# A soliton-based Radio-over-Fiber WDM-PON by micro-optics-electro system

**P. Udomariyasap**
The Establishment of Faculty of Engineering, Chaiyaphum Rajabhat University, Chaiyaphum 36000,Thailand
Email: pongputhai@hotmail.com

**S. Songmuang**
Faculty of Science and Technology, Kasem Bundit University, Bangkok 10250, Thailand.

**S.Mitatha**
[c] Department of Computer Engineering, Faculty of Engineering, King Mongkut's Institute of Technology Ladkrabang (KMITL), Bangkok 10520, Thailand

**N. Thammawongsa**
[d] Faculty of Technology, Udonthani Rajabhat University, Udonthani, 41000, Thailand
Email: nopthamma@gmail.com

and **P.P. Yupapin**
[e] Department of Physics, Faculty of Science, King Mongkut's Institute of Technology Ladkrabang (KMITL), Bangkok 10520, Thailand
Email: kypreech@kmitl.ac.th

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**ABSTRACT**

***This paper proposed a micro-optics-electro system design and a dark soliton laser module for Radio-over-fiber (RoF) WDM-PON network. Experimental investigate soliton transmission through a dispersion channel with and without Dispersion Compensation Fiber (DCF). The soliton pulse generator module schematic model is applied by OptiBPM and OptiSYSTEM programming for RoF WDM-PON network. As a result, the proposed system performance and soliton spectrum dispersion by the experiment simulated channels with and without DCF are shown. According to, the proposed micro-optics-electro system can be manipulated with a bidirectional function to access in a various applications such as sensor node, bioelectronics sensor, micro radio communication, etc.***

***Keywords**: Soliton, Radio-over-fiber, WDM-PON, Optical Waveguide, Micro-optics-electro.*

## 1. INTRODUCTION

Wavelength division multiplexing (WDM) communication systems involve optical components which are able to multiplex and demultiplex a narrow free spectral range (FSR) channel. An add/drop filter is used to separate the channel, ring resonators is the interest type of optical filter due to their high wavelength selectivity, easy model and compactness [1] – [2]. In recent times, ring resonators have been established for many other applications, such as, tunable lasers [3], switching [4], modulators [5], compensators [6], and biosensors [7]. Moreover, the performance of ring resonators can support optical filter in Passive Optical Network (PON) applications but it is limited by internal losses. Therefore, a soliton pulse concept was used as a key role to solve this problem in long-haul communication. A soliton is a wave packet that maintains its shape while it travels at constant speed which cancelled nonlinear and dispersive effects in the medium. [8] – [9]

A micro-optics-electro (MOE) modulator is an optical device which modulates a beam of light by an optical signal and allows controlling the amplitude and phase of an electrical signal.[10] – [11] In Radio-over-Fiber (RoF) WDM-PON communications systems, these modulators decode information by optical ring resonator used to a radio frequency carrier separation. Distributed array antenna is a new research topic for RoF WDM-PON system which can provide and re-usable wavelength for a new cell cite of Remote Access Point (RAP). Wavelength division multiplexing (WDM) systems involve the optical signals to be a wavelength selective switch which have been demonstrated using silica [12] and InP waveguides [13]. In our proposed system micro ring resonators are typically 20 um in diameter, very compact, which enables large scale integration and a large switch array. The whole NxN switching array can reduce optical loss providing other sources of loss (such as bending loss) are minimized. The fast switching MOE composes the technology for high speed optical data packet switching and coding switching in future communication and computing systems.

In this paper, we proposed a 3x3 array MOE switching device combined with soliton laser module for RoF WDM-PON. A technique of soliton-based array MOE switching used to code the data for different RAP based on carrier distributed WDM-PON by FDTD methods in MATLAB programming. The electromagnetic field in the form of WGM can be generated within a ring resonator and described by the time-dependent Maxwell's equations. The results are demonstrated the Beam Propagation Model for management and the system characteristic of proposed system.

