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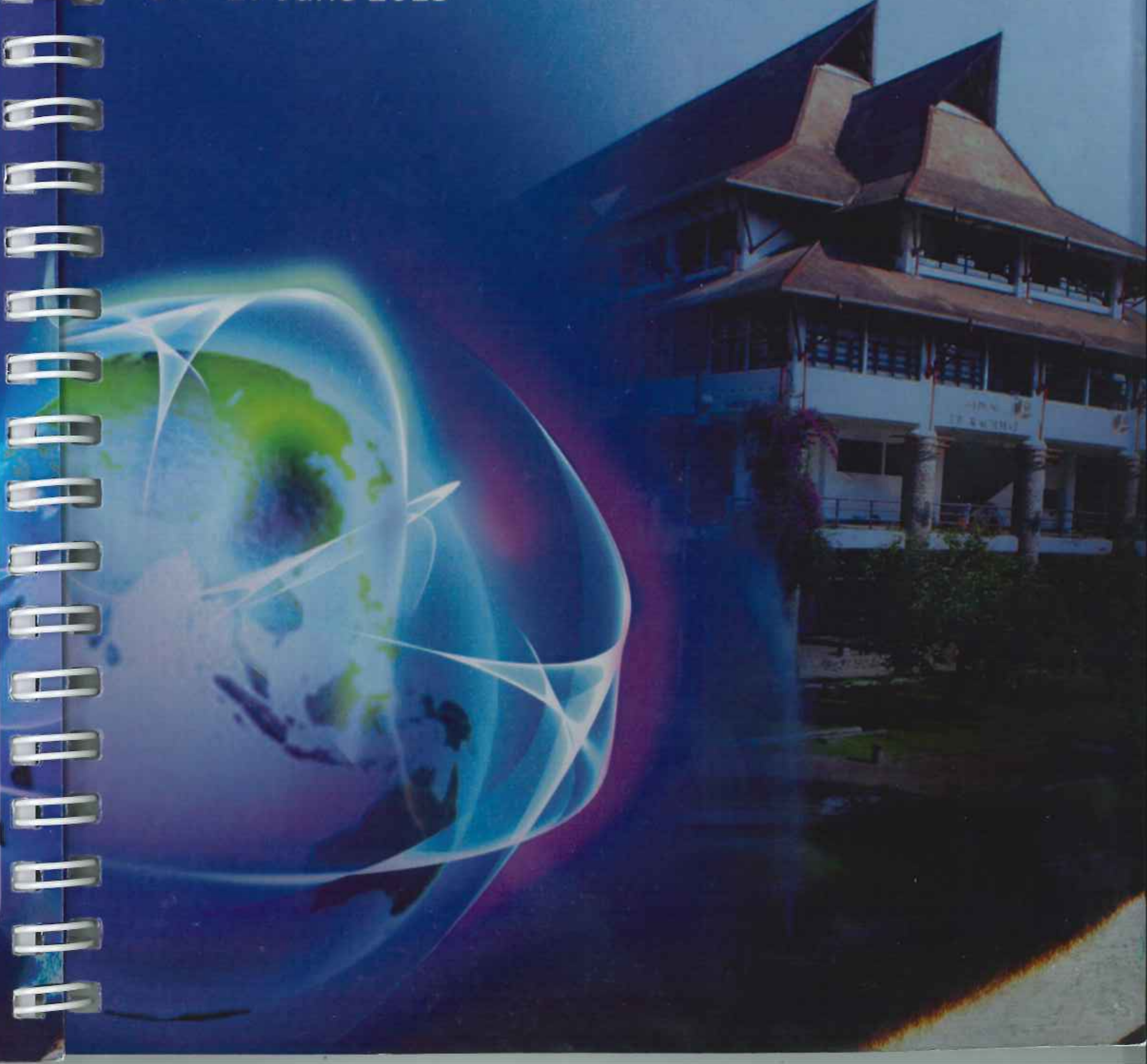

One pass coherent calculations to examine structures in which wave and ray optics couple

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Current structures for solar cells or LEDs often incorporate optical elements that operate in different regimes, with a mixture of coherent and incoherent scattering components. These combined structures provide several computational challenges. On the one hand, the wavelength scale grating structures require one to take into account coherent effects. On the other hand, addressing structures in the ray optics regime such as rough diffusers with full wave simulation methods would typically require a huge computational domain. Furthermore, the total optical path length in such systems tends to be larger than the coherence length of light and thus fully coherent calculations cannot capture all of the real effects.

