

Proceedings of SPIE - The International Society for Optical Engineering

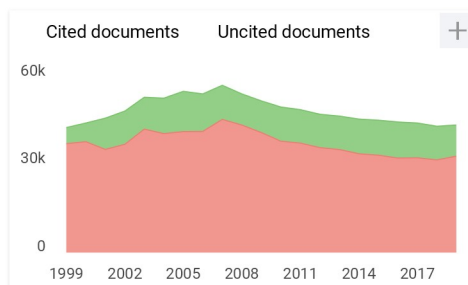
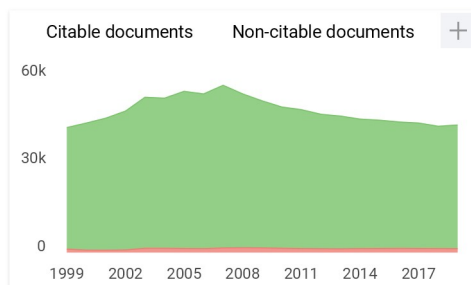
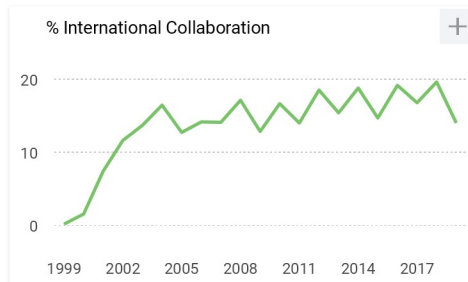
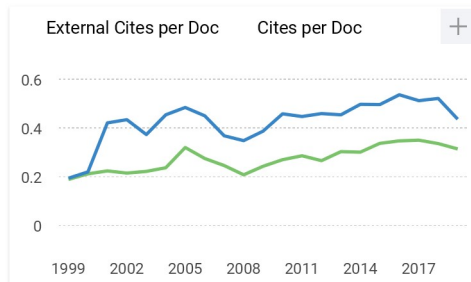
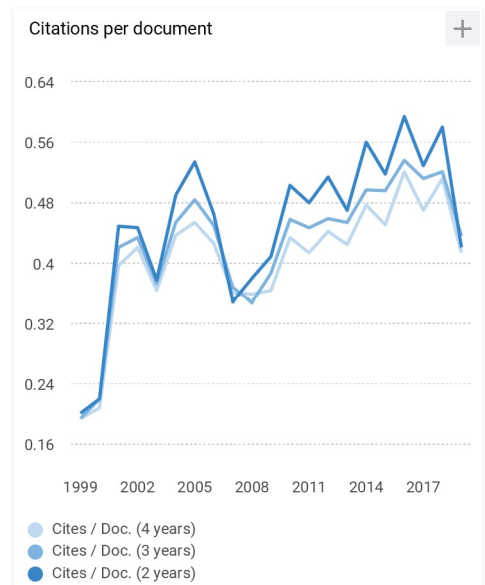
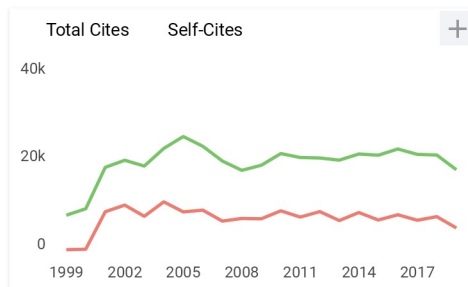
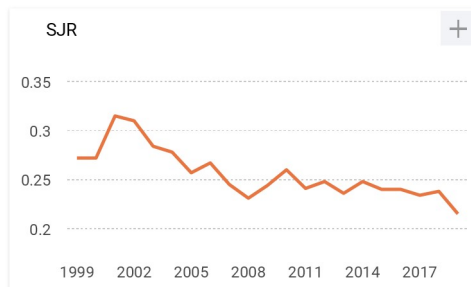
162

H Index

Country [United States](#) -  [SJR Ranking of United States](#)
Subject Area and Category

- [Computer Science](#)
 - [Computer Science Applications](#)
- [Engineering](#)
 - [Electrical and Electronic Engineering](#)
- [Materials Science](#)
 - [Electronic, Optical and Magnetic Materials](#)
- [Mathematics](#)
 - [Applied Mathematics](#)
- [Physics and Astronomy](#)
 - [Condensed Matter Physics](#)

Publisher [SPIE](#)
Publication type [Conferences and Proceedings](#)
ISSN [1996756X, 0277786X](#)
Coverage [1963-2020](#)
Scope SPIE conferences bring together engineers and scientists to present their latest research and to network with peers. Each year SPIE conferences result in approximately 350 proceedings volumes comprising 16,000+ papers and presentation recordings reporting on photonics-driven advancements in areas such as biomedicine, astronomy, defense and security, renewable energy, and more.

 [Homepage](#)
 [Join the conversation about this journal](#)


Proceedings of SPIE - The International Society for...

Not yet assigned quartile

SJR 2019
0.22

powered by scimagojr.com

← Show this widget in your own website

Just copy the code below and paste within your html code:

`<a href="https://www.scim`



Certificate of Appreciation

is awarded to

Dr. Ary Syahriar, DIC.

for his / her participation as

PRESENTER

in the International Seminar on Photonics, Optics, and its Applications (ISPhOA 2016), to be held in Jayakarta Bali Hotel, Legian - Bali, Indonesia, 24-25 August 2016.

Denpasar, 25 August 2016

Faculty of Industrial Technology
Dean,

Dr. Bambang Lelono Widjiantoro

ISPhOA 2016
Chairperson,



Agus Muhammad Hatta, Ph.D

PROCEEDINGS OF SPIE

Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016)

**Agus Muhamad Hatta
Aulia Nasution**
Editors

**24–25 August 2016
Legian – Kuta, Bali, Indonesia**

Organized by
Department of Engineering Physics – FTI
Institut Teknologi Sepuluh Nopember (Indonesia)

Sponsored by
Ministry of Research, Technology and Higher Education (Indonesia)
International Commission for Optics
The Optical Society (United States)
The Abdus Salam International Centre for Theoretical Physics (Italy)
European Optical Society
Optics and Photonics Society of Singapore (Singapore)
PT Telekomunikasi Selular (Indonesia)
Zugo Photonics Pte Ltd. (Singapore)
PT Horiba Indonesia (Indonesia)

Published by
SPIE

Volume 10150

Proceedings of SPIE 0277-786X, V. 10150

SPIE is an international society advancing an interdisciplinary approach to the science and application of light.

Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016)
edited by Agus Muhamad Hatta, Aulia Nasution, Proc. of SPIE Vol. 10150, 1015001
© 2016 SPIE · CCC code: 0277-786X/16/\$18 · doi: 10.1117/12.2263579

Proc. of SPIE Vol. 10150 1015001-1

The papers in this volume were part of the technical conference cited on the cover and title page. Papers were selected and subject to review by the editors and conference program committee. Some conference presentations may not be available for publication. Additional papers and presentation recordings may be available online in the SPIE Digital Library at SPIDigitalLibrary.org.

The papers reflect the work and thoughts of the authors and are published herein as submitted. The publisher is not responsible for the validity of the information or for any outcomes resulting from reliance thereon.

Please use the following format to cite material from these proceedings:

Author(s), "Title of Paper," in *Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016)*, edited by Agus Muhammad Hatta, Aulia Nasution, Proceedings of SPIE Vol. 10150 (SPIE, Bellingham, WA, 2016) Seven-digit Article CID Number.

ISSN: 0277-786X

ISSN: 1996-756X (electronic)

ISBN: 9781510607514

ISBN: 9781510607521 (electronic)

Published by

SPIE

P.O. Box 10, Bellingham, Washington 98227-0010 USA

Telephone +1 360 676 3290 (Pacific Time) · Fax +1 360 647 1445

SPIE.org

Copyright © 2016, Society of Photo-Optical Instrumentation Engineers.

Copying of material in this book for internal or personal use, or for the internal or personal use of specific clients, beyond the fair use provisions granted by the U.S. Copyright Law is authorized by SPIE subject to payment of copying fees. The Transactional Reporting Service base fee for this volume is \$18.00 per article (or portion thereof), which should be paid directly to the Copyright Clearance Center (CCC), 222 Rosewood Drive, Danvers, MA 01923. Payment may also be made electronically through CCC Online at copyright.com. Other copying for republication, resale, advertising or promotion, or any form of systematic or multiple reproduction of any material in this book is prohibited except with permission in writing from the publisher. The CCC fee code is 0277-786X/16/\$18.00.

Printed in the United States of America.

Publication of record for individual papers is online in the SPIE Digital Library.

**SPIE. DIGITAL
LIBRARY**

SPIDigitalLibrary.org

Paper Numbering: *Proceedings of SPIE* follow an e-First publication model. A unique citation identifier (CID) number is assigned to each article at the time of publication. Utilization of CIDs allows articles to be fully citable as soon as they are published online, and connects the same identifier to all online and print versions of the publication. SPIE uses a six-digit CID article numbering system structured as follows:

- The first four digits correspond to the SPIE volume number.
- The last two digits indicate publication order within the volume using a Base 36 numbering system employing both numerals and letters. These two-number sets start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B ... 0Z, followed by 10-1Z, 20-2Z, etc. The CID Number appears on each page of the manuscript.

