June 2012
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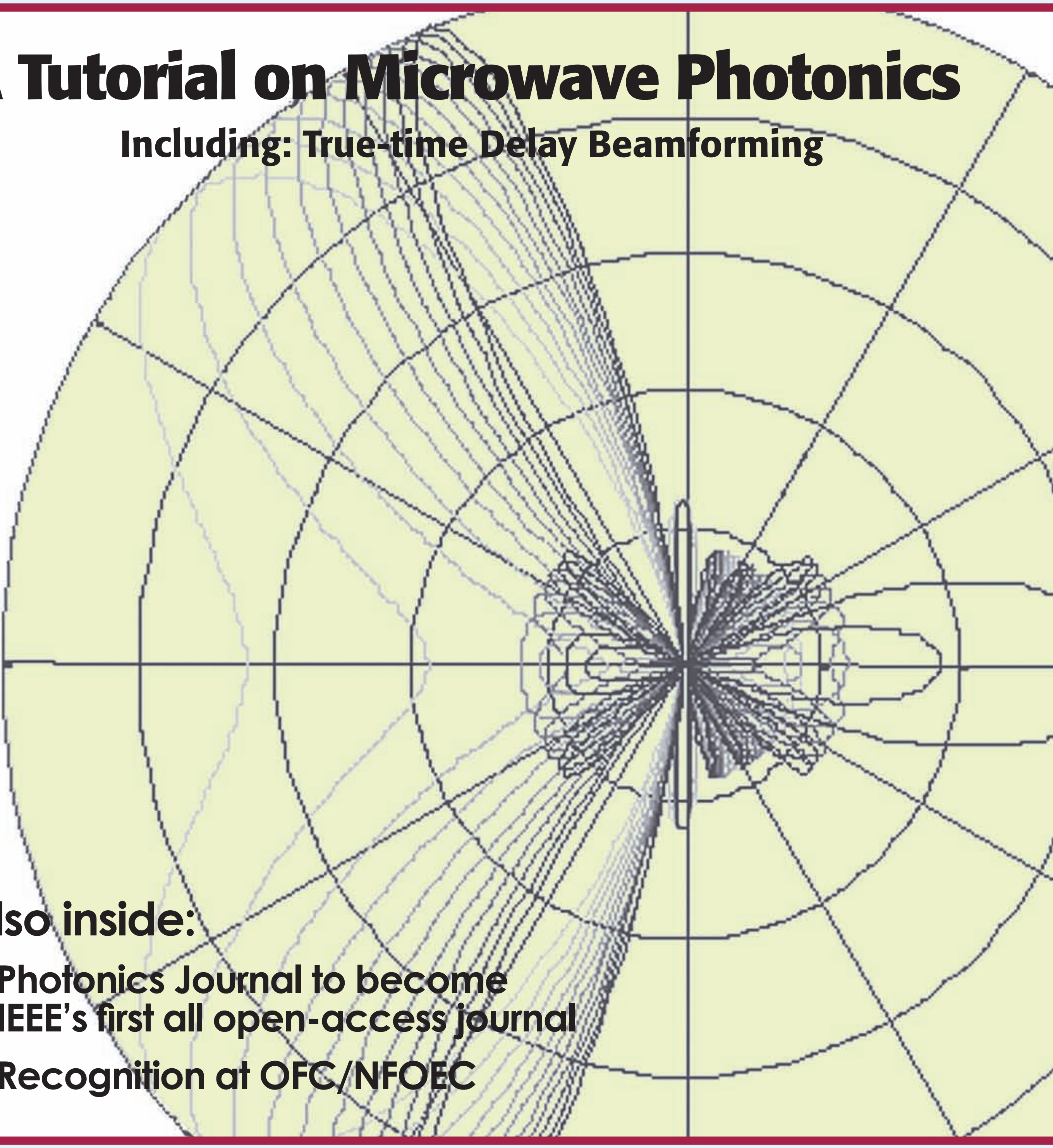
IEEE photonics SOCIETY NEWS

