

# OPTICAL HORIZONS **ADVANCING COMMUNICATION** AND **SENSING**

Edited by NURUL ASHIKIN DAUD NUR NAJAHATUL HUDA SARIS



#### First Edition 2024 © NURUL ASHIKIN DAUD & NUR NAJAHATUL HUDA SARIS 2024

Hak cipta terpelihara. Tiada dibenarkan mengeluar ulang mana mana bahagian artikel, ilustrasi, dan isi kandungan buku ini dalam apa juga bentuk dan cara apa jua sama ada dengan cara elektronik, fotokopi, mekanikal, atau cara lain sebelum mendapat izin bertulis daripada Timbalan Naib Canselor (Penyelidikan & Inovasi), Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor Darul Ta'zim, Malaysia. Perundingan tertakluk kepada perkiraan royalti atau honorarium.

All rights reserved. No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical including photocopying, recording, or any information storage and retrieval system, without permission in writing from Deputy Vice-Chancellor (Research & Innovation), Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor Darul Ta'zim, Malaysia. Negotiation is subject to royalty or honorarium estimation.

#### Editor: NURUL ASHIKIN DAUD & NUR NAJAHATUL HUDA SARIS Editor Penyelaras/Acquisition Editor: MAZLAN SAID Pereka Kulit / Cover Designer: FAHAMIN ABDUL GHANI

Diatur huruf oleh / *Typeset by:* NURUL ASHIKIN DAUD & NUR NAJAHATUL HUDA SARIS Faculty of Electrical Engineering UNIVERSITI TEKNOLOGI MALAYSIA 81310 UTM Johor Bahru Johor Darul Ta'zim, MALAYSIA

Diterbitkan di Malaysia oleh: **PENERBIT UTM PRESS** UNIVERSITI TEKNOLOGI MALAYSIA 81310 UTM Johor Bahru Johor Darul Ta'zim, MALAYSIA (PENERBIT UTM ahli MAJLIS PENERBITAN ILMIAH MALAYSIA–MAPIM dan MABOPA dengan no. keahlian 9101)

Dicetak di Malaysia oleh: JASAMAX ENTERPRISE No. 16, Jalan Kebudayaan 2 Taman Universiti 81300 Skudai, Johor, MALAYSIA



Cataloguing-in-Publication Data Perpustakaan Negara Malaysia A catalogue record for this book is available from the National Library of Malaysia ISBN 978-983-52-2052-4

# CONTENTS

Contributors Preface		vii ix
CHAPTER 1	<b>OPTICAL FIBRE TECHNOLOGY</b> <b>IN COMMUNICATION DEVICES</b> <b>AND SENSING</b> <i>Nurul Ashikin Daud and Nur Najahatul</i> <i>Huda Saris</i>	1
CHAPTER 2	PULSED LASER EMPLOYING SATURABLE ABSORBERS IN MULTIPLE SPECTRA Wei Ling Ooi, Azura Hamzah, Ahmad Haziq Aiman Rosol, and Kawther M. Mustafa	21
CHAPTER 3	MULTIWAVELENGTH RANDOM FIBRE LASER BASED ON DIFFERENT SOA COMBINATIONS Allen Paul David, Nelidya Md Yusoff, Abdul Hadi Sulaiman, and Husni Hani Jameela Sapingi	45
CHAPTER 4	PASSIVE OPTICAL NETWORK-5G FRONTHAUL: OPTICAL DEVICE AND FUNCTIONAL SPLITS Chuah Shi Yi, Arnidza Ramli, Nadiatulhuda Zulkifli, and Nik Noordini Nik Abdul Malik	61

## CHAPTER 5 ADVANCES IN OPTICAL FIBRE: 77 PLASMONIC SENSOR FOR LEAD IONS

Fariza Hanim Suhailin, Liyana Shatar, Ali Abdulkhaleq Abdulhadi Alwahib, and Fatin Hamimi Mustafa

### CHAPTER 6 OPTICAL PROPERTIES AND 95 SENSITIVITY OF FIBRE OPTIC EVANESCENT WAVE SENSOR

Ng Soo Tin, Mohd Rashidi Salim, Hummad Habib Qazi, and Hadi Manap

#### CHAPTER 7 FLOOD MONITORING SYSTEM 111 USING OPTICAL FIBRE SENSOR WITH IoT

Joyenie Vincent Tabak, Muhammad Yusof Mohd Noor, Asrul Izam Azmi, and Ahmad Sharmi Abdullah