Contents

vii	<i>Authors</i>
ix	<i>Conference Committee</i>
xi	<i>Introduction</i>

SECOND INTERNATIONAL SEMINAR ON PHOTONICS, OPTICS, AND ITS APPLICATIONS (ISPHOA 2016)

10150 02	Thermo-optic effects on three waveguide directional couplers [10150-8]
10150 04	Particle tracking by using single coefficient of Wigner-Ville distribution [10150-13]
10150 05	Optimization design of periscope type 3X zoom lens design for a five megapixel cellphone camera [10150-15]
10150 06	Comparative study of boundary conditions with helix [10150-17]
10150 07	Intensity based sensor based on single mode optical fiber patchcords [10150-18]
10150 08	Design and simulation of GRIN objective lenses for an imaging fiber based speckle metrology system [10150-22]
10150 09	Double biprism arrays design using for stereo-photography of mobile phone camera [10150-25]
10150 0B	Analysis of excimer laser radiant exposure effect toward corneal ablation volume at LASIK procedure [10150-30]
10150 0C	Pre-cataract surgery test using speckle pattern [10150-36]
10150 0D	Modeling of Si/Ge based two-dimensional photonic crystal nanocavity [10150-38]
10150 0F	Effect of the focal plane position on CO₂ laser beam cutting of injection molded polycarbonate sheets [10150-42]
10150 0H	Optimization of optical filter using triple coupler ring resonators structure based on polyimide substrate [10150-45]
10150 0L	Investigation of load effect on macro-bend losses for an SMS fiber structure with a small bend radius [10150-50]
10150 0M	Laser-Induced Breakdown Spectroscopy (LIBS) for spectral characterization of regular coffee beans and luwak coffee bean [10150-51]

10150 ON	Thermal signature analysis of human face during jogging activity using infrared thermography technique [10150-59]
10150 OO	Alcohol sensor based on single-mode-multimode-single-mode fiber structure [10150-61]
10150 OP	Crude oil specific gravity sensor design using polymer optical fiber with structural imperfection [10150-63]
10150 OQ	Design of SMS (Single mode-Multi mode coreless-Single mode) optical fiber as corrosion sensor [10150-64]
10150 OR	Relative humidity sensor based on SMS fiber structure using multimode coreless fiber [10150-67]
10150 OS	Experimental study on strain sensing by small-diameter FBG [10150-10]
10150 OT	Improved optical side coupling efficiency by spiral patterned zinc oxide nanorod coatings on large core plastic optical fiber [10150-11]
10150 OU	Black phosphorus as a saturable absorber for generating mode-locked fiber laser in normal dispersion regime [10150-16]
10150 OV	Low-cost chlorophyll meter (LCCM): portable measuring device for leaf chlorophyll [10150-19]
10150 OZ	Liquid salinity sensor based on D-shaped single mode fibers coated with In-Ga-Zn-O thin film [10150-28]
10150 10	Simulations of unpolarized light scattering by micro-bubble [10150-29]
10150 11	Integrated ZnO nanoparticles on paper-based microfluidic: toward efficient analytical device for glucose detection based on impedance and FTIR measurement [10150-31]
10150 13	Electrical properties of ZnO-based photodetector prepared by room temperature DC unbalanced magnetron sputtering [10150-34]
10150 15	An SMS structure based temperature sensor using a chalcogenide multimode fibre [10150-37]
10150 16	Raman tweezers spectroscopy study of free radical induced oxidative stress leading to eryptosis [10150-47]
10150 17	The 3D scanner prototype utilize object profile imaging using line laser and octave software [10150-53]
10150 18	Iris biometric system design using multispectral imaging [10150-55]
10150 19	Recognition of spectral identifier from green coffee beans of arabica and robusta varieties using laser-induced breakdown spectroscopy [10150-56]

- 10150 1A **Spectral identifiers from roasting process of Arabica and Robusta green beans using Laser-Induced Breakdown Spectroscopy (LIBS)** [10150-57]
- 10150 1B **Fabrication of SnO₂ nanoparticles straight waveguide with isopropanol solvent** [10150-58]
- 10150 1C **The effect of packaging material on optical fiber temperature sensor with singlemode multimode singlemode (SMS) structure** [10150-60]
- 10150 1D **Multimode-singlemode-multimode fiber sensor for alcohol sensing application** [10150-62]
- 10150 1E **Packaging aluminum impacting on optical fiber with Singlemode-Multimode-Singlemode (SMS) fiber structure** [10150-66]
- 10150 1F **Alcohol sensor based on u-bent hetero-structured fiber optic** [10150-69]
- 10150 1G **Comparison microbial killing efficacy between sonodynamic therapy and photodynamic therapy** [10150-71]
- 10150 1H **Fabrication slab waveguide based polymethyl methacrylate (PMMA) with spin coating method** [10150-72]
- 10150 1I **Self-mixing interferometry: a novel yardstick for mechanical metrology (Invited Paper)** [10150-75]
- 10150 1J **Static detection of flat head railways depletion using analysis of laser area and position on rail type R-54** [10150-40]
- 10150 1K **Design of biometrics identification system on palm vein using infrared light** [10150-73]
- 10150 1M **Analysis of spectral identifier of fatty acid functional group of packaging frying oil and bulk frying oil with the effect of repeated heating using FTIR (*Fourier Transform InfraRed*) spectroscopy** [10150-65]
- 10150 1N **Quantum teleportation without classical channel** [10150-79]

Authors

Numbers in the index correspond to the last two digits of the six-digit citation identifier (CID) article numbering system used in Proceedings of SPIE. The first four digits reflect the volume number. Base 36 numbering is employed for the last two digits and indicates the order of articles within the volume. Numbers start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B...0Z, followed by 10-1Z, 20-2Z, etc.

Adiati, Rima Fitria, 0B
Adibawa, Marcelinus Alfasisurya S., 0V
Ahmad, H., 0U
Aisyah, Putri Yeni, 0Q
Alam, Hilman Syaeful, 10
Al Amri, M., 1N
Andriawan, Alan, 1H
Anggraeni, Karina, 19
Asnawi, Asnawi, 1B
Astuti, Suryani Dyah, 1G
Azdast, Taher, 0F
Bankapur, Aseefhali, 16
Barkur, Surekha, 16
Bayuwati, Dwi, 07
Benyounis, Khaled Y., 0F
Brambilla, Gilberto, 15
Brotosudarmo, Tatas H. P., 0V
Budiarti, Putria W., 0N
Chan, Kelvin H. K., 08
Chao, Yu-Hao, 05, 09
Chidangil, Santhosh, 16
Chotimah, Ashri Khusnul, 1C
Chu, Pu-Yi, 05, 09
Chuamchaitrakool, P., 04
Darma, Yudi, 13
Daud, P., 0H
Dawprateep, S., 04
Donati, Silvano, 1I
Drantantiyas, Nike Dwi Grevika, 1G
Estu, T. T., 0H
Farrell, Gerald, 15
Fathnan, A. A., 0H
Gatut, Y., 1B
Guru Prasad, A. S., 08
H. Rafis, A. R., 0T
Haridas, Aswin, 08
Harun, S. W., 0U
Hashim, Abdul Manaf, 0D
Hatta, Agus Muhamad, 0L, 0O, 0P, 0Q, 0R, 1C, 1D, 1E, 1F
Heriyanto, Heriyanto, 0V
Hikmatyarsyah, Hikmatyarsyah, 02
Hisyam, M. B., 0U
Hutomo E. P., Evan, 0V
Izdiharruddin, Mokhammad Fahmi, 1I
Juliausti, Endang, 1J
Jutamulia, Suganda, 0C
Kumar, Deepak, 06
Kurniawan, Robi, 13
Kusumawardhani, Apriani, 0B, 0N, 0R
Latiff, A. A., 0U
Li, Qiufeng, 0S
Li, Zheng-Hong, 1N
Liang, Dakai, 0S
Lin, Hong-Yi, 0Z
Liu, Rong-mei, 0S
Mahmudin, D., 0H
Manunggal, Triarsa Tirtadwipa, 17
Mao, Hao-Sheng, 0Z
Masood, Asnawi, 1H
Masykuri, Edwin, 1J
Maulana, Y. Y., 0H
Meemon, P., 04
Mehrabi, Omid, 0F
Moradi, Mahmoud, 0F
Muhammady, Shibghatullah, 13
Mulyanto, Imam, 07
Murukeshan, V. M., 08
Nasution, Aulia M. T., 0M, 18, 19, 1A, 1G, 1K, 1M
Nufiqurakhmah, Nufiqurakhmah, 0M
Nurdini, Mugi, 17
Nurfani, Eka, 13
Pan, Jui-Wen, 05, 09
Patrialova, Sefi N., 1F
Phua, Y. N., 06
Pillay, Shamini, 06
Prabhathan, P., 08
Pramono, Yono Hadi, 1B, 1H
Pratama, Detak Yan, 0Q, 1C, 1E
Prilianti, Kestrilia R., 0V
Putri, Irana Eka, 10
Putri, R. Lucky, 1B
Putri, Vinda Dwi Dini, 1M
R., Mefina Yulias, 0O
Rahmadiansah, Andi, 0B
Rahmah, Fitri, 0L
Rahmasari, Lita, 0D
Redhyka, Grace Gita, 10
Rini Rizki, Artha Bona, 0B
Rofi'ah, Iffihatur, 1D
Rusdi, M. F. M., 0U
Samsi, Agus, 17
Sari, Damayanti, 1E
Sekartedjo, Sekartedjo, 0L, 0O, 0P, 1D, 1F
Setijono, Heru, 0B, 0N
Sugandhi, G., 0H
Sulaiman, W. H., 0T
Sulistianto, Junivan, 0P

Sun, Wen-Shing, 05, 09, 0Z
Suprijanto, Suprijanto, 1J
Sutjahja, Inge M., 13
Suyanto, Hery, 0M, 19, 1A
Syafiq, Muhammad, 1K
Syafriani, Sanif, 0R
Syahriar, Ary, 02
Tien, Chuen-Lin, 05, 09, 0Z
Virdian, Angga, 13
Wahyuono, Ruri Agung, 11
Waleed, S. M., 0T
Waluyo, Tomi Budi, 07
Wang, Pengfei, 15
Widhianto, Benedictus Yohanes Bagus, 18
Widjaja, J., 04, 0C
Wihardjo, Erning, 0C
Wijayanto, Y. N., 0H
Winata, Toto, 13
Wirani, Ayu Puspa, 1A
Yuan, Libo, 15
Yuwono, Rio Akbar, 11
Zahra, Naila, 1J
Zain, Ahmad Rifqi Md., 0D
Zhu, Lujia, 0S
Zubairy, M. Suhail, 1N