A Tutorial on Microwave Photonics

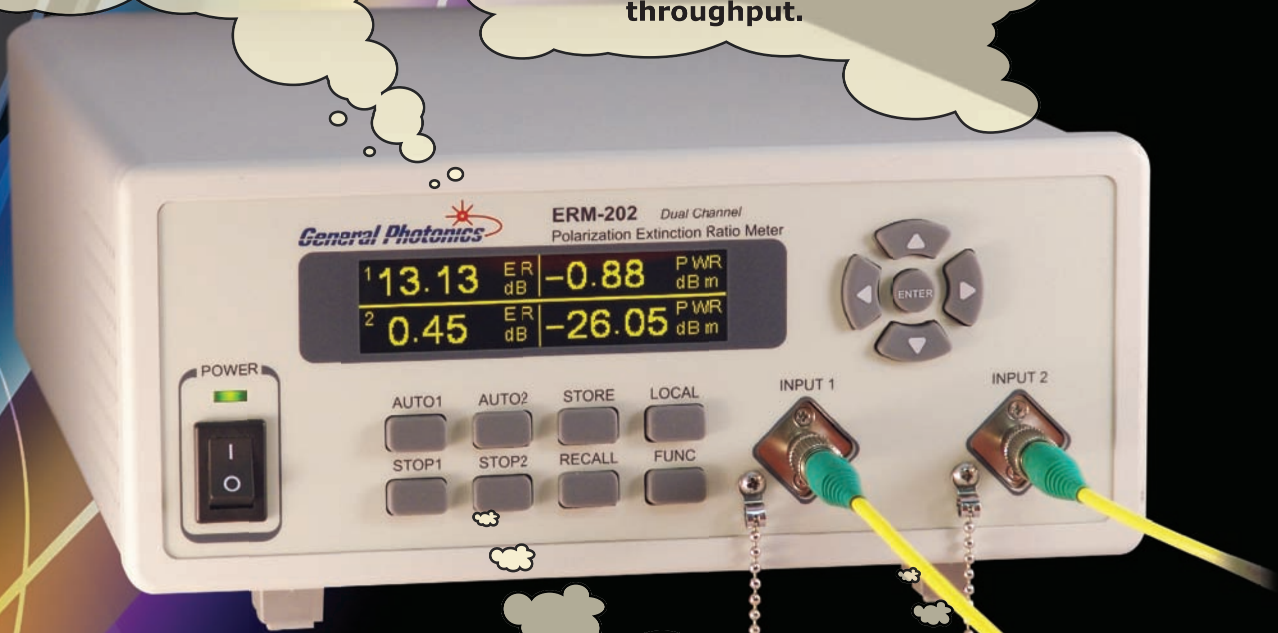
Including: True-time Delay Beamforming



Also inside:

- Photonics Journal to become IEEE's first all open-access journal
- Recognition at OFC/NFOEC

IEEE


General Photonics
ERM-202 Dual Channel
Polarization Extinction Ratio Meter
1 13.13 ER dB
-0.88 PWR dBm
2 0.45 ER dB
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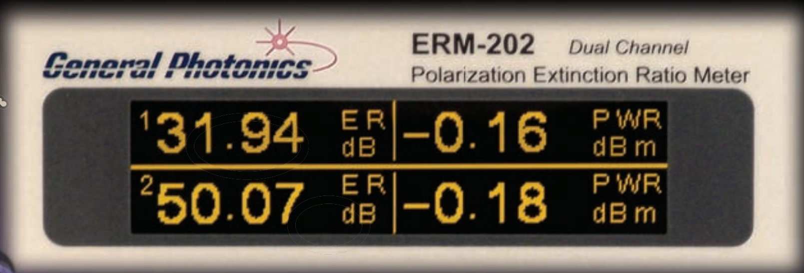
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Polarization Extinction Ratio Meter
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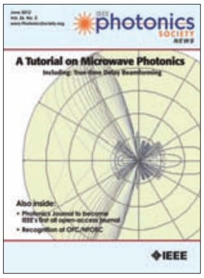

IEEE photonics SOCIETY NEWS

June 2012 Volume 26, Number 3

FEATURES

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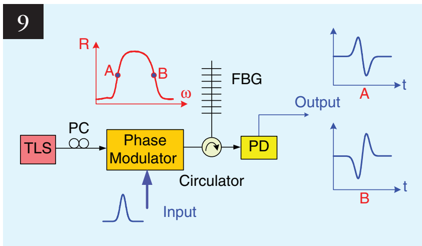

28

29

COLUMNS

Editor's Column

HON TSANG

I must admit that before I was asked to write this, my first column as editor of the Newsletter, that I had only occasionally taken the time to read the editor's column despite being one of the associate editors of the newsletter! So first, a big thank you to those of you taking the time to read this column. In this month's column, I will describe what happens in the preparation of each issue of the newsletter. Unlike other free membership magazines which you may receive from other organizations, the IPS Newsletter does not have any staff writers, and we rely entirely on articles written by members and articles solicited by one of the editors. Each issue of the newsletter is a team effort. At least three months before each issue of the Newsletter the editors listed on the right of this column would typically discuss and identify topics which they think would be interesting for the research highlights section. We would then write to potential contributors to solicit invited articles on those topics. Typically the deadline for submitting articles is about two months before each issue so we would approach potential authors three or more months before each issue. Thus I am writing this first editorial for the June issue in April and all the articles and columns for the June issue were submitted in early April. Apart from the research highlights section the volunteer editors would also solicit articles for conference preview/highlights for the conference section of the newsletter, and occasionally articles for the membership section or other miscellaneous articles such as book reviews. So now having explained the process, I would like to extend an open invitation to all IPS members to contact one of the editors if they wish to suggest topics for inclusion in a future issue of the newsletter. The topic selected for this issue is microwave photonics. Wireless networks are now so widely used in voice and data communications in society that it is often overlooked that photonics can have an important role in such networks, and is not just of importance for the backhaul network connecting the wireless routers but photonics can be useful for beamforming and high speed analog to digital conversion. In this month's issue the tutorial on microwave photonics by Prof. Jianping Yao will introduce some of these techniques and I hope you enjoy the tutorial.

