

Practical Holography, 3rd Edition, Graham Saxby, IOP, 482 pages, ISBN 0-7503-0912-1



About the author

Michael was born on an insignificant little blue-green planet orbiting an unregarded yellow sun out in the unfashionable backwaters of the western spiral arm of the galaxy and is a computer programmer currently working in the games industry. He has been interested in holography and has been making holograms since 1984, with a few long breaks for Real Life. He hopes to soon take over the world by combining his experience in 3D graphics with holography.

Introduction

The release of Graham Saxby's third edition of Practical Holography shows how well the author understands what people need from a complete book on holography. He takes the reader through what a hologram is, the history of holography, what sort of light sources can be used to make a hologram, what kinds have been made to date and so on through to making and displaying your own images.

The book is written in a clear and concise manner and is augmented by additional tips, definitions, and observations in the margins as well as extensive source references at the end of each chapter.

If you're new to the field or hobby of holography you should make this one of the first books you buy. Even if you're an old hand this book will probably show you a few new tricks.

Overview of the book

The first four chapters (What is a hologram, How holography began, Light sources for holography, The basic types of hologram) should be read through by anyone starting out in holography. You don't necessarily need to understand everything in those chapters right off, but by reading those basics you'll be better prepared to digest the rest of the book.

The first chapter explains what a hologram is, interference, diffraction, amplitude and phase gratings in a way that most interested readers will have no trouble understanding.

The book continues through the history of holography, the light sources used to make holograms, the basic types of holograms and describes the materials and processing used in making holograms.

It's in chapter six that Saxby begins explaining how the reader can make their first single-beam hologram using a gas or diode laser. This chapter

has complete details on all the equipment needed, how to set it up, shoot it, process the exposed film and view your finished hologram. If you are unfortunate enough to end up with a dim or non-existent image (which is likely to happen the first time) the author takes you through the steps needed to find out what happened and how to fix the problem.

Chapter seven then takes the reader through more advanced single-beam configurations and introduces a few new tools and methods such as using a spatial filter, index matching film and multi-exposure techniques.

The rest of the book shows a similar progression, taking the reader through more complicated steps such as making transfer holograms, building a holography lab, creating master and copy holograms, homemade optical elements and so on.

For those with a mathematical bent, the first three appendices contain information you'll want to read and digest after going through the first few chapters of the book. These appendices are clearly written and approachable even to those who aren't particularly adept at mathematics. Saxby also includes an appendix with worksheets for computing the geometries needed for several forms of multicolor holograms.

If you've been around the block a time or two (or at least ridden with someone else) you might think that this book would offer little new material. In fact, there is plenty of material for the more experienced holographer. The material ranges from information on fiber optics use, color holography, edge lit holograms and beyond. See the included table of contents from chapter 16 on.

Differences between this and the previous edition

Extensive side notes have been added which expand on and clarify the information given in the main text. These comments could have been left out and the book would not have suffered but by adding them the author gives information that enriches the main text.

The chapter on light sources used for holography has been expanded to include information on diode lasers as well as new information on DPSS (diode-pumped solid-state) and white light laser sources.

The pages devoted to copying holograms have been greatly expanded from one chapter with six pages to two chapters of nearly thirty pages. These cover several techniques for copying both transmission and reflection holograms and close by covering the relatively new technique of edge lighting holograms.

Natural color holography now has a full chapter devoted to it which starts by covering how we perceive color as well as details on how the eye responds to light of differing wavelengths. Details are then given on how individual primary colors are commonly combined to form colors that you

won't find in the natural spectrum. From there the author describes how lasers of differing color may be combined on the table to create a simulated full-color image. While this chapter won't give you all the details you need for natural color holography it will get you started and there are several references at the end of the chapter that can carry you further.