Conference Committee

Conference Chairs

Agus Muhamad Hatta, Institut Teknologi Sepuluh Nopember (Indonesia)
Aulia M.T. Nasution, Institut Teknologi Sepuluh Nopember (Indonesia)

Patronage

Joni Hermana, Institut Teknologi Sepuluh Nopember (Indonesia)
Bambang L. Widjiantoro, Institut Teknologi Sepuluh Nopember (Indonesia)
Agus Muhamad Hatta, Institut Teknologi Sepuluh Nopember (Indonesia)

Advisory Committee

Bambang Hidajat, Indonesian Academy of Science (Indonesia)
Tjia May On, Indonesian Optical Society (Indonesia)
Suganda Jutamulia, University of Northern California (United States)
Harith Bin Ahmad, Photonics Research Centre (Malaysia)
Silvano Donati, Università degli Studi di Pavia (Italy)

Program Committee

Sekartedjo Koentjoro, Institut Teknologi Sepuluh Nopember (Indonesia)
Suganda Jutamulia, University of Northern California (United States)
Joewono Widjaja, Suranaree University of Technology (Thailand)
Harith Bin Ahmad, University of Malaya (Malaysia)
Sulaiman W. Harun, University of Malaya (Malaysia)
Azzedine Boudrioua, Université Paris 13 (France)
Ajoy Kumar Kar, Heriot Watt University (United Kingdom)
Nurdogan Can, Jazan University (Saudi Arabia)
Deddy Kurniadi, Institut Teknologi Bandung (Indonesia)
Sar Sardy, Universitas Al-Azhar Indonesia (Indonesia)
Mohammad D. Al Amri, King Abdulaziz City for Science and Technology (Saudi Arabia)
Sahbudin Shaari, Universiti Kebangsaan Malaysia (Malaysia)
Erning Wihardjo, Krida Wacana Christian University (Indonesia)
Retna Apsari, Universitas Airlangga (Indonesia)
Tan Ching Seong, Multimedia University (Malaysia)
Murukeshan V. Matham, Nanyang Technological University (Singapore)
P. Susthitha Menon, Universiti Kebangsaan Malaysia (Malaysia)
Mohammad Rakib Uddin, Universiti Teknologi Brunei (Brunei)
Sunao Kurimura, National Institute for Material Sciences (Japan)
Sunish Mathews, University College London (United Kingdom)
Endang Juliastuti Mustofa, Institut Teknologi Bandung (Indonesia)
Suprijanto, Institut Teknologi Bandung (Indonesia)

Suryadi Soekardjo, International Islamic University (Malaysia)
Ginu Rajan, University of Wolongong (Australia)
Qian Wang, Data Storage Institute (Singapore)
Sarun Sumriddetchkajorn, National Electronics and Computer Technology (Thailand)
Mohd Zamani Zulkifli, University of Malaya (Malaysia)
Bambang Widiatmoko, Indonesian Institute of Sciences (Indonesia)
M. Danang Birowosuto, Indonesian Institute of Sciences (Indonesia)
Yusuf Nur Wijayanto, Indonesian Institute of Sciences (Indonesia)
Maria M. Suliyanti, Indonesian Institute of Sciences (Indonesia)
Hendradi Hardhienata, Institut Pertanian Bogor (Indonesia)
Purnomo Sidi Priambodo, Universitas Indonesia (Indonesia)
Retno Wigajatri, Universitas Indonesia (Indonesia)
Henri Putra Uranus, Universitas Pelita Harapan (Indonesia)
Moh. Yasin, Universitas Airlangga (Indonesia)
Hery Suyanto, Universitas Udayana (Indonesia)
Rajesh Kanawade, University of Erlangen (Germany)
Aulia M.T. Nasution, Institut Teknologi Sepuluh Nopember (Indonesia)
Agus Muhammad Hatta, Institut Teknologi Sepuluh Nopember (Indonesia)
Ary Syahriar, Universitas Al-Azhar Indonesia (Indonesia)
Tatas H.P. Brotosudarmo, Ma Chung Research Center (Indonesia)
Pengfei Wang, Harbin Engineering University (China)
Eric Jobiliong, Universitas Pelita Harapan (Indonesia)
Azhar Zam, Ryerson University, Toronto (Canada)
L.Y.M. Tobing, Nanyang Technological University (Singapore)

Session Chairs

- 1 Optical Engineering (OE)
Endang Juliastuti Mustofa, Institut Teknologi Bandung (Indonesia)
- 2 Materials for Optics and Photonics (MOP)
Husin Alatas, Institut Pertanian Bogor (Indonesia)
- 3 Biomedical and Optical Spectroscopy (BOS)
Tatas H.P. Brotosudarmo, Ma Chung Research Center (Indonesia)
- 4 Optical Sensing and Metrology (OSM)
Moh. Yasin, Universitas Airlangga (Indonesia)

Introduction

The Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016) was held in Legian – Kuta, Bali. I am delighted that after the first ISPhOA in October 2014, the Department of Engineering Physics was able to hold and organize this second meeting and to attract renowned speakers and participants from many countries. Many fascinating presentations were given in the field of photonics and optics. We warmly thank you for taking this opportunity to join us and to share important new findings.

This event provides an opportunity to bring together students, scientists, and engineers involved in research and development of technologies related to photonics, optics, and its applications. The information presented includes contributions from colleagues of researchers and academicians and comes from diverse sub-topics in the optics and photonics fields.

I would like to thank the continuous support from Institut Teknologi Sepuluh Nopember (ITS) and the Faculty of Industrial Technology ITS. This meeting would not have been possible without generous funds from the Ministry of Research and Higher Education of Republic Indonesia and ITS.

I would also like to thank our sponsors who generously support this conference: PT. Telkomsel, Zugo Photonics, and PT. Horiba Indonesia. Additionally, I would like to take this opportunity to thank our co-sponsors: the International Commission of Optics (ICO), the Abdus Salam International Centre for Theoretical Physics (ICTP), the Optical Society (OSA), European Optical Society (EOS), and the Optics and Photonics Society of Singapore (OPSS). We are really grateful that this conference is also supported by the Indonesian Optical Society, OSA Indonesia Section, OSA – ITS Student Chapter and SPIE – ITS Student Chapter.

A special thank you to all members of the Advisory Committee, Steering Committee, Scientific Committee, Organizing Committee and to our distinguished international board of reviewers for all their support and advice. We would like also to extend our gratitude to our colleagues from the Faculty of Science, University of Udayana for their support.

**Agus Muhamad Hatta
Aulia M.T. Nasution**

PROCEEDINGS VOLUME 10150

SECOND INTERNATIONAL SEMINAR ON PHOTONICS, OPTICS, AND ITS APPLICATIONS (ISPhOA 2016) | 24-25 AUGUST 2016

Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016)

Editor(s): [Agus M. Hatta \(/profile/Agus.Hatta-90794\)](#), [Aulia M. T. Nasution \(/profile/Aulia.Nasution-111956\)](#)

SECOND INTERNATIONAL SEMINAR ON PHOTONICS, OPTICS, AND ITS APPLICATIONS (ISPhOA 2016)
 24-25 August 2016
 Bali, Indonesia

[View the SPIE Conference + Exhibitions Calendar \(/https://spie.org/conferences-and-exhibitions?webSyncID=a5a58c92-a38a-bd9b-4217-961b3eb26768&sessionGUID=8ca2435b-5a3e-ace7-0b74-a9771b7d7359\)](#)

IN THIS VOLUME

2 Sessions, 46 Papers, 0 Presentations

Front Matter: Volume 10150 (1)

Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016)
 (45)

 [Subscribe to Digital Library \(/subscribe-page\)](#)



[VIEW ALL ABSTRACTS](#) + ()

FRONT MATTER: VOLUME 10150

Front Matter: Volume 10150 (/conference-proceedings-of-spie/10150/1015001/Front-Matter-Volume-10150/10.1117/12.2263579.full)

 **Open Access**

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 1015001 (11 November 2016); doi: 10.1117/12.2263579

[Read Abstract +](#)

SECOND INTERNATIONAL SEMINAR ON PHOTONICS, OPTICS, AND ITS APPLICATIONS (ISPhOA 2016)

Thermo-optic effects on three waveguide directional couplers (/conference-proceedings-of-spie/10150/1015002/Thermo-optic-effects-on-three-waveguide-directional-couplers/10.1117/12.2239935.full)

[Hikmatyarsyah Hikmatyarsyah \(/profile/Hikmatyarsyah.Ismail-268331\)](#), [Ary Syahriar \(/profile/Ary.Syahriar-1147\)](#)

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 1015002 (11 November 2016); doi: 10.1117/12.2239935

[Read Abstract +](#)

Particle tracking by using single coefficient of Wigner-Ville distribution (/conference-proceedings-of-

spie/10150/1015004/Particle-tracking-by-using-single-coefficient-of-Wigner-Ville-distribution/10.1117/12.2242418.full)

[J. Widjaja \(/profile/Joewono.Widjaja-11514\)](#), [S. Dawprateep \(/profile/Saowaros.Dawprateep-4249061\)](#), [P. Chuamchaitrakool \(/profile/pornitip.ctrakool-4580\)](#), [P. Meemon \(/profile/Panomsak.Meemon\)](#)

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 1015004 (11 November 2016); doi: 10.1117/12.2242418

[Read Abstract +](#)

Optimization design of periscope type 3X zoom lens design for a five megapixel cellphone camera ([/conference-proceedings-of-spie/10150/1015005/Optimization-design-of-periscope-type-3X-zoom-lens-design-for/10.1117/12.2243280.full](#))
[Wen-Shing Sun](#) ([/profile/Wen-Shing.Sun-24335](#)), [Chuen-Lin Tien](#) ([/profile/Chuen-Lin.Tien-110340](#)), [Jui-Wen Pan](#) ([/profile/notfound?author=Jui-Wen_Pan](#)), [Yu-Hao Chao](#) ([/profile/Yu-Hao.Chao-263078](#)), [Pu-Yi Chu](#) ([/profile/Pu-Yi.Chu-8212](#)).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 1015005 (11 November 2016); doi: 10.1117/12.2243280

