0.9, 0.95 and 1.0 were recorded. Twelve hologram pairs at exposures ranging from 10 μJ/cm^2 to 1.6 mJ/cm^2 were recorded at each visibility. One element of each pair of holograms was developed with AAC developer and fixed with non-hardening Kodak F24 fixer. The other element of the hologram pair was also developed using AAC, and was bleached in an R9 solvent bleach without a fixation step.

After all the holograms were processed, the optical density of the absorption holograms and diffraction efficiency of the phase holograms were measured.

The amplitude of the density modulation (ΔD) as a function of the bias exposure (E_0) at each fringe visibility (V) was calculated via fitting an analytical function to the measured density vs. exposure data and substituting the minimum and maximum exposures. The Lin-curves of the final phase hologram were obtained directly from the diffraction efficiency measurement and were fitted by an analytical function[5]. Then the desired $\sigma(\Delta D)$ characteristics were derived from the $\Delta D(E_0, V)$ curves and the Lin-curves ($\sigma(E_0, V)$).

The square root of the diffraction efficiency, as a function of the amplitude of the density modulation for both absorption and phase holograms, is shown in Figure 1. The curves for the case of absorption holograms were calculated using previous results.[6] The characteristics of the amplitude holograms can be seen on the left and those of the corresponding phase holograms (recorded under identical conditions) on the right. Fringe visibility on recording is indicated on the extreme right of each row. The difference in their $\sigma(\Delta D)$ characteristics is striking. Since absorption holograms[6] were exposed only up to 50 μJ/cm^2, ΔD is monotonically increasing up to about 2.1, and there is no turning point in the graph. The $\sigma(\Delta D)$ characteristics of the phase holograms are completely different. There is a turning point in them, except of that at $V = 1.0$. The turning points are around the maxima of the $\sigma(E_0, V)$ function (not shown here). These curves at each visibility follow a more or less straight line with a quasi-uniform slope (ranging from 0.25 to 0.3) almost up to the turning point. The second part of the graphs (after the turning point) is not straight. The figure suggests that the falling part of $\sigma(\Delta D)$ nearly retraces the rising part close to $V = 0.8$, so this characteristic is quasi-linear over the whole exposure range. The dip in the graphs of the phase holograms discernible from $V = 0.8$ onwards corresponds to a bias exposure $E_0 = 70$ μJ/cm^2, that is about the inflexion point of the density vs. bias exposure curves.

It is felt that these characteristics may help in the optimization of the processing of beached holograms. Various combinations of developers (cathecol and pyrogallol) and bleaches (R9, R10 and EDTA) have recently been compared, and experiments with other silver halide materials are also planned.

I. Bányász, I. Pascual, A. Beléndez and **A. Fimia**

Contact:
I. Bányász
Dpto. Interuniversitario de Optica Universidad de Alicante
Apdo. 99, E-03080 Alicante, Spain
Phone: +34 65 90 35 09 or
+34 65 90 37 91
Fax: +34 65 90 37 91
E-mail: istvan@aclis.labopti.ua.es

(continued on p. 11)

Meeting Calendar

1998

ODS—Optical Data Storage Topical Meeting 1998

10-13 May

Aspen, CO USA

Tutorials and tabletop exhibit. Sponsored by SPIE/IEEE-LEOS/OSA. Contact Optical Society of America at 2010 Massachusetts Ave., NW, Washington, DC 20036.
Phone: 202/223-8130. Fax: 202/223-1096.
Web: http://www.osa.org

Optical Data Storage Topical Meeting

10-13 May

Aspen, CO USA

SPIE to publish proceedings. Contact: Lorenda Wieder or Suzanne Gerhart, OSA, 2010 Massachusetts Ave. NW, Washington, DC 20036-1023. Phone: (1) 202/223-8130.
Fax: (1) 202/416-6100. E-mail: lwieder@osa.org or sgerha@osa.org

16th International Conference on Coherent and Nonlinear Optics (ICONO '98)

29 June-3 July

Moscow, Russia

SPIE is a cosponsor. Contact: Prof. Nikolai Koroteev, Faculty of Physics and International Laser Ctr., M.V. Lomonosov Moscow State Univ., Moscow 119899, Russia. Phone: 795/939-1225 or 939-3093. Fax: 795/939-3113. E-mail: icono98@comsim1.ilc.msu.su Web: www.ilc.msu.su/icono/icono.html.

Photonics Taiwan

Asia Pacific Symposium on Optoelectronics

9-11 July

Taipei International Convention Center
Taipei, Taiwan China

Cosponsored by SPIE Taiwan Chapter, PIDA-Photonics Industry Development Association, National Science Council.