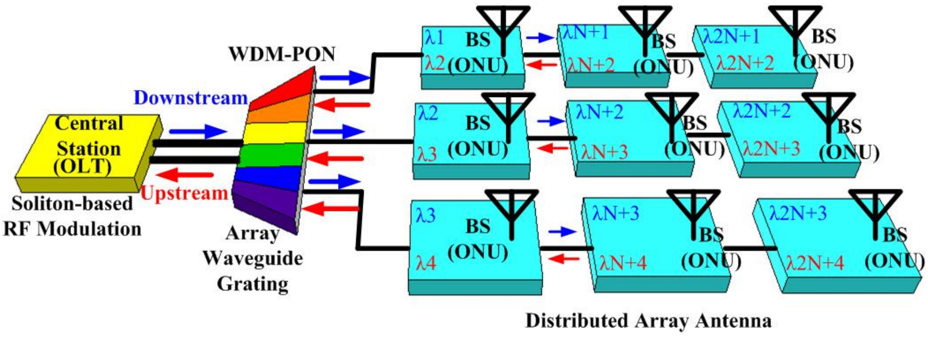


***Fig.1*** *Distributed array antenna for RoF WDM-PON system.*

## 2. SOLITON-BASED RADIO-OVER-FIBER WDM-PON

A 3x3 array MOE switching device is constructed by PANDA ring resonator [14] and excites a acoustic mechanical of light wave within micro ring resonators called Whispering Gallery Mode (WGMs). The form of WGMs electromagnetic field is described in 2D and 3D FDTD methods based on the "Yee' scheme" and perfectly matched layer absorbing boundary condition was applied by Berenger [15], [16]. A PANDA ring resonator is shown in Fig. 2. Through port fields and Drop port fields are described.[17]

$$E_{Th} = x_1 y_1 E_{in} + \left( j x_1 x_2 y_2 \sqrt{\kappa_1} E_4 E_l E_1 - x_1 x_2 \sqrt{\kappa_1 \kappa_2} E_R E_{ad} \right) e^{-\frac{\alpha}{2}\frac{L}{2} - jk_n \frac{L}{2}} \quad (1)$$

$$E_{Dr} = x_2 y_2 E_{ad} + j x_2 \sqrt{\kappa_2} E_r E_1 e^{-\frac{\alpha}{2}\frac{L}{2} - jk_n \frac{L}{2}} \quad (2)$$

Where $x_1 = \sqrt{1-\kappa_1}$ , $y_1 = \sqrt{1-\gamma_1}$ , $x_2 = \sqrt{1-\kappa_2}$ , $y_2 = \sqrt{1-\gamma_2}$ , $\kappa_1$ and $\kappa_2$ is the intensity coupling coefficient, $\gamma_1$ and $\gamma_2$ is the fractional coupler intensity loss, α is the attenuation coefficient, $\kappa_n = 2\pi/\lambda$ is the wave propagation number, λ is the input wavelength light field and $L=2\pi R_{ad}$, which $R_{ad}$ is the radius of add-drop device. The circulated light fields, $E_l$ and $E_r$ are the light field circulated components of the ring radii, $R_l$ and $R_r$ which coupled into the left and right sides of the add-drop optical multiplexing system, respectively. [17] The simulation results are obtained by using the MATLAB programming. The ring material is *InGaAsP/InP*, where the device parameters are given as following: $R_1 = R_2 =$ 0.6 um, $R_{ad} = 1.3$, $A_{eff} = 0.1$ μm$^2$, $n_{eff} = 3.14$, $n_2 = 1.3 \times 10^{-17}$ cm$^2$/W, $\kappa_1 = \kappa_2 = \kappa_3 = \kappa_4 = 0.5$, $\gamma = 0.01$, $\lambda_0 =$ 1,550 nm.

An experiment of A 3x3 array MOE switching device for RoF WDM-PON and presented an WDM based 10 Gbit/s PON system, as shown in Fig. 3. A Radio data are combined with soliton laser by Mach-Zhender modulator which distributed carrier for RoF WDM-PON. A baseband signal connected with WDM (Array Waveguide grating) to multiplex wavelength, a signal pass through a single mode fiber transmission channel, over 20 km, and vice versa.

