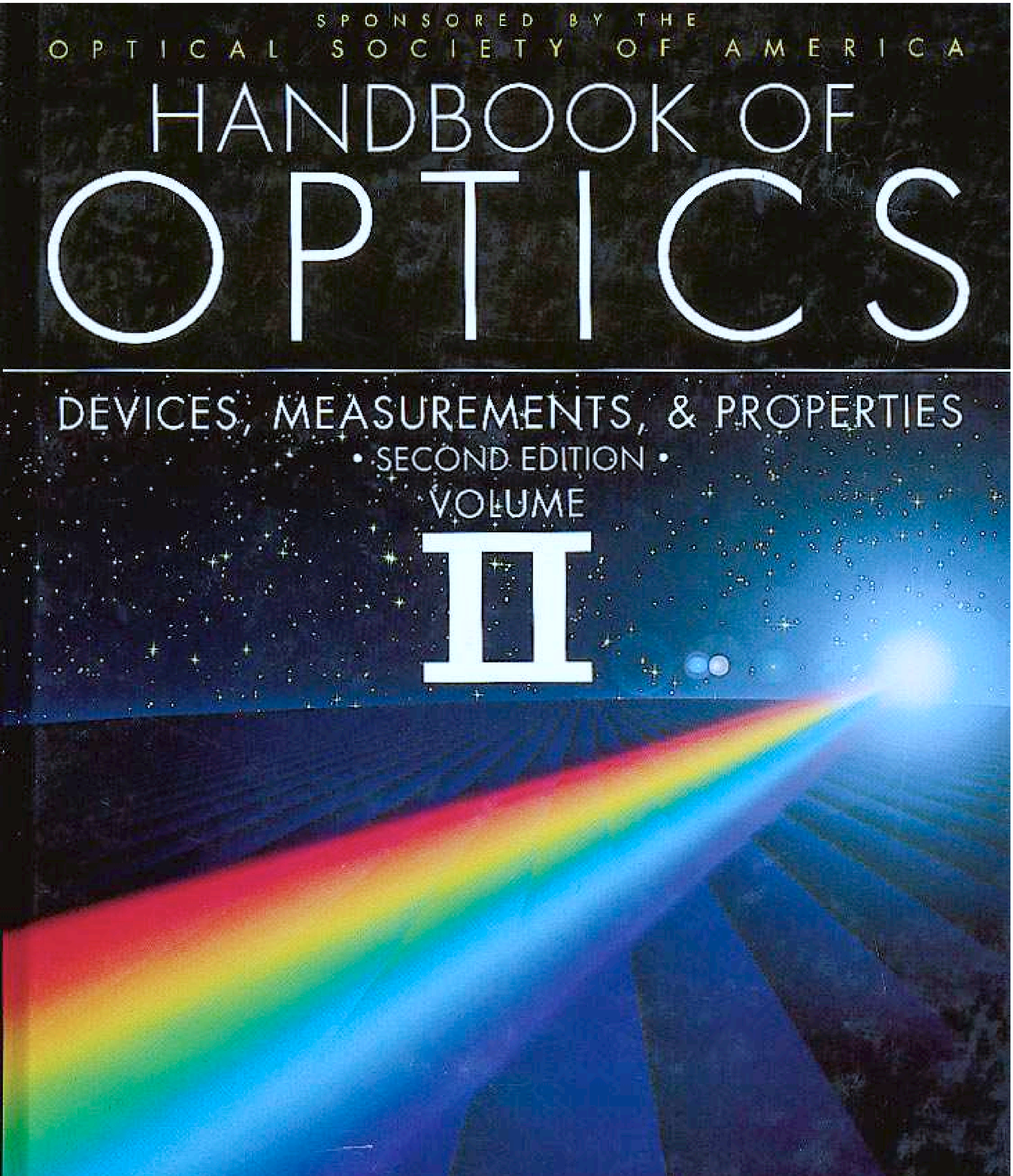
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DEVICES, MEASUREMENTS, & PROPERTIES
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VOLUME
II

HANDBOOK OF OPTICS

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Devices, Measurements, and Properties

Second Edition

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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
$\bar{\sigma}$	$\sigma_{rms}/2y$
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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