A chapter has been added covering non-silver processes for making holograms and even includes limited information on coating your own glass plates. This chapter starts out by mentioning the high sensitivity of silver-halide emulsions and discussing the major reasons for its use. Saxby moves on to the details of dichromated gelatin (DCG) use and outlines methods for mixing DCG, coating glass plates, exposure and processing. If you're interested in extremely bright holograms, this section will definitely whet your appetite for rolling your own plates. From there he moves on to brief discussions of SHSG, photopolymers, photothermoplastics and other processes. He doesn't go into the same detail in the later sections as he does for DCG but there are plenty of references at the end of the chapter.

Holographic stereograms now have an entire chapter devoted to them. This chapter includes instructions for making several different kinds of stereogram and details for creating good source material, usually photographs. The author even outlines some methods for computer control of a simple holoprinter as well as color control to obtain achromatic and full-color transfers.

A new chapter on the use of holography in biology and medicine includes information on hologram use for dental training, ophthalmology and stereogram use with PET and CAT scan data.

The appendix on processing formulas has been updated and expanded and now includes instruction on creating your own emulsion.

So, the book is perfect is it?

While there are a few typographical errors that the publisher is working to correct in future printings, there really isn't much that I could find fault with. A few relatively minor complaints are detailed below.

Interferometer testing isn't introduced until chapter 11 but making your first hologram begins in chapter 6. The reasoning behind this is likely twofold.

1. All the table setups prior to chapter 11 involve using a single beam for the reference and object light and there are less stringent stability requirements for single-beam setups.
2. Setting up an interferometer requires two mirrors, one beam splitter and one lens as well as mounts for all of those elements and Saxby makes an effort to minimize the equipment needed to get going.

Forcing the reader to buy additional optics needed only for the interferometer could be seen as an impediment to bringing people into the field. My only complaint with that reasoning (if that really is what determined where table testing was placed in the book) is that knowing your environment can be critical in understanding your failures when starting out in holography. You will have a few failures in the beginning, especially if you're not working in a dedicated laser lab. While single-beam setups are less sensitive to vibration problems, they aren't immune and testing your area with an interferometer can give you invaluable information about what limitations you start out with.

Not all film listed is still available (Kodak no longer makes plates) or available to the general public (most photopolymer material). This is not surprising as this is an area of the field that is in constant change. New materials are appearing as old materials are being refined or disappear completely. You'd be better served by doing an Internet search or checking in the Holography Forum (www.holographyforum.org) for the current state of the art.

My soft cover copy is only three months old and is already coming apart at the binding. This may be a problem with that particular run.

All three editions of Practical Holography have included a hologram of some kind. The first edition actually included two, an embossed hologram on the cover and a silver-halide hologram on the first page. Unfortunately the second and third editions have only included embossed holograms on the cover and while I'm sure that type was selected for the relatively low production cost, they are not the best examples of the art. The depth of field available with embossed holograms is severely limited and while they are visible in almost any light, embossed holograms lack the impressive sense of 3D available from simple reflection holograms on silver-halide or photopolymer.

Summary

I have no trouble at all in recommending the third edition of Practical Holography to everyone interested in holography. There's something for every holographer in this book.

Table of contents

Foreword to first edition	xv
Preface to third edition	xvii
Preface to second edition	xviii
From the preface to first edition	xx

PART 1: PRINCIPLES OF HOLOGRAPHY	1
Chapter 1: What is a hologram?	3
Stereoscopy	3
Defining the problem	6
The problem solved	7
Interference	8
An experiment with interference fringes	8
Diffraction	11
Amplitude and phase gratings	13
Chapter 2: How holography began	16
References	22
Chapter 3: Light sources for holography	24
Light as an electromagnetic phenomenon	24
Propagation of electromagnetic waves	24
Oscillators	26
Properties of light beams	27
Atoms and energy	28
Stimulated emission	29
The three-level solid-state laser	30
Q-switching	33
Four-level gas lasers	34
Mirrors and windows in CW lasers	35
Ion lasers	37
Tunable lasers	39
Semiconductor (diode) lasers	40
Diode-pumped solid-state (DPSS) lasers	41
Pseudowhite lasers	42
Warning notices	43
Avoiding accidents	43
Protective eyewear	44
Pulse laser	44
The laser itself	44
Further reading	45
Chapter 4: The basic types of hologram	46
Laser transmission holograms	46
Replaying the image	46
The real image	47
Reflection holograms	48
Phase holograms	50
Image-plane holograms	51
White-light transmission holograms	52
Other types of hologram	55