Hon Tsang

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President's Column

HIDEO KUWAHARA

OFC/NFOEC 2012

The world's largest event in the field of optical communications was held on March 4–8 in Los Angeles. As always, a variety of technological advancements were announced. One of the big trends was the emergence of 100 Gb/s systems, including 100G field trials, real-time coherent receivers and actual deployment plans. The feasibility of 100G system has been enabled by the advent of ultra high-speed electronics, including A/D converters and digital signal processing, representing a major milestone in optical communications. If we look back at the major historical milestones leading to higher optical communications capacity, each step was a big achievement. In the 1970s, discrete transistors having the highest operating frequency were selected and used to achieve systems with the capacity of several hundred Mb/s. In the 80s the most advanced ICs were developed to achieve systems exceeding 1 Gb/s. In the 90s compound semiconductor transistors were investigated to achieve 10 Gb/s systems, but they sometimes suffered from reliability and/or power consumption issues, and WDM was developed with the advent of erbium doped fiber amplifiers. After the ICT (information and communication technologies) bubble burst in early 2000s, 40Gb/s systems were developed using electronics reaching what was considered to be the upper limit, and several different modulation schemes were proposed to implement this capacity. In each step, optical communications was always the area where the most advanced high-speed electronics was applied first. In moving ahead to the next step, to 400Gb/s or even 1Tb/s systems, new technologies will emerge to pave the way. In the device area, OFC/NFOEC 2012 topics included the integration of photonics crystals, nanocavity lasers, and CMOS photonics, with a focus on achieving higher performance/speed, lower power consumption and smaller size. There were many presentations on spatial division multiplexing schemes using multicore fiber or multimode transmission. From a business point of view, the Market Watch Panels and Service Provider Summit were well attended, and an impressive panel was assembled for the Mission (Im)Possible Monetizing Telecommunications Network.

Awards

In the opening plenary session of OFC/NFOEC 2012, we had an award ceremony and several awards were presented. The John Tyndall Award from the IEEE Photonics Society, the OSA and Corning went to Prof. John Bowers, University of California, Santa Barbara. The IEEE Photonics Society Young Investigator Award was presented to William Green of IBM. Eighteen new IPS-associated IEEE Fellows have been authorized for this year, and five members were awarded at OFC/NFOEC 2012. Similar Fellow presentations are planned at CLEO 2012 in San Jose in May, and the IEEE Photonics Conference in Burlingame in September. Please join me in congratulating these award winners and new Fellows.

Board of Governors Meeting (BOG)

We will have the 2012 Board of Governor meeting at CLEO2012. With eight elected BOG members who have already started their terms from 2010 and 2011, four new elected members are joining this year. The new BoG members are: Sebastian Bigo of Alcatel-Lucent, France, Andrew Kirk of McGill University, Canada, Fumio Koyama of the Tokyo Institute of Technology, Japan, and Peter Smowton of Cardiff University, UK. In our IPS full BoG we have these 12 elected members plus Jim Coleman as Past-President, myself as President, Dalma Novak as Secretary Treasurer and five Vice Presidents: Kent Choquette as VP of Conference, Chenuppati Jagadish as VP of Finance & Administration, Jeff Kash as VP of Membership & Regional Activities, Robert Tkach as VP of Publications, and Thomas Koch as VP of Technical Affairs. These Executive members are all voting members of the IPS BoG.

Photonics Technology Letters (PTL)

We are always reviewing the status of our IPS publications with an eye to make them more attractive and competitive. Photonics Technology Letters is our flagship letters publication, and we have had long and intensive discussions, including at the Editorial Meeting held at OFC/NFOEC in 2011 and 2012, mainly on the appropriate page count of PTL and turn-around times in the reviewing process. We are planning to increase the page limit to 4 pages from the conventional 3 pages to strengthen our competitiveness with other letters publications. In this new development, for example, authors of conference papers, which are typically 3 pages, can submit updated or extended versions of their work. Seb Savory, the Editor-in-Chief of PTL, will explain these changes in more detail in his editorial.