[Read Abstract +](#)

Comparative study of boundary conditions with helix ([/conference-proceedings-of-spie/10150/1015006/Comparative-study-of-boundary-conditions-with-helix/10.1117/12.2243425.full](#))
[Shamini Pillay](#) ([/profile/Shamini.Pillay-274349](#)), [Deepak Kumar](#) ([/profile/notfound?author=Deepak_Kumar](#)), [Y. N. Phua](#) ([/profile/notfound?author=Y._N._Phua](#)).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 1015006 (11 November 2016); doi: 10.1117/12.2243425

[Read Abstract +](#)

Intensity based sensor based on single mode optical fiber patchcords ([/conference-proceedings-of-spie/10150/1015007/Intensity-based-sensor-based-on-single-mode-optical-fiber-patchcords/10.1117/12.2243600.full](#))
[Dwi Bayuwati](#) ([/profile/Dwi.Bayuwati-7185](#)), [Tomi Budi Waluyo](#) ([/profile/notfound?author=Tomi_Budi_Waluyo](#)), [Imam Mulyanto](#) ([/profile/notfound?author=Imam_Mulyanto](#)).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 1015007 (11 November 2016); doi: 10.1117/12.2243600

[Read Abstract +](#)

Design and simulation of GRIN objective lenses for an imaging fiber based speckle metrology system ([/conference-proceedings-of-spie/10150/1015008/Design-and-simulation-of-GRIN-objective-lenses-for-an-imaging/10.1117/12.2243778.full](#))
[P. Prabhathan](#) ([/profile/Patinharekandy.Prabhathan-107027](#)), [A. S. Guru Prasad](#) ([/profile/Dr.GuruPrasadAS](#)), [Aswin Haridas](#) ([/profile/Aswin.Haridas-3767348](#)), [Kelvin H. K. Chan](#) ([/profile/notfound?author=Kelvin_H._Chan](#)), [V. M. Murukeshan](#) ([/profile/Vadakke.Murukeshan-15183](#)).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 1015008 (11 November 2016); doi: 10.1117/12.2243778

[Read Abstract +](#)

Double biprism arrays design using for stereo-photography of mobile phone camera ([/conference-proceedings-of-spie/10150/1015009/Double-biprism-arrays-design-using-for-stereo-photography-of-mobile/10.1117/12.2243788.full](#))
[Wen-Shing Sun](#) ([/profile/Wen-Shing.Sun-24335](#)), [Pu-Yi Chu](#) ([/profile/Pu-Yi.Chu-8212](#)), [Yu-Hao Chao](#) ([/profile/Yu-Hao.Chao-263078](#)), [Jui-Wen Pan](#) ([/profile/notfound?author=Jui-Wen_Pan](#)), [Chuen-Lin Tien](#) ([/profile/Chuen-Lin.Tien-110340](#)).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 1015009 (11 November 2016); doi: 10.1117/12.2243788

[Read Abstract +](#)

Analysis of excimer laser radiant exposure effect toward corneal ablation volume at LASIK procedure

([/conference-proceedings-of-spie/10150/101500B/Analysis-of-excimer-laser-radiant-exposure-effect-toward-corneal-ablation/10.1117/12.2243826.full](#))

[Rima Fitri Adiati](#) ([/profile/Rima.Adiati-247936](#)), [Artha Bona Rini Rizki](#) ([/profile/Artha.Rini-Rizki-9365](#)), [Apriani Kusumawardhani](#) ([/profile/notfound?author=Apriani_Kusumawardhani](#)), [Heru Setijono](#) ([/profile/notfound?author=Heru_Setijono](#)), [Andi Rahmadiansah](#) ([/profile/notfound?author=Andi_Rahmadiansah](#)).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 101500B (11 November 2016); doi: 10.1117/12.2243826

[Read Abstract +](#)

Pre-cataract surgery test using speckle pattern ([/conference-proceedings-of-spie/10150/101500C/Pre-cataract-surgery-test-using-speckle-pattern/10.1117/12.2244634.full](#))
[Suganda Jutamulia](#) ([/profile/Suganda.Jutamulia-5326](#)), [Erning Wihardjo](#) ([/profile/erning.wihardjo-4806](#)), [Joewono Widjaja](#) ([/profile/Joewono.Widjaja-11514](#)).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 101500C (11 November 2016); doi: 10.1117/12.2244634

[Read Abstract +](#)

Modeling of Si/Ge based two-dimensional photonic crystal nanocavity ([/conference-proceedings-of-spie/10150/101500D/Modeling-of-SiGe-based-two-dimensional-photonic-crystal-nanocavity/10.1117/12.2247522.full](#))
[Lita Rahmasari](#) ([/profile/Lita.Rahmasari-280029](#)), [Ahmad Rifqi Md. Zain](#) ([/profile/ahmad-rifqi.md-zain-4031905](#)), [Abdul Manaf Hashim](#) ([/profile/notfound?author=Abdul_Manaf_Hashim](#)).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 101500D (11 November 2016); doi: 10.1117/12.2247522

[Read Abstract +](#)

Effect of the focal plane position on CO2 laser beam cutting of injection molded polycarbonate sheets

([/conference-proceedings-of-spie/10150/101500F/Effect-of-the-focal-plane-position-on-CO2-laser-beam/10.1117/12.2248416.full](#))

[Mahmoud Moradi](#) ([/profile/Mahmoud.Moradi-282133](#)), [Omid Mehrabi](#) ([/profile/notfound?author=Omid_Mehrabi](#)), [Taher Azdast](#) ([/profile/notfound?author=Taher_Azdast](#)), [Khaled Y. Benyounis](#) ([/profile/notfound?author=Khaled_Benyounis](#)).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 101500F (11 November 2016); doi: 10.1117/12.2248416

[Read Abstract +](#)**Optimization of optical filter using triple coupler ring resonators structure based on polyimide substrate**

(/conference-proceedings-of-spie/10150/101500H/Optimization-of-optical-filter-using-triple-coupler-ring-resonators-structure/10.1117/12.2248459.full)

D. Mahmudin (/profile/Dadin.Mahmudin-274305), *T. T. Estu* (/profile/notfound?author=T._Estu), *A. A. Fathnan* (/profile/notfound?author=A._Fathnan), *Y. Y. Maulana* (/profile/notfound?author=Y._Maulana), *P. Daud* (/profile/notfound?author=P._Daud), *G. Sugandhi* (/profile/notfound?author=G._Sugandhi), *Y. N. Wijayanto* (/profile/Yusuf.Wijayanto-4820).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 101500H (11 November 2016); doi: 10.1117/12.2248459

[Read Abstract +](#)**Investigation of load effect on macro-bend losses for an SMS fiber structure with a small bend radius**

(/conference-proceedings-of-spie/10150/101500L/Investigation-of-load-effect-on-macro-bend-losses-for-an/10.1117/12.2248468.full)

Fitri Rahmah (/profile/Fitri.Rahmah-7048), *Sekartedjo Sekartedjo* (/profile/Sekartedjo.Koentjoro-4983), *Agus Muhamad Hatta* (/profile/Agus.Hatta-90794).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 101500L (11 November 2016); doi: 10.1117/12.2248468

[Read Abstract +](#)**Laser-Induced Breakdown Spectroscopy (LIBS) for spectral characterization of regular coffee beans and luwak coffee bean**

(/conference-proceedings-of-spie/10150/101500M/Laser-Induced-Breakdown-Spectroscopy-LIBS-for-spectral-characterization-of-regular/10.1117/12.2248469.full)

Nufiqurakhmah Nufiqurakhmah (/profile/Nufiqurakhmah.Ardani-282727), *Aulia Nasution* (/profile/Aulia.Nasution-111956), *Hery Suyanto* (/profile/Hery.Suyanto-9635).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 101500M (11 November 2016); doi: 10.1117/12.2248469

[Read Abstract +](#)**Thermal signature analysis of human face during jogging activity using infrared thermography technique**

(/conference-proceedings-of-spie/10150/101500N/Thermal-signature-analysis-of-human-face-during-jogging-activity-using/10.1117/12.2248478.full)

Putria Widya Budiarti (/profile/Putria.Budiarti-7917), *Apriani Kusumawardhani* (/profile/notfound?author=Apriani._Kusumawardhani), *Heru Setijono* (/profile/notfound?author=Heru._Setijono).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 101500N (11 November 2016); doi: 10.1117/12.2248478

[Read Abstract +](#)**Alcohol sensor based on single-mode-multimode-single-mode fiber structure**

(/conference-proceedings-of-spie/10150/101500O/Alcohol-sensor-based-on-single-mode-multimode-single-mode-fiber/10.1117/12.2248489.full)

Mefina Yulias R. (/profile/MEFINA-YULIAS.ROFIANINGRUM-282587), *A. M. Hatta* (/profile/Agus.Hatta-90794), *Sekartedjo Sekartedjo* (/profile/Sekartedjo.Koentjoro-4983).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 101500O (11 November 2016); doi: 10.1117/12.2248489

[Read Abstract +](#)**Crude oil specific gravity sensor design using polymer optical fiber with structural imperfection**

(/conference-proceedings-of-spie/10150/101500P/Crude-oil-specific-gravity-sensor-design-using-polymer-optical-fiber/10.1117/12.2248492.full)

Junivan Sulistianto (/profile/Junivan.Sulistianto-282772), *Agus M. Hatta* (/profile/Agus.Hatta-90794), *Ir. Sekartedjo* (/profile/Sekartedjo.Koentjoro-4983).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 101500P (11 November 2016); doi: 10.1117/12.2248492