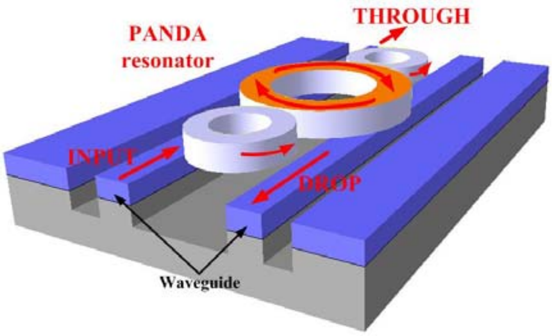


***Fig. 2*** *Cross section of a MOE switching device for RoF WDM-PON.*

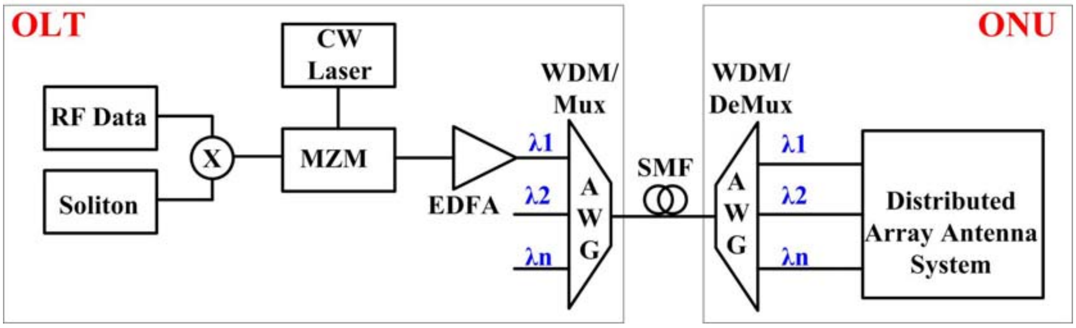


***Fig. 3*** *Sub-carrier Soliton data modulation and system.*

## 3. RESULTS

In simulation, the WGMs can be generated and controlled to localize within center ring and two side rings, which depend on the used parameters and conditions, where the other input signals can be modulated by the ADD port (Control port) signals. The WGM switching signals can also be controlled to switch up or down direction for MOE switching by gold coating at the bottom, which can be useful for provide wavelength for a Remote Access Point link control which the proposed results are shown. In Fig. 4 illustrated a 3x3 MOE switch generated by PANDA ring with WGMs (unchanged) and an array controllable to KMITL symbol display is shown in Fig.4.