Color holography	56
Embossed holograms	56
Chapter 5: Materials, exposure and processing	57
The silver halide process	57
Technical requirements for holographic materials	59
Constituents of a developer	59
Bleaches	63
Other processes	65
PART 2: PRACTICAL DISPLAY HOLOGRAPHY	67
Chapter 6: Making your first hologram	69
Basic requirements	69
The laser	71
A beam expander	72
Support for the laser	73
Support for the plate	74
Setting up for the exposure	75
Setup with a small diode laser	76
An alternative setup for a larger laser	76
Processing solutions	77
Exposing	77
Processing	77
Viewing the image	78
A one-step real image	79
Displaying your hologram	79
What went wrong?	80
Suppliers of holographic materials	81
Further reading	81
Chapter 7: Single-beam techniques 1	83
Single-beam holograms of unstable subject matter	83
Building a single-beam frame	87
A rear-surface mirror system without double reflections	89
The laser	89
Triangular benches	91
Spatial filtering	92
Setting up with a spatial filter	94
Making an electrically operated shutter	95
Safelights	96
Index-matching fluid	97
Exposing and processing	99
Getting the exposure right	100
Multi-exposure techniques	100

Chapter 8: Single-beam techniques 2	103
The transfer principle	103
Making a reflection master hologram	103
Transmission transfer holograms	105
360° holograms	106
Further applications of single-beam holograms	114
Mounting and finishing holograms	114
Troubleshooting	115
Chapter 9: Bypass holograms	120
Transmission master holograms	121
Reflection master holograms	123
Reflection transfer holograms	124
Full-aperture transmission transfer holograms	124
Rainbow holograms	125
Reflection holograms from transmission masters	125
Transflection holograms	126
Other configurations	127
References	127
Chapter 10: Building a holographic laboratory	128
Laboratory space	128
The optical table	129
Building a sand table	129
Supporting the optical components	132
Building a concrete table	133
Metal tables	134
Table supports	135
Bases for optical components	136
Excluding drafts	137
Mounting the laser	138
A gantry for overhead equipment	139
Cantilevers	140
Draft excluder	142
Processing area	142
Storeroom	143
Display area	143
References	143
Chapter 11: Master holograms on a table	144
Beamsplitters	144
Other types of beamsplitter	145
Illuminating the subject	146
Collimating mountings	150
Plate holder	151

Collimating mirror	r152
How stable is your table	153
Basic configuration for transmission master holograms	156
What went wrong?	160
Backlighting and background illumination	161
Silhouettes and black holes	161
Supine subjects	162
Frontal illumination	163
Multiple-exposure techniques	163
Masters for rainbow holograms	165
Reflection master holograms	165
Working with plates	166
Cutting glass	167
Processing plates	168
Optical fiber systems for holography	168
Multimode fibers	168
Single-mode fibers	169
Launching the beam	169
Making holograms with fiber optics	170
Connecting fiber ends	171
Further reading	172
Chapter 12: Transfer reflection holograms	173
Parallax in transfer holograms	174
Reflection transfer holograms from transmission masters	176
How to deal with weak master images	178
Side and underneath beam master transfers	178
The role of the Bragg condition	181
Two-channel transfer holograms	182
Holograms of stereoscopic pairs of photographs	183
Multi-channel images	184
Converging reference beams	185
Pellicular collimating mirrors	187
Copying holograms	188
Copies by scanning	189
What went wrong?	191
Chapter 13: Transfer transmission holograms	192
Full-aperture transfer holograms	192
Rainbow holograms	193
Geometry of a rainbow hologram	194
Slit width	196
A one-dimensional beam expander	197
A convergent reference beam	198
Multi-channel rainbow holograms	199