[Read Abstract +](#)**Design of SMS (Single mode-Multi mode coreless-Single mode) optical fiber as corrosion sensor**

(/conference-proceedings-of-spie/10150/101500Q/Design-of-SMS-Single-mode-Multi-mode-coreless-Single-mode/10.1117/12.2248493.full)

Putri Yeni Aisyah (/profile/Putri.Aisyah-251409), *Agus M. Hatta* (/profile/Agus.Hatta-90794), *Detak Yan Pratama* (/profile/notfound?author=Detak._Yan._Pratama).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 101500Q (11 November 2016); doi: 10.1117/12.2248493

[Read Abstract +](#)**Relative humidity sensor based on SMS fiber structure using multimode coreless fiber**

(/conference-proceedings-of-spie/10150/101500R/Relative-humidity-sensor-based-on-SMS-fiber-structure-using-multimode/10.1117/12.2248498.full)

Sanif Syafrani (/profile/sanif.syafrani-282791), *Agus M. Hatta* (/profile/Agus.Hatta-90794), *Apriani Kusumawardhani* (/profile/notfound?author=Apriani._Kusumawardhani).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 101500R (11 November 2016); doi: 10.1117/12.2248498

[Read Abstract +](#)

Experimental study on strain sensing by small-diameter FBG ([/conference-proceedings-of-spie/10150/101500S/Experimental-study-on-strain-sensing-by-small-diameter-FBG/10.1117/12.2241497.full](#))

[Rong-mei Liu](#) ([/profile/Rong-Mei.Liu-92693](#)), [Qiufeng Li](#) ([/profile/notfound?author=Qiufeng_Li](#)), [Lujia Zhu](#) ([/profile/notfound?author=Lujia_Zhu](#)), [Dakai Liang](#) ([/profile/notfound?author=Dakai_Liang](#)).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 101500S (11 November 2016); doi: 10.1117/12.2241497

[Read Abstract +](#)

Improved optical side coupling efficiency by spiral patterned zinc oxide nanorod coatings on large core plastic optical fiber ([/conference-proceedings-of-spie/10150/101500T/Improved-optical-side-coupling-efficiency-by-spiral-patterned-zinc-oxide/10.1117/12.2241640.full](#))

[A. R. H. Rafis](#) ([/profile/notfound?author=A_R_H_Rafis](#)), [W. H. Sulaima](#) ([/profile/notfound?author=W_H_Sulaima](#)), [S. M. Waleed](#) ([/profile/notfound?author=S_M_Waleed](#)).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 101500T (11 November 2016); doi: 10.1117/12.2241640

[Read Abstract +](#)

Black phosphorus as a saturable absorber for generating mode-locked fiber laser in normal dispersion regime

([/conference-proceedings-of-spie/10150/101500U/Black-phosphorus-as-a-saturable-absorber-for-generating-mode-locked/10.1117/12.2243416.full](#))

[A. A. Latiff](#) ([/profile/Anas.Abdul-Latiff-273601](#)), [M. F. M. Rusdi](#) ([/profile/notfound?author=M_F_Rusdi](#)), [M. B. Hisyam](#) ([/profile/notfound?author=M_B_Hisyam](#)), [H. Ahmad](#) ([/profile/harith.ahmad-1405](#)), [S. W. Harun](#) ([/profile/notfound?author=S_W_Harun](#)).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 101500U (11 November 2016); doi: 10.1117/12.2243416

[Read Abstract +](#)

Low-cost chlorophyll meter (LCCM): portable measuring device for leaf chlorophyll ([/conference-proceedings-of-spie/10150/101500V/Low-cost-chlorophyll-meter-LCCM--portable-measuring-device-for/10.1117/12.2243607.full](#))

[Evan Hutomo E. P.](#) ([/profile/evanhutomo-274000](#)), [Marcelinus Alfasisurya S. Adibawa](#) ([/profile/notfound?author=Marcelinus_Alfasisurya_S_Adibawa](#)), [Kestrlia R. Prilianti](#) ([/profile/notfound?author=Kestrlia_R_Prilianti](#)), [Heriyanto Heriyanto](#) ([/profile/notfound?author=Heriyanto_Heriyanto](#)), [Tatas H. P. Brotosudarmo](#) ([/profile/Tatas-Hardo-Panintjingati.Brotosudarmo-286900](#)).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 101500V (11 November 2016); doi: 10.1117/12.2243607

[Read Abstract +](#)

Liquid salinity sensor based on D-shaped single mode fibers coated with In-Ga-Zn-O thin film ([/conference-proceedings-of-spie/10150/101500Z/Liquid-salinity-sensor-based-on-D-shaped-single-mode-fibers/10.1117/12.2243813.full](#))

[Chuen-Lin Tien](#) ([/profile/Chuen-Lin.Tien-110340](#)), [Hao-Sheng Mao](#) ([/profile/notfound?author=Hao-Sheng_Mao](#)), [Hong-Yi Lin](#) ([/profile/notfound?author=Hong-Yi_Lin](#)), [Wen-Shing Sun](#) ([/profile/Wen-Shing.Sun-24335](#)).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 101500Z (11 November 2016); doi: 10.1117/12.2243813

[Read Abstract +](#)

Simulations of unpolarized light scattering by micro-bubble ([/conference-proceedings-of-spie/10150/1015010/Simulations-of-unpolarized-light-scattering-by-micro-bubble/10.1117/12.2243818.full](#))

[Grace Gita Redhyka](#) ([/profile/Grace-Gita.Redhyka-260752](#)), [Ivana Eka Putri](#) ([/profile/notfound?author=Ivana_Eka_Putri](#)), [Hilman Syaeful Alam](#) ([/profile/notfound?author=Hilman_Syaeful_Alam](#)).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 1015010 (11 November 2016); doi: 10.1117/12.2243818

[Read Abstract +](#)

Integrated ZnO nanoparticles on paper-based microfluidic: toward efficient analytical device for glucose detection based on impedance and FTIR measurement ([/conference-proceedings-of-spie/10150/1015011/Integrated-ZnO-nanoparticles-on-paper-based-microfluidic--toward-efficient/10.1117/12.2243827.full](#))

[Rio Akbar Yuwono](#) ([/profile/notfound?author=Rio_Akbar_Yuwono](#)), [Mokhammad Fahmi Izzidharruddin](#) ([/profile/notfound?author=Mokhammad_Fahmi_Izzidharruddin](#)), [Ruri Agung Wahyuono](#) ([/profile/Ruri-Agung.Wahyuono-1350](#)).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 1015011 (11 November 2016); doi: 10.1117/12.2243827

[Read Abstract +](#)

Electrical properties of ZnO-based photodetector prepared by room temperature DC unbalanced magnetron sputtering ([/conference-proceedings-of-spie/10150/1015013/Electrical-properties-of-ZnO-based-photodetector-prepared-by-room-temperature/10.1117/12.2243831.full](#))

[Eka Nurfani](#) ([/profile/Eka.Nurfani-273163](#)), [Angga Virdian](#) ([/profile/notfound?author=Angga_Virdian](#)), [Robi Kurniawan](#) ([/profile/notfound?author=Robi_Kurniawan](#)), [Shibghatullah Muhammady](#) ([/profile/notfound?author=Shibghatullah_Muhammady](#)), [Inge M. Sutjahja](#) ([/profile/notfound?author=Inge_Sutjahja](#)), [Toto Winata](#) ([/profile/notfound?author=Toto_Winata](#)), [Yudi Darma](#) ([/profile/notfound?author=Yudi_Darma](#)).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 1015013 (11 November 2016); doi: 10.1117/12.2243831

[Read Abstract +](#)**An SMS structure based temperature sensor using a chalcogenide multimode fibre** ([/conference-proceedings-of-spie/10150/1015015/An-SMS-structure-based-temperature-sensor-using-a-chalcogenide-multimode/10.1117/12.2246833.full](#))*Pengfei Wang* ([/profile/Pengfei.Wang-96850](#)), *Libo Yuan* ([/profile/Libo.Yuan-12012](#)), *Gilberto Brambilla* ([/profile/notfound?author=Gilberto_Brambilla](#)), *Gerald Farrell* ([/profile/Gerald.Farrell-16222](#)).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 1015015 (11 November 2016); doi: 10.1117/12.2246833

[Read Abstract +](#)**Raman tweezers spectroscopy study of free radical induced oxidative stress leading to eryptosis** ([/conference-proceedings-of-spie/10150/1015016/Raman-tweezers-spectroscopy-study-of-free-radical-induced-oxidative-stress/10.1117/12.2248461.full](#))*Surekha Barkur* ([/profile/Surekha.Barkur-3447](#)), *Aseefhali Bankapur* ([/profile/Aseefhali.Bankapur-111527](#)), *Santhosh Chidangil* ([/profile/Santhosh.Chidangil-31666](#)).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 1015016 (11 November 2016); doi: 10.1117/12.2248461

[Read Abstract +](#)**The 3D scanner prototype utilize object profile imaging using line laser and octave software** ([/conference-proceedings-of-spie/10150/1015017/The-3D-scanner-prototype-utilize-object-profile-imaging-using-line/10.1117/12.2248471.full](#))*Mugi Nurdini* ([/profile/Mugi.Nurdini-282738](#)), *Trikarsa Tirtadwipa Manunggal* ([/profile/notfound?author=Trikarsa_Tirtadwipa_Manunggal](#)), *Agus Samsi* ([/profile/notfound?author=Agus_Samsi](#)).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 1015017 (11 November 2016); doi: 10.1117/12.2248471

[Read Abstract +](#)**Iris biometric system design using multispectral imaging** ([/conference-proceedings-of-spie/10150/1015018/Iris-biometric-system-design-using-multispectral-imaging/10.1117/12.2248473.full](#))*Benedictus Yohanes Bagus Yohanes Bagus Widhianto* ([/profile/Benedictus-Yohanes-Bagus.Widhianto-282745](#)), *Aulia M. T. Nasution* ([/profile/Aulia.Nasution-111956](#)).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 1015018 (11 November 2016); doi: 10.1117/12.2248473

