Infrared and Millimeter Waves

VOLUME 5
COHERENT SOURCES AND APPLICATIONS, Part I

Edited by
Kenneth J. Button

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PREFACE

The subject of sources of radiation will become a subset of volumes, consisting so far of Volume 1 (Sources of Radiation), Volume 5 (Coherent Sources and Applications, Part I), and Volume 7 (Coherent Sources and Applications, Part II). Volume 1 dealt with gyrotrons, free electron lasers, IMPATT devices, pulsed optically pumped lasers, backward wave oscillators, and the ledatron. This was far from complete, of course, so we have tried to arrange for complete coverage as quickly as possible. Professor Kneubühl and Professor Sturzenegger gave us "Electrically Excited Submillimeter-Wave Lasers" in time to be published as Chapter 5 in Volume 3. Now Professor Kneubühl and Professor Affolter have given us "Distributed-Feedback Gas Lasers" as Chapter 6 in this book. In Volume 4 (Millimeter Systems), N. Bruce Kramer gave us full coverage of traveling-wave tubes, IMPATT and Gunn diodes. We are still waiting for someone to write up the very important extended interaction oscillator and amplifier. We do have the GaAs TUNNETT diodes in this book (Chapter 4), written by Professor Nishizawa, who originally developed this device.

As we continue to develop this subset on sources of millimeter and far-infrared radiation, we have the space to include a broader treatment by dealing with *performance* and *applications*. The keynote of this book, Volume 5, is the opening chapter on coherent sources and their scientific applications by Professor Benjamin Lax. This is followed by a very comprehensive treatment of spectroscopy of molecules by far-infrared laser emission prepared by Professor J. O. Henningsen. A similarly comprehensive treatment of Stark spectroscopy and frequency tuning in optically pumped far-infrared molecular lasers is given by Professor F. Strumia and Professor M. Inguscio. Then we were quite fortunate to get a follow-up on gyrotron oscillators and amplifiers in the form of "Measured Performance of Gyrotron Oscillators and Amplifiers" (Chapter 5) by some of the leaders of the outstanding group at Naval Research Laboratory, Dr. V. L. Granatstein, Dr. M. E. Read, and Dr. L. R. Barnett.

Volume 7 (Coherent Sources and Applications, Part II), will open with "CW Optically Pumped Lasers" by Professor Thomas A. DeTemple and Dr. E. Danielewicz. Professor DeTemple had already published his contribution on pulsed optically pumped far-infrared lasers in Volume 1. This

will be followed by a chapter on mid-infrared optically pumped molecular lasers by Robert G. Harrison and Pradeep K. Gupta and a short chapter on the optimization of optically pumped far-infrared lasers by Dr. Konrad Walzer.

Dr. Philip Sprangle, who is also one of the leaders of the outstanding Plasma Physics Division of the Naval Research Laboratory, has contributed a chapter on free-electron lasers to Volume 7 as a complement to his theoretical chapter on the subject that appeared in Volume 1. Following this is a treatment of the oratron, originally known as the Smith–Purcell free-electron laser, which is a promising version of the FEL for generating coherent millimeter- and submillimeter-wave radiation. A definitive chapter describing this device has been prepared by Dr. Donald E. Wortman and Dr. Richard P. Leavitt to appear in Volume 7 (Coherent Sources and Applications, Part II). In this third book of the subset on sources, we shall have space to expand again into the applications with a chapter on high-frequency gyrotrons and applications to tokamak plasma heating by Kenneth E. Kreischer and Richard J. Temkin of the Plasma Fusion Center at M.I.T. This chapter was commissioned for the forthcoming volume on tokamak plasma diagnostics but its originality and the importance of its concepts earned it early publication in Coherent Sources and Applications, Part II. The subject of nonlinear frequency conversion in bulk crystals and semiconductor diodes will be developed by Dr. Dane D. Bicanic in "Generation of Tunable Laser Sidebands in the Terahertz Region by Frequency Mixing of the HCN Laser and a Microwave Source in a Metal–Semiconductor Diode". The basic subject of metal–semiconductor junctions as frequency converters has been covered by Dr. Martin V. Schneider in Chapter 4 of Volume 6.

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VOLUME 5 COHERENT SOURCES AND APPLICATIONS, PART I

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CHAPTER 1

Coherent Sources and Scientific Applications

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I. Introduction

Coherent sources for resonance spectroscopy now extend from the microwave to the ultraviolet region. Pioneers in this area of research, such as Professor Gordy, began with microwave sources that were developed during World War II for radar. The challenges of spectroscopy demanded coherent sources at shorter wavelengths. One of the first techniques for this purpose was to use harmonic generation of a microwave source and a crystal multiplier to obtain 5-mm radiation (Beringer, 1946). Professor Gordy and his students adapted this technique to make tunable millimeter sources in 1948 to study a variety of molecules (Gordy, 1948). During subsequent years they made numerous such measurements of gaseous mole-

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