What went wrong?	200
Edge-lit holograms	201
Chapter 14: Holograms including focusing optics	205
Demagnifying and magnifying	205
Image enlargement and reduction	207
Focused-image holograms	210
Focused-image reflection holograms	212
One-step rainbow holograms	213
Synthetic-slit holograms	217
Fourier-transform holograms	218
References	223
Chapter 15: Homemade optical elements	224
Liquid-filled lenses	224
One-dimensional collimators	224
What to do in case of leaks	227
Other sizes and focal lengths	227
Calculations for designing a liquid-filled lens	227
Two-dimensional collimating lenses	229
Measurements for a collimating lens	230
Focusing lenses	231
Holographic optical elements (HOES)	232
Calculation of focal length	233
Holographic diffraction gratings	234
Holographic lenses	235
Making holographic mirrors and beamsplitters	236
Holographic collimating mirrors	237
Aberrations of HOEs	238
Multi-beam HOEs	239
A more uniform laser beam	240
References	240
Chapter 16: Portraiture and pulse laser holography	241
Construction of a ruby laser	242
Safety considerations	242
Maintenance of pulse lasers	243
Other types of pulse laser	243
Setting up a pulse laser studio	243
Special problems with holographic portraiture	245
Lighting for portraiture	245
Exposure	248
Processing	248
Other subject matter	248
Double and multiple pulses	249
References	240

Chapter 17: Holography in natural colors	251
The eye and color perception	252
The CIE chromaticity diagram	254
Color transmission holograms	256
Denisyuk holograms in color	257
Transfer holograms in color	258
Portraiture in color	258
The problem of color accuracy	258
The future of color holography	259
References	259
Chapter 18: Achromatic and pseudocolor holograms	260
Achromatic white-light transmission holograms	260
Dispersion compensation	261
The achromatic angle for transmission masters	262
Achromatic reflection holograms	264
Pseudocolor holograms	266
Pseudocolor single-beam reflection holograms	266
Pseudocolor transfer reflection holograms	268
Accurate color registration by geometry	269
How to obtain precise registration	270
Pseudocolor white-light transmission holograms	271
Obtaining better registration	273
One-step pseudocolor WLT holograms	275
References	277
Chapter 19: Holographic stereograms	279
The multiplexing principle	279
Making a multiplexed hologram	280
Cylindrical stereograms	282
Making a Cross hologram	284
Flat image-plane stereograms	285
The scope of modern stereographic imagery	286
Geometrier for photographic originations	286
Perspective and distortion	287
Wide-angle distortion	289
Alignment and spacing of the photographs	290
Long base stereograms	291
Registration	291
Computer control of imagery	292
Basic considerations for a stereographic holoprinter	292
Exposing	295
Stereogram masters from photographic prints	296
Preventing dropouts	297
Computer image processing	298

Achromatic and color stereograms	300
Transferring achromatic stereograms	301
Full-color stereograms	303
Full-color WLT transfer stereograms	304
Full-color reflection transfer stereograms	305
Color balance	307
Color accuracy: WLT or reflection?	307
Calculating distances	308
Stereograms with full parallax	308
Perspective correction by pre-distortion	309
Conical stereograms	311
Volume multiplexed holograms	312
References	314
Chapter 20: Non-silver processes for holography	316
Dichromated gelatin (DCG)	317
Rendering DCG sensitive to red light	319
Coating plates	319
Exposing	320
Processing	321
Sealing the hologram	321
Color control	322
Silver halide sensitized gelatin (SHSG)	322
Photopolymers	322
Photothermoplastics	323
Photoresists	324
Photochromic materials	324
Bacteriorhodopsin	325
Photorefractive crystals	325
References	326
Chapter 21: Embossed holograms	328
The initial artwork	328
Holographic recording	329
Making the photoresist master	329
Depositing the conductive layer	330
The first-generation master	331
Electroforming of final shims	331
The embossing process	332
Further reading	333
References	333
Chapter 22: Display techniques	334
Basic types of hologram and their display	335
Displaying holograms at home	336