[Read Abstract +](#)**Recognition of spectral identifier from green coffee beans of arabica and robusta varieties using laser-induced breakdown spectroscopy** ([/conference-proceedings-of-spie/10150/1015019/Recognition-of-spectral-identifier-from-green-coffee-beans-of-arabica/10.1117/12.2248474.full](#))*Karina Anggraeni* ([/profile/Karina.Anggraeni-282737](#)), *Aulia Nasution* ([/profile/Aulia.Nasution-111956](#)), *Hery Suyanto* ([/profile/Hery.Suyanto-9635](#)).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 1015019 (11 November 2016); doi: 10.1117/12.2248474

[Read Abstract +](#)**Spectral identifiers from roasting process of Arabica and Robusta green beans using Laser-Induced Breakdown Spectroscopy (LIBS)** ([/conference-proceedings-of-spie/10150/101501A/Spectral-identifiers-from-roasting-process-of-Arabica-and-Robusta-green/10.1117/12.2248475.full](#))*Ayu Puspa Wirani* ([/profile/Ayu-Puspa.Wirani-282253](#)), *Aulia Nasution* ([/profile/Aulia.Nasution-111956](#)), *Hery Suyanto* ([/profile/Hery.Suyanto-9635](#)).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 101501A (11 November 2016); doi: 10.1117/12.2248475

[Read Abstract +](#)**Fabrication of SnO₂ nanoparticles straight waveguide with isopropanol solvent** ([/conference-proceedings-of-spie/10150/101501B/Fabrication-of-SnO2-nanoparticles-straight-waveguide-with-isopropanol-solvent/10.1117/12.2248477.full](#))*R. Lucky Putri* ([/profile/lucky.rahayu-282463](#)), *Yono H. Pramono* ([/profile/notfound?author=Yono_Pramono](#)), *Asnawi Asnawi* ([/profile/notfound?author=Asnawi_Asnawi](#)), *Y. Gatut* ([/profile/notfound?author=Y_Gatut](#)).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 101501B (11 November 2016); doi: 10.1117/12.2248477

[Read Abstract +](#)**The effect of packaging material on optical fiber temperature sensor with singlemode multimode singlemode (SMS) structure** ([/conference-proceedings-of-spie/10150/101501C/The-effect-of-packaging-material-on-optical-fiber-temperature-sensor/10.1117/12.2248487.full](#))*Ashri Khusnul Chotimah* ([/profile/Ashri.Khusnul-Chotimah-282771](#)), *Agus Muhamad Hatta* ([/profile/Agus.Hatta-90794](#)), *Detak Yan Pratama* ([/profile/notfound?author=Detak_Yan_Pratama](#)).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 101501C (11 November 2016); doi: 10.1117/12.2248487

[Read Abstract +](#)

Multimode-singlemode-multimode fiber sensor for alcohol sensing application ([/conference-proceedings-of-spie/10150/101501D/Multimode-singlemode-multimode-fiber-sensor-for-alcohol-sensing-application/10.1117/12.2248491.full](#))
Iftihatur Rofi'ah ([/profile/iftihatur.rofi'ah-282781](#)), *A. M. Hatta* ([/profile/Agus.Hatta-90794](#)), *Sekartedjo Sekartedjo* ([/profile/Sekartedjo.Koentjoro-4983](#)).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 101501D (11 November 2016); doi: 10.1117/12.2248491

[Read Abstract +](#)

Packaging aluminum impacting on optical fiber with Singlemode-Multimode-Singlemode (SMS) fiber structure ([/conference-proceedings-of-spie/10150/101501E/Packaging-aluminum-impacting-on-optical-fiber-with-Singlemode-Multimode-Singlemode/10.1117/12.2248497.full](#))

Damayanti Sari ([/profile/Damayanti.Sari-282676](#)), *Agus Hatta* ([/profile/Agus.Hatta-90794](#)), *Detak Yan Pratama* ([/profile/notfound?author=Detak_Yan_Pratama](#)).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 101501E (11 November 2016); doi: 10.1117/12.2248497

[Read Abstract +](#)

Alcohol sensor based on u-bent hetero-structured fiber optic ([/conference-proceedings-of-spie/10150/101501F/Alcohol-sensor-based-on-u-bent-hetero-structured-fiber-optic/10.1117/12.2248500.full](#))

Sefi N. Patrialova ([/profile/Sefi.Patrialova-282795](#)), *Agus M. Hatta* ([/profile/Agus.Hatta-90794](#)), *Sekartedjo Sekartedjo* ([/profile/Sekartedjo.Koentjoro-4983](#)).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 101501F (11 November 2016); doi: 10.1117/12.2248500

[Read Abstract +](#)

Comparison microbial killing efficacy between sonodynamic therapy and photodynamic therapy ([/conference-proceedings-of-spie/10150/101501G/Comparison-microbial-killing-eficacy-between-sonodynamic-therapy-and-photodynamic-therapy/10.1117/12.2248503.full](#))

Nike Dwi Grevika Drantantiyas ([/profile/NIKE.DRANTANTIYAS-4191751](#)), *Suryani Dyah Astuti* ([/profile/Suryani-Dyah.Astuti-4137276](#)), *Aulia M. T. Nasution* ([/profile/Aulia.Nasution-111956](#)).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 101501G (11 November 2016); doi: 10.1117/12.2248503

[Read Abstract +](#)

Fabrication slab waveguide based polymethyl methacrylate (PMMA) with spin coating method ([/conference-proceedings-of-spie/10150/101501H/Fabrication-slab-waveguide-based-polymethyl-methacrylate-PMMA-with-spin-coating/10.1117/12.2248504.full](#))

Alan Andriawan ([/profile/Alan.Andriawan-282792](#)), *Yono Hadi Pramono* ([/profile/notfound?author=Yono_Hadi_Pramono](#)), *Asnawi Masoed* ([/profile/notfound?author=Asnawi_Masoed](#)).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 101501H (11 November 2016); doi: 10.1117/12.2248504

[Read Abstract +](#)

Self-mixing interferometry: a novel yardstick for mechanical metrology ([/conference-proceedings-of-spie/10150/101501I/Self-mixing-interferometry-a-novel-yardstick-for-mechanical-metrology/10.1117/12.2248912.full](#))

Silvano Donati ([/profile/Silvano.Donati-7753](#)).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 101501I (11 November 2016); doi: 10.1117/12.2248912

[Read Abstract +](#)

Static detection of flat head railways depletion using analysis of laser area and position on rail type R-54

([/conference-proceedings-of-spie/10150/101501J/Static-detection-of-flat-head-railways-depletion-using-analysis-of/10.1117/12.2247552.full](#))

Edwin Masykuri ([/profile/notfound?author=Edwin_Masykuri](#)), *Endang Juliastuti* ([/profile/Endang.Juliastuti-6431](#)), *Suprijanto Suprijanto* ([/profile/Dr.Suprijanto-281364](#)), *Naila Zahra* ([/profile/Naila.Zahra-2787](#)).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 101501J (11 November 2016); doi: 10.1117/12.2247552

[Read Abstract +](#)

Design of biometrics identification system on palm vein using infrared light ([/conference-proceedings-of-spie/10150/101501K/Design-of-biometrics-identification-system-on-palm-vein-using-infrared/10.1117/12.2248505.full](#))

Muhammad Syafiq ([/profile/Muhammad.Syafiq-248238](#)), *Aulia M. T. Nasution* ([/profile/Aulia.Nasution-111956](#)).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 101501K (11 November 2016); doi: 10.1117/12.2248505

[Read Abstract +](#)

Analysis of spectral identifier of fatty acid functional group of packaging frying oil and bulk frying oil with the effect of repeated heating using FTIR (Fourier Transform InfraRed) spectroscopy ([/conference-proceedings-of-spie/10150/101501M/Analysis-of-spectral-identifier-of-fatty-acid-functional-group-of/10.1117/12.2248496.full](#))

Vinda Dwi Dini Putri ([/profile/Vinda.Putri-282744](#)), *Aulia M. T. Nasution* ([/profile/Aulia.Nasution-111956](#)).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 101501M (11 November 2016); doi: 10.1117/12.2248496

[Read Abstract +](#)

Quantum teleportation without classical channel (</conference-proceedings-of-spie/10150/101501N/Quantum-teleportation-without-classical-channel/10.1117/12.2267245.full>)
M. Al Amri (</profile/Mohammad.Al-Amri-287668>), *Zheng-Hong Li* (/profile/notfound?author=Zheng-Hong_Li), *M. Suhail Zubairy* (</profile/M.-Suhail.Zubairy-13174>).

Proc. SPIE 10150, Second International Seminar on Photonics, Optics, and Its Applications (ISPhOA 2016), 101501N (11 November 2016); doi: 10.1117/12.2267245

[Read Abstract +](#)

Thermo-optic Effects on Three Waveguide Directional Couplers

Hikmatyarsyah* , Ary Syahriar

Department of Electrical Engineering, Faculty of Science and Technology, University of Al Azhar Indonesia, Sisingamangaraja Street, Kebayoran Baru, Jakarta, 12110, Phone (021) 727 92753, Fax (021) 724 4767

ABSTRACT

We studied the thermo-optic effects in detuned antisymmetric three waveguide directional couplers analytically, we analyzed the effects on switching operation on several temperature changes, which cause different switching characteristics, especially the value of propagation constant mismatch. Based on this research, it concluded that the system with three identical waveguides in which the beam launched into middle waveguide is better system to withstand cross state condition in higher temperature. Note that the system's limit changes of propagation constant mismatch in which could hold the cross state performance is $\Delta\beta = -0.4 - 0.4$ before heated, $\Delta\beta = -1.4 - 1.4$ after heated 10°C and $\Delta\beta = -2.7 - 2.7$ after heated 20°C.

