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Handbook of Nonlinear Optical Crystals

Second, Revised and Updated Edition

With 39 Figures

Springer

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To our Parents

Preface

Four years ago when we had finished our work on the first edition of our Handbook we didn't even suppose that three years later it would become necessary to greatly revise and update the material. It happened because of the following developments.

1. The invention and tremendous development of modern nonlinear optical crystals such as BBO, LBO, KTP, $ZnGeP_2$, etc.
2. Rapid progress in laser techniques (femtosecond CPM laser, Ti: sapphire laser, diode-pumped solid-state lasers, etc.).
3. The appearence of numerous organic crystals which can be synthesized with predictable properties.
4. Progress in the theory of nonlinear frequency conversion utilizing biaxial crystals, femtosecond pulses, etc.
5. Accumulation of new data on the properties of nonlinear optical crystals.

In accordance with the above, we have made many changes in the text. The first chapter was revised by D.N. Nikogosyan, the second one by V.G. Dmitriev and D.N. Nikogosyan, and the fourth one by G.G. Gurzadyan. The third chapter, containing the main reference material on 77 nonlinear optical crystals was completely rewritten and updated by D.N. Nikogosyan. The Appendix containing the list of most commonly used laser wavelengths was compiled by D.N. Nikogosyan. We would appreciate any valuable comments and recommendations that will allow us to further improve the Handbook.

We would like to thank H.K.V. Lotsch for fruitful and long-lasting cooperation.

Moscow, Yerevan, Troitzk
Russia, Armenia
December 1995

V. G. Dmitriev
G. G. Gurzadyan
D. N. Nikogosyan

Preface to the First Edition

Since the invention of the first laser 30 years ago, the frequency conversion of laser radiation in nonlinear optical crystals has become an important technique widely used in quantum electronics and laser physics for solving various scientific and engineering problems. The fundamental physics of three-wave light interactions in nonlinear optical crystals is now well understood. This has enabled the production of various harmonic generators, sum- and difference-frequency generators, and optical parametric oscillators based on nonlinear optical crystals that are now commercially available. At the same time, scientists continue an active search for novel, highly efficient nonlinear optical materials.

Therefore, in our opinion, there is a great need for a handbook of nonlinear optical crystals, intended for specialists and practitioners with an engineering background. This book contains a complete description of the properties and applications of all nonliner optical crystals of practical importance reported in the literature up to the beginning of 1990. In addition, it contains the most important equations for calculating the main parameters (such as phase-matching direction, effective nonlinearity, and conversion efficiency) of nonlinear frequency converters.

Dolgoprudnyi, Yerevan, Troitzk
USSR
October 1990

V. G. Dmitriev
G. G. Gurzadyan
D. N. Nikogosyan

Contents

List of Abbreviations

a	Aperture
c	Cut
cont	Continuum
cr	Critical
cw	Continuous wave
DF	Difference frequency
DFG	Difference-frequency generation
dif	Diffraction
DROPO	Doubly-resonant optical parametric oscillation
ds, dis	Dispersive spreading
e	Extraordinary
eff	Effective
exp	Experimental
f	Fast
fcg	Free-carrier generation
FIHG	Fifth-harmonic generation
FOHG	Fourth-harmonic generation
ICSFG	Intracavity sum-frequency generation
ICSHG	Intracavity second-harmonic generation
int	Internal
IR	Infrared
L	Linear
NCPM	Non-critical phase matching
NL	Nonlinear
no pm	No phase matching
o	Ordinary
OPO	Optical parametric oscillation
OR	Optical rectification
p	Pulse
PM, pm	Phase matching
PL	Parametric luminescence
pr	Photorefraction
qs	Quasistatic
s	Slow
SF	Sum frequency

SFG	Sum-frequency generation
SFM	Sum-frequency mixing
SH	Second harmonic
SHG	Second-harmonic generation
SIHG	Sixth-harmonic generation
SROPO	Singly-resonant optical parametric oscillation
SRS	Stimulated Raman scattering
theor	Theoretical
THG	Third-harmonic generation
thr	Threshold
tsa	Thermal self-action
TWOPO	Traveling-wave optical parametric oscillation
unc	Unconverted
UV	Ultraviolet