To address these complications, a simulation technique is developed, which takes into account coherent effects where they matter the most while circumventing the need to fully implement the ray optic section of the structure. We avoid the extensive domain in our calculations by working directly with the wavefront coming out of the ray optics section instead of its geometry. As any wavefront can be represented as a superposition of plane waves, we instead calculate the response of the wave section to different plane wave inputs. Phase relations are considered to be lost as soon as light enters or goes back to the ray optics section, hence the term one pass coherent (OPC). Details of the method will be presented.

We will first discuss the beneficial impact of limited coherence on absorption in solar cell structures. Secondly, we will show how the method is versatile in handling arbitrary diffusing structures. We demonstrate these points by showing simulation results of solar cell structures which couple 1D gratings with a ray optics segment. Here, the gratings have a period of 400nm, an ellipsoidal shape with depth of 300nm and diameter of 280nm, and coated with 50nm of ITO.

Under limited coherence, light can be absorbed more strongly over a broad wavelength range when the structure fulfills certain geometrical conditions. This can be seen in Fig. 1 which shows the reflectance of a thin film solar structure with a grating top and a flat specular reflector at the bottom for various poly-Si thicknesses under fully coherent and OPC conditions. The effect is due to a less stringent phase condition for guided modes to exist when coherence is limited.

We can utilize the method to effectively study solar cell structures which combine gratings and rough diffusers. A single plane wave calculation sweep provides all the information to calculate any kind of bottom diffuser. Fig. 2(a) shows how we can model such structures with a single grating period. Fig. 2(b) shows the reflectance one would obtain for such a combined structure under OPC condition.

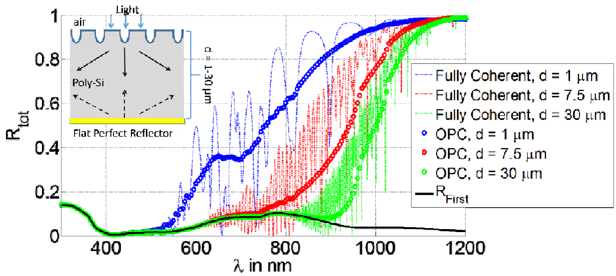

Fig. 1 Reflectance curves under fully coherent and one pass coherent conditions for top grating-flat bottom solar cell structures with different Si thicknesses.

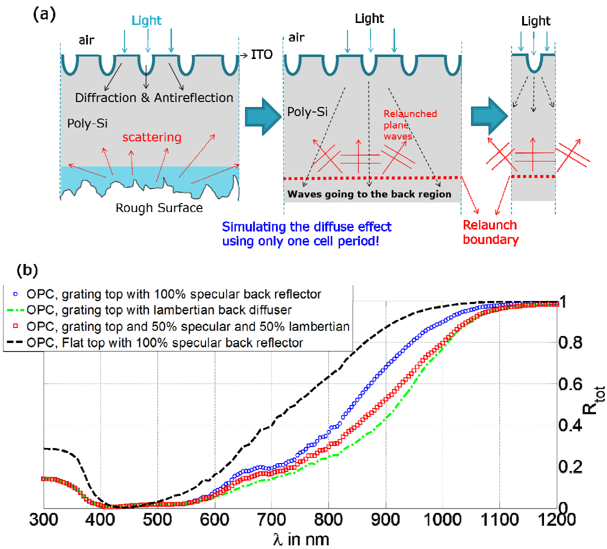

Fig. 2 (a) Modelling schematic of the OPC calculations. (b) Example reflectance of combined structure as compared to an all flat structure assuming poly-Si thickness d= 2.5µm.