Keywords: thermo-optic effect, detuned antisymmetrically three-guide directional coupler, cross state, propagation constant mismatch.

1. INTRODUCTION

Two waveguide directional coupler is the common optical coupler components used in optical communication system. It has two input ports and two output ports, and is composed of two closely spaced waveguides. By placing a third waveguide between the two waveguides is what this paper analyzed. One advantage of using this scheme is that it can reduce the physical length of the device significantly from conventional system due to minimum coupling length requirement¹. But at the time of fabrication, frequent imperfections happen in the making of coupling length of the coupler. In this manner, to balance it out, the propagation constant mismatch or $\Delta\beta$ between two interacting waveguides or the coupling constants can be varied electrically to match the imperfection². Then the optical beam is switched completely from one waveguide to another (cross state) without changing the coupling length which function of propagation direction. In this paper, Applying three silica (SiO₂) waveguides of an optical switch are identical and equally spaced and used 1550 nm in wavelength, we examine the switching mechanism for cases where an initial power/beam is launched into a waveguide one and into a waveguide two. For each power-launched case, switching voltage is applied so that the overall index is detuned antisymmetrically. After the system is detuned, we observing temperature dependence as function of propagation constant mismatch where the cases are heated every 10°C from assume the initial temperature is 25°C to 45°C.

2. TEMPERATURE EFFECT ON REFRACTIVE INDEX

The thermo-optic effect is a phenomenon by which the refractive index of a substance changes with temperature. In most used material like silica glass, this effect is characterized by an increase in the refractive index as the temperature rises. Since absolute refractive index is generally a function of both wavelength and temperature, it is important to know refractive indices at the optical system's design operating temperature. Further, for large, refractive, optical components, spatial variation of both a material's refractive index and its thermo-optic coefficient (dn/dT) can be potentially damaging to optical system performance³.

*hikmatyar19@gmail.com; phone (+62) 815 1987 0773;

Differentiating the Lorentz-Lorenz equation with respect to temperature, gives the temperature dependence of refractive index⁴. Decreasing density with temperature decreases refractive index, whereas a positive change in polarizability with temperature increases refractive index. Therefore, high thermal expansion materials such as the alkali and thallium halides have negative thermo-optic coefficients, whereas low thermal expansion materials such as diamond and silicon carbide have positive thermo-optic coefficients (TOC). Due to small contribution of thermal expansion coefficient (TOE) to influence the switching, so that it can be ignored.

In this study, the typical values of the refractive index of the SiO₂ are around 1.46 and at 1550 nm, respectively⁵. Relation between refractive index and thermo-optic coefficient given by⁶ :

$$n_T = n_R + (T - R) \left(\frac{dn}{dT} \right) \quad (1)$$

where T is the temperature in °C, R is the room temperature, n_T and n_R are the refractive index at T and at room temperature, respectively. From Equation (1) gives positive TOC on this proposed 7 μm core width planar waveguide-type which the relation between effective refractive index as function of temperature as shown in Figure 1 below.

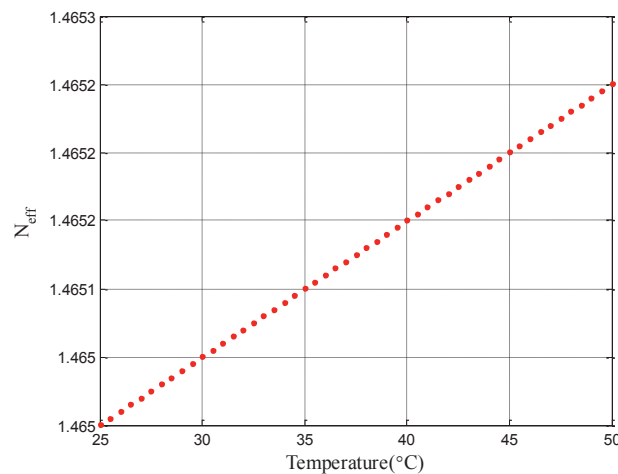


Figure 1. Increases effective refractive index as function of rising temperature for 7 microns width of core SiO₂ planar waveguide-type.

3. THREE WAVEGUIDE DIRECTIONAL COUPLER SYSTEM

Consider the waveguides are identical, symmetric, equally spaced as Figure 2. The coupled-mode equations for this three-waveguide system are described as follows⁷:

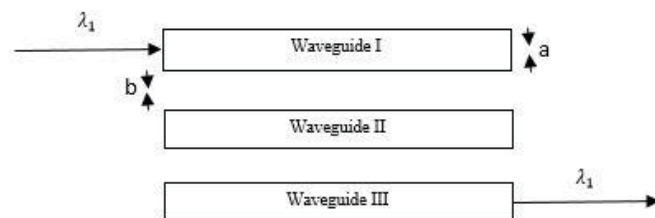


Figure 2. The proposed system of three identical directional coupler on this SiO₂ planar type waveguide where a and b are both 7 microns and refractive index $n=1.465$ at $\lambda=1550$ nm.

$$\frac{d}{dz}A_1(z) = -j\kappa_1 A_2(z)e^{j\Delta\beta_1 z} \quad (2a)$$

$$\frac{d}{dz}A_2(z) = -j\kappa_1 A_1(z)e^{-j\Delta\beta_1 z} - j\kappa_3 A_3(z)e^{-j\Delta\beta_3 z} \quad (2b)$$

$$\frac{d}{dz}A_3(z) = -j\kappa_3 A_2(z)e^{j\Delta\beta_3 z} \quad (2c)$$

Where

$$\Delta\beta_1 = \beta_1 - \beta_2 \quad (3a)$$

$$\Delta\beta_3 = \beta_3 - \beta_2 \quad (3b)$$

β_1, β_2 and β_3 is the propagation constant of each waveguide. $\Delta\beta_1$ and $\Delta\beta_3$ are extent of detuning of β_1 and β_3 from β_2 , respectively. Since in this paper, where the case of each waveguide is identical and equally spaced, $\kappa_1 = \kappa_3 = \kappa$.

The solution when $\Delta\beta_1 = \Delta\beta_3 = 0$ can be written as⁸ :

1. Initial condition for waveguide 1 as source of power is applied inside of it will be:

$$a(z) = \begin{bmatrix} \frac{1}{2} + \frac{1}{2} \cos(\kappa\sqrt{2}z) \\ -\frac{1}{\sqrt{2}} j \sin(\kappa\sqrt{2}z) \\ -\frac{1}{2} + \frac{1}{2} \cos(\kappa\sqrt{2}z) \end{bmatrix} \quad (4a)$$

2. Initial condition for waveguide 2 as source of power is applied inside of it will be:

$$a(z) = \begin{bmatrix} -\frac{1}{\sqrt{2}} j \sin(\kappa\sqrt{2}z) \\ \cos(\kappa\sqrt{2}z) \\ -\frac{1}{\sqrt{2}} j \sin(\kappa\sqrt{2}z) \end{bmatrix} \quad (4b)$$

From initial condition 1 above, we can get the coupling length by:

$$L_{c1} = \frac{\pi}{\sqrt{2}\kappa} (2m - 1) \quad (5)$$

From initial condition 2 above, we can get the coupling length by:

$$L_{c2} = \frac{\pi}{2\sqrt{2}\kappa} (2m - 1) \quad (6)$$

It shows that when the initial power is launched into different waveguide, the power will switched to another waveguide at different length, based on Equation (5) and (6) above. When the electric field is applied to waveguide via electrodes, the overall index profile is changed due to the electro-optic effect. In order to analyze the behavior of optical switching, we observing $(\Delta\beta_1, \Delta\beta_3)$ into $\Delta\beta_1 = -\Delta\beta_3 = \Delta\beta$, which is called detuned antisymmetrically.

4. ANTISYMMETRIC DETUNING

Antisymmetric detuning means that the overall β 's of both waveguides one and three are changed from that of waveguide two by the same amount but in opposite directions⁸. Therefore, $\Delta\beta_1 = -\Delta\beta_3 = \Delta\beta$.

The solutions for antisymmetric detuning in term of matrix will be⁷,

$$\begin{bmatrix} a_1(z) \\ a_2(z) \\ a_3(z) \end{bmatrix} = \begin{bmatrix} c_1 + \frac{\kappa^2}{\kappa'^2} & c_2 & c_3 - \frac{\kappa^2}{\kappa'^2} \\ c_2 & 2c_3 + \frac{\Delta\beta^2}{\kappa'^2} & -c_2^* \\ c_3 - \frac{\kappa^2}{\kappa'^2} & -c_2^* & c_1^* + \frac{\kappa^2}{\kappa'^2} \end{bmatrix} \cdot \begin{bmatrix} a_1(0) \\ a_2(0) \\ a_3(0) \end{bmatrix} \quad (7)$$

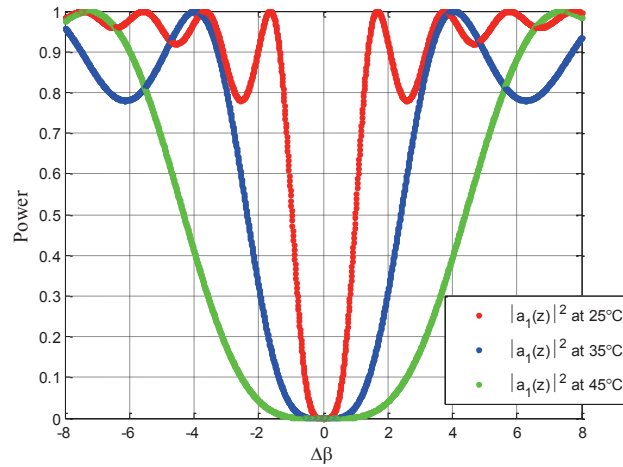
Where

$$\begin{aligned} c_1 &= \left(1 - \frac{\kappa^2}{\kappa'^2}\right) \cos \kappa' z - j \frac{\Delta\beta}{\kappa'} \sin \kappa' z \\ c_2 &= -j \frac{\kappa}{\kappa'} \sin \kappa' z + \frac{\kappa \Delta\beta}{\kappa'^2} (\cos \kappa' z - 1) \\ c_3 &= \frac{\kappa^2}{\kappa'^2} \cos \kappa' z \\ \kappa'^2 &= \Delta\beta^2 + 2\kappa^2 \end{aligned} \quad (8)$$