Window displays	339
Displays to accompany lectures and presentations	339
Submitting holograms for exhibitions	340
Packing a hologram for forwarding to an exhibition	340
Organizing an exhibition of holograms	341
Lighting arrangements	341
Light sources	341
Installing the exhibits	342
Floor plan	342
Relevant information	343
Environment	344
Photographing holograms	344
Equipment	345
Reflection holograms	346
Transmission holograms	349
Viewpoint and parallax	350
Unusual holograms	351
Photographing holograms at exhibitions	351
Using flash	351
Presenting slides of holograms	352
Copyright	352
References	352
PART 3: APPLIED HOLOGRAPHY	353
Chapter 23: Holography and measurement	355
Direct measurements using holography	355
The principle of holographic interferometry	356
Real-time interferometry	356
Double-exposure interferometry	357
Time-average interferometry	359
Strobed interferometry	360
Visualization of fluid flows	360
Doubled illuminating beams	362
A camera for holographic interferometry	362
Sandwich holography	363
Reference mirror rotation	365
Fringe measurement	365
Speckle interferometry	365
Holographic contouring	366
Summary of applications	367
Further reading	368
References	369
Chapter 24: Data storage and diffractive elements	371

Why holographic data storage?	371
Data processing	372
Spatial filtering with Fourier-transform holograms	372
Fourier-transform holograms: the principles	375
Image de-blurring	376
Correlation filtering	376
Computer-generated holograms (CGHs)	378
Applications of Fourier-transform CGHs	378
Strategies for making CGHs	380
CGHs with a personal computer	381
Diffraction optical elements	381
Basic types of DOE	382
Fabrication of DOES	385
Applications of DOES	386
Further reading	386
References	387
Chapter 25: Holography in biology and medicine	389
Dental holography	389
Histology and pathology	389
Ophthalmic holography	391
Multiplexed holograms	392
Holograms and diagnostics	393
References	393
Chapter 26: Holographic motion pictures and video	395
Making the image move	395
Real-time holography	395
Holographic movies	397
Holographic video and television	398
References	400
Chapter 27: Other applications of holography	402
Far-field holography	402
Holomicrography	403
Microwave holography	404
Infrared holography	405
Ultraviolet holography	405
X-ray holography	406
Electron holography	406
Acoustic holography	406
Light-in-flight holography	408
Polarization holography	410
Conoscopic holography	411
Pseudodeep holograms	412

Digital holography	413
Conclusion	414
References	414
Appendix 1: The mathematical background to holography	417
Formation of a hologram	417
Reconstruction of the image	420
Traveling and standing waves	420
Bragg diffraction	421
Effects of shrinkage during processing	424
Modulation and contrast	425
Appendix 2: The Fourier approach to image formation	429
Fourier series	431
Fourier transform	435
Reciprocal relationship of x-space and frequency space	438
The Fourier convolution theorem	441
Two-dimensional objects	443
Further reading	446
Appendix 3: Geometries for creative holography	447
Designing a setup for a white-light transmission hologram	447
Worksheet for multicolor WLT holograms	451
Multicolor layouts designed by geometry	453
Locating the hinge point and illumination axis	455
Multicolor WLT hologram geometry	456
Multicolor reflection hologram geometry	457
References	458
Appendix 4: Fringe stabilization	459
Error detector	460
Expanding the fringes	460
Comparator and amplifier	463
Transducer	463
Appendix 5: Processing formulas	466
Developers for silver halide emulsions	466
Developers for transmission holograms	466
Developer for true-color holograms	468
The pyrochrome process	468
Image color control	469
Solution-physical developers	470
Rehalogenating bleaches	470
Haze removal	471
Oxidized developing agents as bleaches	471
Pre- and post-swelling	472

Silver halide sensitized gelatin processing	472
Preparation of red-sensitive DCG emulsion	474
Making your own holographic emulsion	475
Electroplating formulas	477
References	478

Index