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Poster Presentations
9th International Symposium on Modern Optics and Its Applications (ISMOA 2013)

PP-01 *Physical and Optical Properties of Erbium doped Phosphate Glasses embedded with Fe3O4 Nanoparticles*
Puzi ANIGRAHAWATI and M. R. SAHAR (Faculty of Science, Universiti Teknologi Malaysia, Malaysia)

PP-02 *Annealing treatment effect on the structure and photovoltaic properties of ZnO-CNTs thin film*
Azimah OMAR, Huda ABDULLAH, Mohd Ambar YARMO, Mohd Zikri RAZALI, Sahbudin SHAARI, Mohd Raihan TAHA (Department of Electrical, Electronics & System Engineering, Faculty of Engineering & Built Environment, Universiti Kebangsaan Malaysia, Malaysia)

PP-03 *Dielectric Function Analisys of ZnO Film by means of Angle Dependent Spectroscopic Ellipsometry Measurement*
Resti MARLINA, R. FAUZIAH, T.S. HERNG, J. DING, Y. DARMA and A. RUSYDI (Department of Physics, Institut Teknologi Bandung, Indonesia)

PP-04 *The influence of co-dopants (Flourine and Phosphor) on the Photosenstivity of Germanosilicate glasses*
Arif HIDAYAT (Jurusan Fisika - FMIPA, Universitas Negeri Malang, Indonesia)

PP-05 *Q-switched Multi-wavelength Brillouin Erbium fiber laser*
N. M. ALI, S. J. TAN, M. A. ISMAIL, S. W. HARUN and H. AHMAD (Department of Electrical Engineering, University of Malaya, Malaysia)

PP-06 *Electric field Induced variation of refractive index of DR1 thin film deposited by EVA-PVD*
I.B.G. Narayana WIJAYA and HERMAN (Physics of Magnetism and Photonics Group, Institut Teknologi Bandung, Indonesia)

PP-07 *Chitosan/graphene oxide thin films for sensitivity enhancement of surface plasmon resonance sensor towards Pb(II) ion*
N.F. LOKMAN, F. SUJA', H. ABDULLAH, A.A. ABU BAKAR (Department of Civil and Structural, Faculty of Engineering and Built Environment, National University of Malaysia, Malaysia)

PP-08 *Study of Dopant Effect on the Photocurrent Density in Al Doped Employed as Electron Transport Layer in P3HT:PCBM Based Photovoltaic Device*
Annisa APRILIA, Pardi Sampe TOLA, Waode Sukmawati ARSYAD, Priastuti WULANDARI, Rahmat HIDAYAT (Physics of Magnetism and Photonics Research Division, Faculty of Mathematical and Natural Sciences, Bandung Institute of Technology, Indonesia)

PP-09 *Synthesis and Characterization of PVA-Ag Nanocomposite Thin Films Biosensor for Detection of E. coli in Water*
Norshafadzila M. NAIM, Huda ABDULLAH, Mohd Ambar YARMO, Akrajas Ali UMAR, Sahbudin SHAARI (Department of Electrical, Electronic and System Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, Malaysia)

PP-10 *In Vivo Effect of Nd:YAG Laser-Induced Optical Breakdown on Mice Skin Tissue*
Retna APSARI, Dwi WINARNI, Siswanto PRIBADI, Noriah BIDIN (Department of Physics, Faculty of Science and Technology, Airlangga University, Indonesia)

PP-11 *Optical Tomography System for Measuring the Turbidity Level of Water*
Sallehuddin IBRAHIM, Mohd Amri Md YUNUS and Mohd Taufiq Mohd KHAIRI (Faculty of Electrical Engineering, University Teknologi Malaysia, Malaysia)