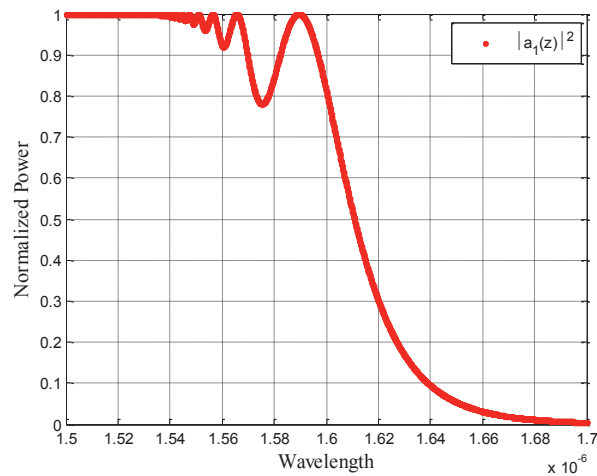
4.1 Initial power launched into waveguide one

Since the light is launched entirely into waveguide one, the initial conditions are $a_1 = 1, a_2 = 0, a_3 = 0$ at $z = 0$. And for the beam incident on waveguide one to cross over to waveguide three completely at $z = L$, the following conditions are required: $a_1 a_1^* = a_2 a_2^* = 0, a_3 a_3^* = 1$. From Eq. (7), the initial conditions equation for detuned antisymmetrically will be

$$\begin{bmatrix} a_1(z) \\ a_2(z) \\ a_3(z) \end{bmatrix} = \begin{bmatrix} c_1 + \frac{\kappa^2}{\kappa'^2} \\ c_2 \\ c_1 - \frac{\kappa^2}{\kappa'^2} \end{bmatrix} \quad (9)$$



(a)



(b)

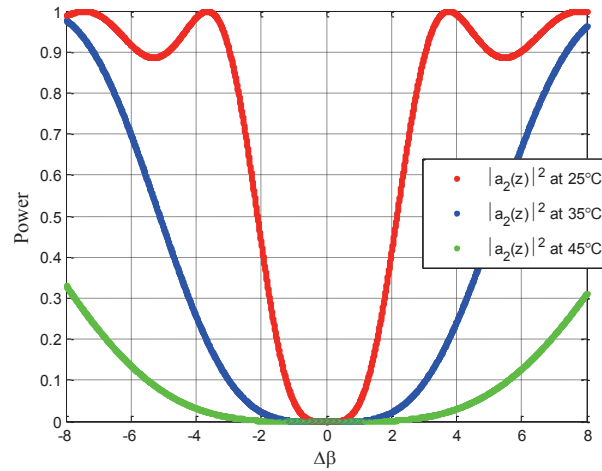
Figure 3. (a) Switching operation in three-guide detuned antisymmetrically in which beam launched into waveguide one system as function of temperature. (b) The relation between normalized power as function of wavelength range for optical communication.

Figure 3 (a) above shows how the switching operation on three waveguide system with detuned antisymmetrically in which beam is launched into waveguide one before heated (red line), after heated 10°C (blue line) and heated 20°C (green line) using thermo-optic effect from Equation (1), it will have perfect switched (cross state) to waveguide three only if $\Delta\beta=0$ where z or L_{c1} (coupling length) in Eq. (7) are multiple odd integer. Figure 3 (b) shows the $a_1(z)$ in matrix Equation (9) relates with applicable wavelength. Note from Figure 3 (a), the range in order to keep cross state condition, ($\Delta\beta = -0.1 - 0.1$) before heated, ($\Delta\beta = -0.7 - 0.7$) after heated 10°C, and ($\Delta\beta = -1.15 - 1.15$) after heated 20°C, and requirement for bar state condition, $\Delta\beta = 1.732$ before heated to 4 after heated 10°C and 7.2 after heated 20°C.

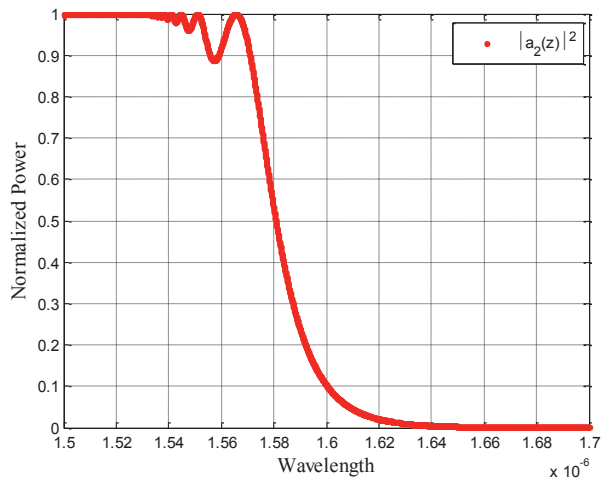
4.2 Initial power launched into waveguide two

Since the light is launched into waveguide two, the initial conditions are $a_1 = 0$, $a_2 = 1$, $a_3 = 0$ at $z = 0$. And for the beam incident on waveguide one to cross over to waveguide three completely at $z = L$, the following conditions are required : $a_1 a_1^* + a_3 a_3^* = 1$, $a_2 a_2^* = 0$. From Eq. (7), the initial conditions equation for detuned antisymmetrically will be

$$\begin{bmatrix} a_1(z) \\ a_2(z) \\ a_3(z) \end{bmatrix} = \begin{bmatrix} c_2 \\ 2c_3 + \frac{\Delta\beta^{2*}}{\kappa'^2} \\ -c_2^* \end{bmatrix} \quad (10)$$



(a)



(b)

Figure 4. (a) Switching operation in three-guide detuned antisymmetrically in which beam launched into waveguide two system as function of temperature. (b) The relation between normalized power as function of wavelength range for optical communication.

Figure 4 (a) above shows how the switching operation on three waveguide system with detuned antisymmetrically in which beam is launched into waveguide two before heated (red line), after heated 10°C (blue line) and after heated 20°C (green line), it will have perfect switching only if $\Delta\beta=0$. And for bar state condition it will require minimum $\Delta\beta=\sqrt{15}$. But there is no requirement for exact length ratio for switching to occur. Figure 4 (b) shows the $a_2(z)$ in matrix Equation (10) relates with applicable wavelength. Note from Figure 4 (a), the range in order to keep cross state condition, ($\Delta\beta = -0.4 - 0.4$) before heated and ($\Delta\beta = -1.4 - 1.4$) after heated 10°C, and ($\Delta\beta = -2.7 - 2.7$) after heated 20°C, and for bar state requirement condition, $\Delta\beta = 3.87$ before heated to 8.8 after heated 10°C and turn to 16 after heated 20°C.

5. CONCLUSION

The changes in switching operation on three waveguide directional coupler with detuned based on thermo-optic effect are analyzed. Results are summarized as follows.

1. For the case where the initial power is launched into waveguide one and the system is detuned antisymmetrically, odd integer multiples of L_{c1} are required for the perfect switching.
2. For the case where the initial power is launched into waveguide two and the system is detuned antisymmetrically, is expected to play important role because there are no requirement for exact length ratio for switching to occur. Thus, even in the case where the switch is operated at another waveguide so that a different coupling length may be required, only an adjustment of the applied voltage allows a complete switching operation.
3. From simulation results, it clearly show us that the systems after heated more impervious to keep the switching performance (cross state) while as it shifting the propagation constant mismatch due to rising temperature, but the system after heated will effecting to the bar state condition where each system has higher $\Delta\beta$ value to satisfy that power completely return back to initial waveguide than before they heated. And the system with three waveguides directional coupler detuned antisymmetrically where the initial power is launched into waveguide two has better cross state condition system at 35°C and 45°C but the system has the biggest requirement value of $\Delta\beta$ for bar state condition compared to the system where the initial power is launched into waveguide one.

REFERENCES

- [1] H. A. Haus and C. G. Fonstad, "Three-waveguide couplers for improved sampling and filtering," *IEEE J. Quantum Electron.*, vol. QE-17, pp. 2321-2325, Dec. 1981.
- [2] C. L. Chen, "*Foundations for Guided-Wave Optics*, Wiley", Canada, p. 121, 2007.
- [3] Douglas B.L & Bradley J.F , "*Temperature-dependent absolute refractive index measurements of sntetic fused silica*", NASA Goddard Space Flight Center : Greenbelt, 2006.
- [4] W. J. Tropf and M. E. Thomas., "Infrared Refractive Index and Thermo-optic Coefficient Measurement at APL ", Johns Hopkins APL Technical Digest, Vol. 19, Number 3, 1998.
- [5] D. Lee, K.H Kim, S.H Hwang, Min-Hee Lee, El-Hang Lee., "Optimization of Thermo-optic parameters for Temperature-Insensitive LPWG Refractometers ", ETRI Journal, Vol. 28, Number 6, December 2006.
- [6] G. Ghosh, Michiyuki Endo, T. Iwasaki, "*Temperature Dependent Sellmeier Coefficients and Chromatic Dispersion for Some Optical Fiber Glasses*", Journal of Ligthwave Technology, Vol. 12, Number 8, August 1994.
- [7] Chang-Min Kim; Young-Joon Im, "Switching operations of three-waveguide optical switches," in *Selected Topics in Quantum Electronics, IEEE Journal of* , vol.6, no.1, pp.170-174, Jan.-Feb. 2000.
- [8] B. Carrie, "Three Waveguide Coupling and Switching: ECE 674 Integrated Optics," December 2005.