International Symposium on Optical Science, Engineering, and Instrumentation

SPIE's 1998 Annual Meeting

19-24 July

San Diego, CA USA

Technical Exhibit
SPIE Short Courses and Education Program.

IS&T's NIP14

14th International Conference on Digital Printing Technologies

18-23 October

Westin Harbour Castle
Toronto, Ontario, Canada

Contact IS&T, 7003 Kilworth Lane, Springfield, VA 22151. Phone: 703/642-9090. Fax: 703/642-9094. E-mail: info@imaging.org
Web: www.imaging.org.

Photonics East®

1-6 November

Hynes Convention Center
Boston, MA USA

Technical Exhibit
SPIE Short Courses and Education Program

IS&T/SID's 6th Color Imaging Conferece

17-20 November

The SunBurst Hotel
Scottsdale, AZ USA

Contact IS&T. Phone: (1) 703/642-9090. Fax: (1) 703/642-9094. E-mail: info@imaging. org
Web: www.imaging.org.
SPIE Short Courses.

1999

Photonics West®

23-29 January

San Jose Convention Center
San Jose, CA USA
Including international symposia on

- **LASE '99—High-Power Lasers and Applications**
- **OPTOELECTRONICS '99—Integrated Devices and Applications**
- **BiOS '99—International Biomedical Optics Symposium**
- **SPIE/IS&T's EI '99—Electronic Imaging: Science and Technology**

Technical Exhibit 26-28 January
Education Program and Short Courses
For more information, contact SPIE or e-mail pw99@spie.org.

Abstract Due Date: 29 June 1998!

For information on SPIE meetings contact:
SPIE, P.O. Box 10
Bellingham, WA 98227-0010 USA
Phone (1) 360/676-3290 • Fax (1) 360/647-1445
E-mail spie@spie.org
WWW http://www.spie.org/

Characterization of bleached holograms

(continued from p. 4)

References

1. K. S. Pennington and J. S. Harper, *Techniques for producing low-noise, improved efficiency holograms*, **Appl. Opt. 9**, pp. 1643-50, 1970.
2. L. H. Lin, *Method for characterizing hologram-recording materials*, **J. Opt. Soc. Am. 61**, pp. 203-208, 1971.
3. R. L. van Renesse and F. A. J. Bouts, *Efficiency of bleaching agents for holography*, **Optik 38**, pp. 156-68, 1973.
4. A. A. Ward and L. Solymar, *Diffraction efficiency limitations of holograms recorded in silver-halide emulsions*, **Appl. Opt. 28**, pp. 1850-55, 1989.
5. I. Bányász, A. Beléndez, I. Pascual and A. Fimia, *Method for the characterization of hologram processing*, **J. Modern Optics**, in press.
6. I. Bányász, A. Fimia, A. Beléndez, L. Carretero, *Nonlinear recording of amplitude holograms in Agfa 8E75HD: comparison of two developers*, **Opt. Comm 111**, pp. 225-232, 1994.

Enlarging holograms under white light

(continued from p. 7)

persion of light it will be necessary to obtain an significant increase on the number of lines/mm with which the screens are made in order to allow a larger audience. To bring color images to the public, it will also be necessary to find a new process to obtain bright diffraction at one third of the visible spectrum bandwidth.

J. J. Lunazzi
Physics Institute
Campinas State University
C.P.6165
Campinas-SP- Brazil 13083-100
E-mail: lunazzi@digicron.com
URL: www.digicron.com/lunazzi

References

1. E. N. Leith et al., *Holographic cinematography*, **Appl. Opt. 11** (9), pp. 2016-2023, 1972.
2. V. G. Komar, O. B. Serov, *Works on the holographic cinematography in the USSR*, **Proc. SPIE 1183**, pp. 170-182, 1989.
3. J. J. Lunazzi, *Holophotography, a complete stereo technique*, Proc. IS&T Annual Meeting, p.50, 1989.
4. J. J. Lunazzi, *A new proposal for holography in white light*, Proc. Holography '89 (Varna, Bulgaria), p.8, 1989.
5. J. J. Lunazzi and P. M. Boone, *One step technique for enlarging straddling holographic images by white-light projection onto a diffractive screen*, **Opt. Lett. 19** (22), pp.1897-1899, 1994.
6. J. J. Lunazzi, *New possibilities in the utilization of holographic screens*, **Proc. SPIE 1667**, pp. 289-293, 1992.
7. J. J. Lunazzi et al., *Enlarging holograms under white light: 35mm format*, Proc. VI Symp. on Laser and Applications of the São Paulo State (São Carlos-SP - Brazil), p.244, 1994.
8. J. J. Lunazzi, *Enlarging Holograms Under White Light*, **Proc. SPIE 2778**, pp. 469-470, 1996.