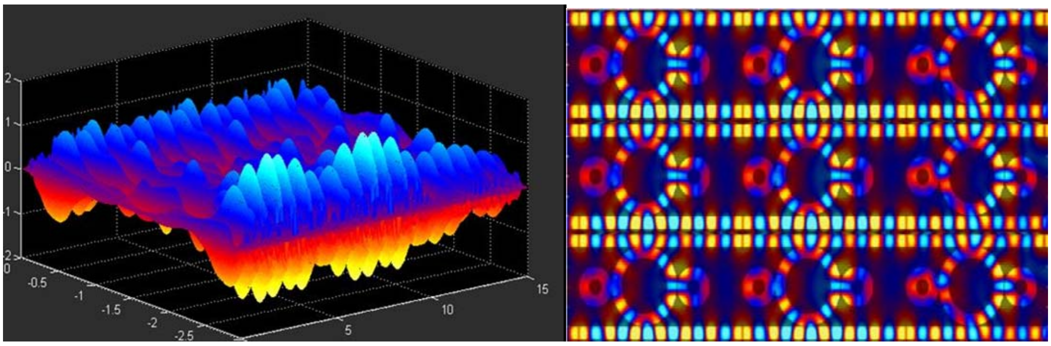

***Fig. 4*** *3x3 MOE Switch generated by PANDA ring with WGMs (unchanged).*

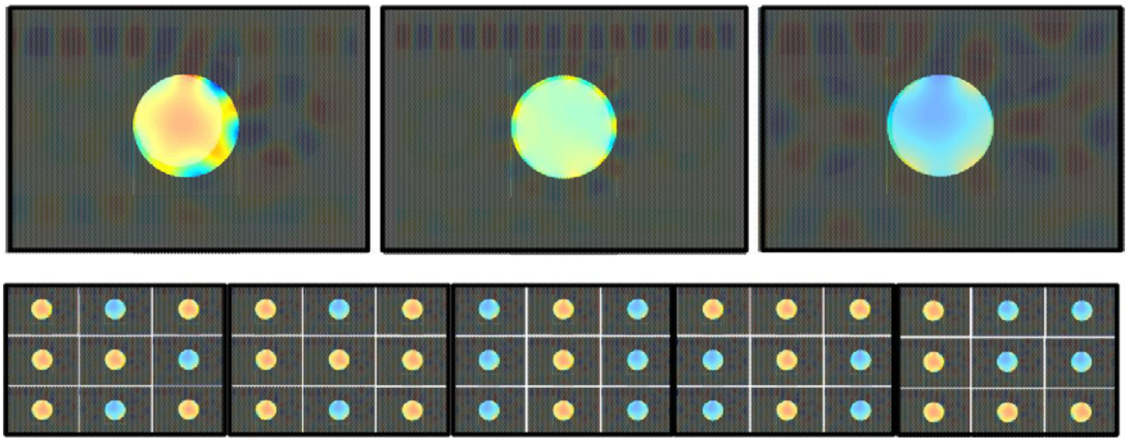

***Fig 5** Array controllable to KMITL symbol display.*

## 4. CONCLUSION

In this paper, we proposed a 3x3 array MOE switching device combined with soliton laser module for RoF WDM-PON. A technique of soliton-based array MOE switching used to code the data for different RAP based on carrier distributed WDM-PON by FDTD methods in MATLAB programming. The electromagnetic field in the form of WGM can be generated within a ring resonator and described by the time-dependent Maxwell's equations. The results are demonstrated the Beam Propagation Model for management and the system characteristic of proposed system.

## REFERENCES

[1] J.D. Wineland, J.J. Bollinger, W.M. Itano, J.D. Prestage, Angular momentum of trapped atomic particles. JOSA B, 2, 1721-1730, 1985.
[2] J.C. Knight, N. Dubreuil, V. Sandoghdar, J. Hare, V. Lefevre-Seguin, J.M. Raimond, S. Haroche. Characterizing whispering-gallery modes in microspheres by direct observation of the optical standing-wave pattern in the near field. Opt. Lett., 21, 698-670, 1996.
[3]. M.F. Yanik, S. Fan, Stopping and storing light coherently. Phys. Rev. Lett., 92, 083901-3, 2004.
[4]. P.P. Yupapin, N. Pornsuwancharoen, Proposed nonlinear microring resonator arrangement for stopping and storing light. IEEE Photon. Technol. Lett., 21, 404-406, 2009.
[5] T.Y.L. Ang, N.Q. Ngo, Tunable flat-band slow light via contra-propagating cavity modes in twin coupled microresonators. JOSA B, 29, 924-933, 2012.
[6] N. Thammawongsa, S. Tunsiri, M.A. Jalil, J. Ali, P.P. Yupapin, Storing and harvesting atoms/molecules on-chip: Challenges and applications. J. Biosens. Bioelectron., 3, 114-115, 2012.
[7] L.J. Matheu, R. Maurizio, Q. Romain, Plasmon nano-optical tweezers. Nat. Photonics, 5, 349-356, 2011.
[8] A. Ashkin, Acceleration and trapping of particles by radiation pressure. Phys. Rev. Lett., 24, 156-159, 1970.
[9] N. Suwanpayak, M.A. Jalil, C. Teeka, J. Ali, P.P. Yupapin, Optical vortices generated by a PANDA ring resonator for drug trapping and delivery applications, Biomed. Opt. Express, 2, 159-168, 2011.
[10] L.P. Berenger, Perfectly matched layer for the FDTD solution of wave-structure interaction problem, IEEE Trans. Antennas Propag., 44(1), 110-118, 1996.
[11] K. S. Yee, Numerical solution of initial boundary value problems involving Maxwell's equations in isotropic media, IEEE Trans. Antennas Propagat., 14, 302-307, 1966.
[12] A. Chiasera, Y. Dumeige, P. Feron, M. Ferrari, Y. Jestin, G. N.Conti, S. Pelli, S. Soria and G. C. Righini, Spherical whispering-gallery-mode microresonators, Laser Photon. Rev., 4, 457–482, 2010.

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