PP-12 *Comparison of Snake Active Contour Method and Ellipse Fit in Quantitative Analysis of Fundus Image for Glaucoma Diagnosis*
Dwi Esti KUSUMANDARI (Technical Implementation Unit for Instrumentation Development, Indonesian Institute of Sciences, Indonesia)

PP-13 *Synthesis and characterization of carbon encapsulated Fe3O4 nanoparticles from local iron sand by coprecipitation and ultrasonic method for solar steam generator and other applications*
Nandang MUFTI, An Nafiqi Frandicha W, and Abdullah FUAD (Department of Physics, State University of Malang, Indonesia)

PP-14 *Biomedical optical instruments on a microchip*
L. CHANG, B. I. AKCA, F. CIVITCI, N. ISMAIL, R. M. de RIDDER, K. WÖRHOFF, H.J.W.M. HOEKSTRA, and M. POLLNAU (Integrated Optical Microsystems Group, University of Twente, Netherlands)

PP-15 *Design of Cascaded Mach Zehnder Interleaver Based on Silica Waveguide*
Ary SYAHRIAR, **Ratih R. PALUPI** (Department of Electrical Engineering, University of Al Azhar Indonesia, Indonesia)

PP-16 *Optical Loss Analysis in 13-Channel SOI-based AWG for CWDM Network*
Nurjuliana JUHARI, Sahbudin SHAARI, P Susthitha MENON and Abang Annuar EHSAN (Institute of Microengineering and Nanoelectronics (IMEN), Universiti Kebangsaan Malaysia, Malaysia)

PP-17 *Gain Performance of Cascaded and Hybrid Semiconductor Optical Amplifier in CWDM-PON*
Khadijah ISMAIL, P. Susthitha MENON, Sahbudin SHAARI, Hesham BAKARMAN, A Ashrif A BAKAR and Norhana ARSAD (Institute of Microengineering and Nanoelectronics (IMEN), Universiti Kebangsaan Malaysia, Malaysia)

PP-18 *Annealing Temperature Effect on In/CNT Photoanode by Sol-gel Method for Dye Sensitized Solar Cells*
Savisha MAHALINGAM, Huda ABDULLAH, Sahbudin SHAARI (Department of Electrical, Electronic and System Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, Malaysia)

PP-19 *Thermo Optic Effects on Cascaded Silica Based Microring Resonator in Serial Configuration*
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PP-20 *Transmittance Analysis of Cascaded Microring-Resonators for Optical Networks*
Dadin MAHMUDIN, Pamungkas DAUD and Yusuf Nur WIJAYANTO (Research Center for Electronics and Telecommunications, Indonesian Institute of Science, Indonesia)

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(Department of Electrical, Electronic and System Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, Malaysia)

PP-22 *Structural and Dielectric Properties of ZnFe2O4 - SiO2 Nanoparticles for Microwave Application*
Mohd Syafiq ZULFAKAR, Huda ABDULLAH, Wan Nasarudin WAN JALAL, Sahbudin SHAARI, Mohd Ambar YARMO (Department of Electrical, Electronic and System Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, Malaysia)

PP-23 *Mode Solving of Hollow-Core Photonic Bandgap Fibers*
Henri P. URANUS and Hugo J. W. M. HOEKSTRA (Dept. Electrical Engineering, University of Pelita Harapan, Indonesia)

PP-24 *One pass coherent calculations to model structures with both wave and ray optics segments*
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PP-25 *Performance of Cu2O-based Screening-engineered Field-effect Photovoltaics (SFPV) Analyzed by Finite Element Methods*
Fuad Indra ALZAKIA and David-A. MENDELS (Center of Mobile, Micro, and Nanotechnology, Surya University, Indonesia)

PP-26 *Characteristics of a Dielectric Slab Waveguide Device with a Slit and an Embedded Metallic Grating at Terahertz Frequency*
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PP-27 *Time Resolved Measurement of He Plasma Emission for the Study of Metastable He Excited States Involving Energy Transfer*
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M. Z. ZULKIFLI, F. D. MUHAMMAD, H. AHMAD (Photonics Research Centre, University of Malaya, Malaysia)