HANDBOOK OF OPTICAL MATERIALS

The CRC Press
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HANDBOOK OF OPTICAL MATERIALS

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CRC PRESS

Boca Raton London New York Washington, D.C.

Library of Congress Cataloging-in-Publication Data

Weber, Marvin J., 1932-
Handbook of optical materials / Marvin J. Weber.
p. cm.
Includes bibliographical references and index.
ISBN 0-8493-3512-4 (alk. paper)
1. Optical materials—Handbooks, manuals, etc. 2. Lasers—Handbooks, manuals, etc. 3. Electrooptics—Handbooks, manuals, etc. I. Title.

QC374 .W43 2002
621.36—dc21 2002073628

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No claim to original U.S. Government works
International Standard Book Number 0-8493-3512-4
Library of Congress Card Number 2002073628
Printed in the United States of America 1 2 3 4 5 6 7 8 9 0
Printed on acid-free paper

Preface

The *Handbook of Optical Materials* is a compilation of the physical properties of optical materials used in optical systems and lasers. It contains extensive data tabulations but with a minimum of narration, in a style similar to that of the *CRC Handbook of Chemistry and Physics*. References to original or secondary sources of the data are included throughout. The objective of the handbook is to provide a convenient, reliable source of information on the properties of optical materials.

Data in a handbook of optical materials can be presented by material (e.g., SiO_2, CaF_2, Ge), by property (e.g., refractive index, thermal expansion, hardness), by wavelength region (e.g., infrared, visible, ultraviolet), or by application (e.g., transmitting optics, laser hosts, polarizers). In this handbook data are grouped by material properties. Thereby one can compare different materials with respect to their properties and suitability for a particular application.

The volume is divided into sections devoted to various forms of condensed matter (crystals, glasses, polymers, metals), liquids, and gases. Within each section physical properties, linear and nonlinear optical properties, and many special properties such as electrooptic, magnetoopic, and elastooptic properties of the materials are tabulated. The optical solids included are mainly inorganic materials; optical liquids are mainly organic substances.

If by an optical material one means a material that exhibits some optical property such as transmission, absorption, reflection, refraction, scattering, etc., the number of materials to be considered becomes unmanageable. Thus the inclusion of materials in this volume is selective rather than exhaustive. In the case of commercial optical glasses, for example, properties of representative types of glasses are given but not properties for all compositional variations. Glasses with special properties or for special applications are included, however.

Bulk materials rather than thin films and multilayer structures are considered. Although optical glasses epitomizes an engineered material, other engineered optical materials such as nanomaterials, quantum wells, or photonic crystals are also not included (although one of the last is listed in Appendix II).

Although today optics can encompass x-ray and millimeterwave optics, coverage is limited to materials for the spectral range from the vacuum ultraviolet (~100 nm) to the infrared (up to 100 μm) portion of the electromagnetic spectrum.

Among optical materials and properties not treated explicitly are photorefractive materials, liquid crystals, optical fibers, phase-change optical recording materials, luminescent materials (phosphors, scintillators), optical damage, and materials preparation and fabrication.

Much of the numerical data in this handbook is from Volumes III, IV, V, and Supplement 2 of the *CRC Handbook of Laser Science and Technology.* These volumes should be consulted for more detailed descriptions of properties and their measurement (the contents of the volumes and the contributors are given in the following pages). In many instances the data in these volumes have been reformatted and combined with additions and recent developments. Several new sections have been added. For example, gases can play various roles as

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an optical material—as transmitting media, active media for Faraday rotation, frequency conversion, filter, and phase conjugation. Physical and optical properties of a selected number of gases are therefore included in a final section.

The discovery of new optical materials has been accompanied by a somewhat bewildering and befuddling proliferation of abbreviations and acronyms. An appendix has been added to decode several hundred of these terms. Common or mineralogical names for optical materials are also included. Methods of preparing optical materials and thin films have developed their own terminology; many of these abbreviations are given in another appendix.

This volume has benefited from the efforts of many contributors to the *CRC Handbook of Laser Science and Technology* series. I am indebted to them for what in many cases have been very extensive compilations. In the course of preparing this volume I have also benefited from other input provided by Mark Davis, Alexander Marker, Lisa Moore, John Myers, and Charlene Smith; these are gratefully acknowledged. Finally, I appreciate the excellent help provided by Project Editors Samar Haddad and Joette Lynch, Production Supervisor Helena Redshaw, and the staff of the CRC Press in the process of preparing this handbook.

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The Author

Marvin John Weber received his education at the University of California, Berkeley, and was awarded the A.B., M.A., and Ph.D. degrees in physics. After graduation, Dr. Weber continued as a postdoctoral Research Associate and then joined the Research Division of the Raytheon Company where he was a Principal Scientist working in the areas of spectroscopy and quantum electronics. As Manager of Solid State Lasers, his group developed many new laser materials including rare-earth-doped yttrium orthoaluminate. While at Raytheon, he also discovered luminescence in bismuth germanate, a scintillator crystal widely used for the detection of high energy particles and radiation.

During 1966 to 1967, Dr. Weber was a Visiting Research Associate with Professor Arthur Schawlow's group in the Department of Physics, Stanford University.

In 1973, Dr. Weber joined the Laser Program at the Lawrence Livermore National Laboratory. As Head of Basic Materials Research and Assistant Program Leader, he was responsible for the physics and characterization of optical materials for high-power laser systems used in inertial confinement fusion research. From 1983 to 1985, he accepted a transfer assignment with the Office of Basic Energy Sciences of the U.S. Department of Energy in Washington, DC, where he was involved with planning for advanced synchrotron radiation facilities and for atomistic computer simulations of materials. Dr. Weber returned to the Chemistry and Materials Science Department at LLNL in 1986 and served as Associate Division Leader for condensed matter research and as spokesperson for the University of California/National Laboratories research facilities at the Stanford Synchrotron Radiation Laboratory. He retired from LLNL in 1993 and is at present a staff scientist in the Department of Nuclear Medicine and Functional Imaging of the Life Sciences Division at the Lawrence Berkeley National Laboratory.

Dr. Weber is Editor-in-Chief of the multi-volume *CRC Handbook Series of Laser Science and Technology*. He has also served as Regional Editor for the *Journal of Non-Crystalline Solids*, as Associate Editor for the *Journal of Luminescence* and the *Journal of Optical Materials*, and as a member of the International Editorial Advisory Boards of the Russian journals *Fizika i Khimiya Stekla* (Glass Physics and Chemistry) and *Kvantovaya Elektronika* (Quantum Electronics).

Among several honors he has received are an Industrial Research IR-100 Award for research and development of fluorophosphate laser glass, the George W. Morey Award of the American Ceramics Society for his basic studies of fluorescence, stimulated emission, and the atomic structure of glass, and the International Conference on Luminescence Prize for his research on the dynamic processes affecting luminescence efficiency and the application of this knowledge to laser and scintillator materials.

Dr. Weber is a Fellow of the American Physical Society, the Optical Society of America, and the American Ceramics Society and a member of the Materials Research Society.

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