INDEX

123

## CONTRIBUTORS

- **Abdul Hadi Sulaiman** Institute of Power Engineering, Universiti Tenaga Nasional, Selangor, Malaysia
- Ahmad Haziq Aiman Rosol Malaysia-Japan International Institute of Technology, Universiti Teknologi Malaysia, Kuala Lumpur, Malaysia
- Ahmad Sharmi Abdullah Faculty of Electrical Engineering, Universiti Teknologi Malaysia, Johor Bahru, Malaysia
- **Ali Abdulkhaleq Abdulhadi Alwahib** Laser and Optoelectronic Department, University of Technology-Iraq, Baghdad, Iraq
- **Allen Paul David** Faculty of Electrical Engineering, Universiti Teknologi Malaysia, Johor Bahru, Malaysia
- **Arnidza Ramli** Faculty of Electrical Engineering, Universiti Teknologi Malaysia, Johor Bahru, Malaysia
- Asrul Izam Azmi Faculty of Electrical Engineering, Universiti Teknologi Malaysia, Johor Bahru, Malaysia
- **Azura Hamzah** Malaysia-Japan International Institute of Technology, Universiti Teknologi Malaysia, Kuala Lumpur, Malaysia
- Chuah Shi Yi Faculty of Electrical Engineering, Universiti Teknologi Malaysia, Johor Bahru, Malaysia
- Fariza Hanim Suhailin Faculty of Science, Universiti Teknologi Malaysia, Johor Bahru, Malaysia
- Fatin Hamimi Mustafa Faculty of Electrical Engineering, Universiti Teknologi Malaysia, Johor Bahru, Malaysia
- Hadi Manap Faculty of Electrical and Electronics Engineering Technology, Universiti Malaysia Pahang Sultan Abdullah, Pahang, Malaysia

Hummad Habib Qazi Comsats University Islamabad, Lahore Campus, Pakistan

Husni Hani Jameela Sapingi Malaysia-Japan International Institute of Technology, Universiti Teknologi Malaysia, Kuala Lumpur, Malaysia

- Joyenie Vincent Tabak Faculty of Electrical Engineering, Universiti Teknologi Malaysia, Johor Bahru, Malaysia
- Kawther M. Mustafa Malaysia-Japan International Institute of Technology, Universiti Teknologi Malaysia, Kuala Lumpur, Malaysia
- Liyana Shatar Faculty of Science, Universiti Teknologi Malaysia, Johor Bahru, Malaysia
- **Mohd Rashidi Salim** Faculty of Electrical Engineering, Universiti Teknologi Malaysia, Johor Bahru, Malaysia
- **Muhammad Yusof Mohd Noor** Faculty of Electrical Engineering, Universiti Teknologi Malaysia, Johor Bahru, Malaysia
- Nadiatulhuda Zulkifli Faculty of Electrical Engineering, Universiti Teknologi Malaysia, Johor Bahru, Malaysia
- **Nelidya Md Yusoff** Razak Faculty of Technology and Informatics, Universiti Teknologi Malaysia, Kuala Lumpur, Malaysia
- **Ng Soo Tin** Faculty of Electrical Engineering, Universiti Teknologi Malaysia, Johor Bahru, Malaysia
- Nik Noordini Nik Abd Malik Faculty of Electrical Engineering, Universiti Teknologi Malaysia, Johor Bahru, Malaysia
- **Nur Najahatul Huda Saris** Faculty of Electrical Engineering, Universiti Teknologi Malaysia, Johor Bahru, Malaysia
- **Nurul Ashikin Daud** Faculty of Electrical Engineering, Universiti Teknologi Malaysia, Johor Bahru, Malaysia
- Wei Ling Ooi Malaysia-Japan International Institute of Technology, Universiti Teknologi Malaysia, Kuala Lumpur, Malaysia

# PREFACE

Optical Horizons: Advancing Communication and Sensing is a collaborative work authored by esteemed experts in the field of optical communication devices and sensors that delves into the latest advancements in this photonics technology. Our endeavour, which represents the joint efforts of the Lightwave Communication Research Group (LCRG) at the Faculty of Electrical Engineering (Fakulti Kejuruteraan Elektrik, FKE), Universiti Teknologi Malaysia Johor Bahru, together with the collective expertise of researchers who are at the forefront of optical technology, aims to provide an illuminating resource for those engaged in the intricate world of optical technology. In this book, you will find a comprehensive exploration of the latest developments in optical fibre technology, focusing on key components such as amplifiers, lasers, and sensors. We hope this book will be useful to researchers and students studying optical photonics. We express our gratitude to the LCRG members, contributors, and FKE for their encouragement and support throughout the completion of this book.

Nurul Ashikin Daud Nur Najahatul Huda Saris Universiti Teknologi Malaysia 2024