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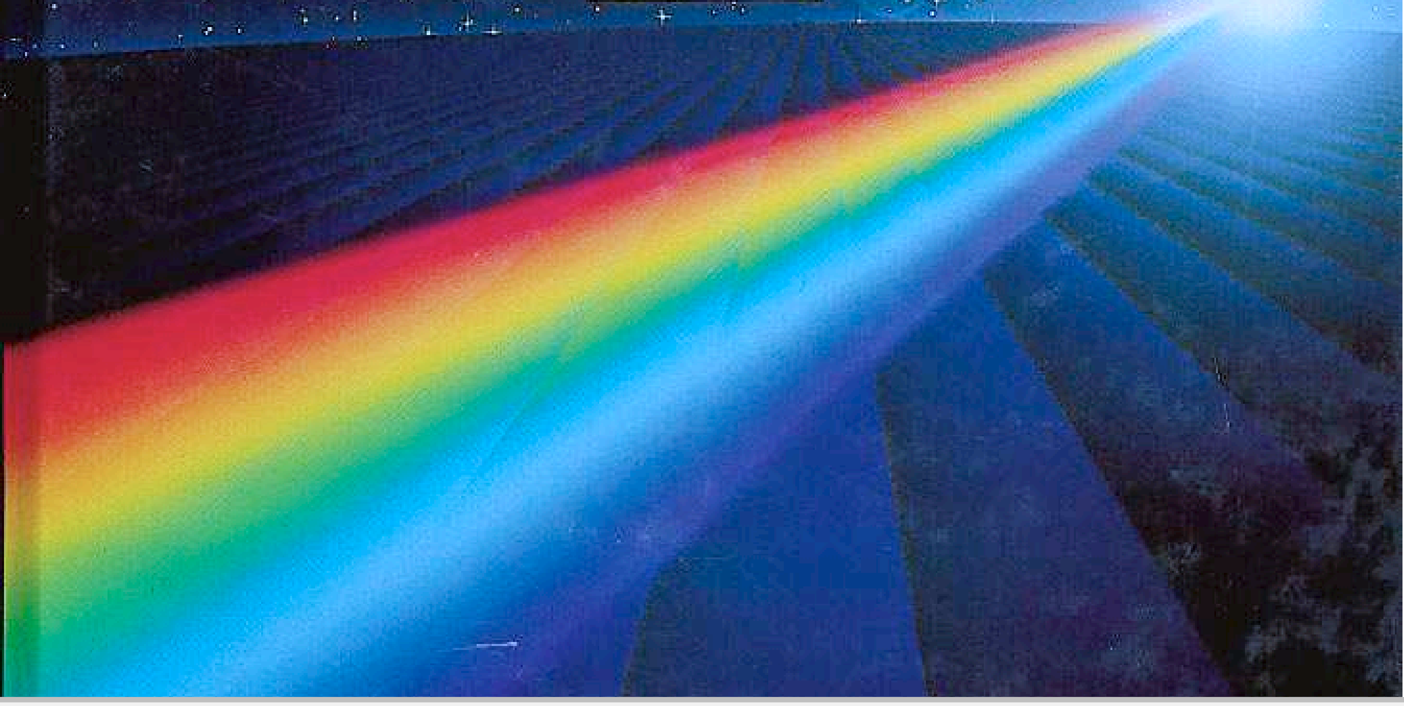
HANDBOOK OF OPTICS

DEVICES, MEASUREMENTS, & PROPERTIES

• SECOND EDITION •

VOLUME

II



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McGRAW-HILL, INC.

New York San Francisco Washington, D.C. Auckland Bogota
Caracas Lisbon London Madrid Mexico City Milan
Montreal New Delhi San Juan Singapore
Sydney Tokyo Toronto

Library of Congress Cataloging-in-Publication Data

Handbook of optics / sponsored by the Optical Society of America ;
Michael Bass, editor in chief. — 2nd ed.
p. cm.
Includes bibliographical references and index.
Contents: — 2. Devices, measurement, and properties.
ISBN 0-07-047974-7
1. Optics—Handbooks, manuals, etc. 2. Optical instruments—
Handbooks, manuals, etc. I. Bass, Michael. II. Optical Society
of America.
QC369.H35 1995
535—dc20 94-19339
CIP

1 2 3 4 5 6 7 8 9 DOC/DOC 9 0 9 8 7 6 5 4

ISBN 0-07-047974-7

The sponsoring editor for this book was Stephen S. Chapman, the editing supervisor was Paul R. Sobel, and the production supervisor was Suzanne W. Babeuf. It was set in Times Roman by The Universities Press (Belfast) Ltd.

Printed and bound by R.R. Donnelly & Sons Company.

This book is printed on acid-free paper.

CHAPTER 7
MINIATURE AND MICRO-OPTICS

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7.1 GLOSSARY

A, B, C, D	constants
$A(r, z)$	converging spherical wavefront
c	curvature
D	diffusion constant
d	diffusion depth
EFL	effective focal length
f	focal length
g	gradient constant
h	radial distance from vertex
i	imaginary
k	conic constants
k	wave number
LA	longitudinal aberration
l_0	paraxial focal length
M	total number of zones
NA	numerical aperture
n	refractive index
r	radial distance from optical axis
r_{mask}	mask radius
r_m	radius of the mth zone
t	fabrication time
$\bar{u}$	slope
W_{ijk}	wavefront function
X	shape factor
x, y	Cartesian coordinates
y	height

Z	sag
z	optical axis
Δ	relative refractive difference
ρ	propagation distance
λ	wavelength
$\bar{\sigma}$	$\sigma_{\text{rms}}/2y$
σ_{rms}	rms wavefront error
Φ	phase
ψ	special function

7.2 INTRODUCTION

Optical components come in many sizes and shapes. A class of optical components that has become very useful in many applications is called micro-optics. We define micro-optics very broadly as optical components ranging in size from several millimeters to several hundred microns. In many cases, micro-optic components are designed to be manufactured in volume, thereby reducing cost to the customer. The following paragraphs describe micro-optic components that are potentially useful for large-volume applications. The discussion includes several uses of micro-optics, design considerations for micro-optic components, molded glass and plastic lenses, distributed-index planar lenses, Corning's SMILE™ lenses, microFresnel lenses, and, finally, a few other technologies that could become useful in the near future.

7.3 USES OF MICRO-OPTICS

Micro-optics are becoming an important part of many optical systems. This is especially true in systems that demand compact design and form factor. Some optical fiber-based applications include fiber-to-fiber coupling, laser-diode-to-fiber connections, LED-to-fiber coupling, and fiber-to-detector coupling. Microlens arrays are useful for improving radiometric efficiency in focal-plane arrays, where relatively high numerical aperture (NA) microlenslets focus light onto individual detector elements. Microlens arrays can also be used for wavefront sensors, where relatively low-NA lenslets are required. Each lenslet is designed to sample the input wavefront and provide a deviation on the detector plane that is proportional to the slope of the wavefront over the lenslet area. Micro-optics are also used for coupling laser diodes to waveguides and collimating arrays of laser diodes. An example of a large-volume application of micro-optics is data storage, where the objective and collimating lenses are only a few millimeters in diameter.[1]

7.4 MICRO-OPTICS DESIGN CONSIDERATIONS

Conventional lenses made with bulk elements can exploit numerous design parameters, such as the number of surfaces, element spacings, and index/dispersion combinations, to achieve performance requirements for NA, operating wavelength, and field of view. However, fabricators of micro-optic lenses seek to explore molded or planar technologies, and thus the design parameters tend to be more constrained. For example, refractive

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