Photonics Journal (PJ)

Photonics Journal is moving to an 'open access' publication model, providing authors with much wider readership of their published articles. Beginning April 15th, authors had the option to submit their papers under the existing submission rules, but also had the option of publishing them in Photonics Journal under the new 'open-access' model for just $1,350 (lowered from $2,800). This one low open-access fee covers papers up to 8 pages, with additional pages at $120 each. After July 1, all papers will be submitted under the new open access model. In addition, on January 1, 2013, all back issues of Photonics Journal, including all 2012 papers, will become open access. The Photonics Journal will be IEEE's first open access journal.

Technology Hot Topics or Road Map

I think IPS should have our perspective on photonics technologies, and I started discussions with some members on hot topics or road mapping of photonics technologies. In the next several months I would like to have more concrete activities on this issue.

IEEE Milestone Event

I think readers of the IPS Newsletter may know Gordon Day, the IEEE President for 2012, because he served as President of LEOS in 2000. As in past years, the IEEE will celebrate IEEE Milestones in Engineering (see IEEE Milestones at www.ieeeghn.org). Gordon is especially excited about celebrating Milestones in photonics technologies. The first of these this year will be commemorating low-loss optical fiber for communication developed at Corning.

CLEO 2012 will be over by the time this column is posted in the June Newsletter, and I suppose various new advances will have been reported and further progress made by then. In July we have OECC 2012, the Asia-Pacific equivalent of OFC or ECOC, which will be held in Busan, Korea. OECC 2012 has the CLEO Focus Session, as well. I will be happy to greet you in Busan.

With warm wishes,
Hideo Kuwahara
Fellow
Fujitsu Laboratories Ltd.

A Tutorial on Microwave Photonics

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Abstract: The broad bandwidth and low loss offered by modern photonics have led to an ever-increasing interest in the design and implementation of photonically assisted systems for the generation, processing, control and distribution of microwave signals, an area called microwave photonics. In this article, a tutorial on microwave photonics is presented with an emphasis on photonic true-time delay beamforming, radio-over-fiber and UWB-over-fiber distribution and photonic analog-to-digital conversion.

Introduction

A tutorial on microwave photonics with an emphasis on the photonic generation of microwave signals and photonic processing of microwave signals was presented recently [1]. In general, the microwave photonics techniques cover the following topics: 1) photonic generation of microwave signals, 2) photonic processing of microwave signals, 3) photonic distribution of microwave signals, and 4) photonic analog-to-digital conversion. In this article, the topics including photonic true-time delay beamforming, radio-over-fiber and UWB-over-fiber and photonics analog-to-digital conversion will be discussed.

Photonic True-Time Delay Beamforming

Phased array antennas (PAA) are playing an important role in modern radar, sonar and wireless communication systems. Conventional phased array antennas are realized based on electrical phase shifters, which suffer from the well-known beam squint problem, limiting the phase array antennas for narrowband operations. For many applications, however, it is highly desirable that the phase array antennas can operate in a broad band. An effective solution is to use true-time delay beamforming.

Squint Phenomenon

The squint phenomenon is characterized by the position of the main lobe of the array factor being oriented at different angles for different microwave frequencies. In other words, the energy associated with different frequencies is oriented in different directions and thus restricts the use of the antenna for narrowband applications only.

As can be seen from Fig. 1(a), to steer the beam to a direction with angle of θ relative to the broadside direction, a phase shifter with a phase shift of $\Delta\phi$ is required, which is given

$$\Delta\phi = 2\pi\frac{\Delta L}{\lambda} = 2\pi\frac{d\sin\theta}{\lambda} \tag{1}$$

The beam pointing direction is then given by

$$\theta = \sin^{-1}\left(\frac{\lambda}{2\pi d}\Delta\phi\right) \tag{2}$$

As can be seen the beam pointing direction is a function of the microwave wavelength or frequency. Therefore, a beamforming system using electronic phase shifters will only support narrowband operation or the beam will be corrupted, a phenomenon called *beam squint*. The problem can be solved if the phase shifter is replaced by a true-time delay line, as shown in Fig. 1(b), where a true-time delay line with a length of $\Delta L = d\sin\theta$ is used. The beam pointing direction is now given by

$$\theta = \sin^{-1}\left(\frac{\Delta L}{d}\right) \tag{3}$$

It can be seen that the beam pointing direction is independent of the microwave frequency. A wide instantaneous bandwidth operation that is squint free is ensured. Fig. 1(c) shows the beam squint effect for a phased array antenna using electronic phase shifters operating at a frequency band of 10–20 GHz. The far-field radiation pattern of the array factor for the frequency band between 10 and 20 GHz clearly shows that the orientation of the main lobe varies with the feed signal frequency. This phenomenon decreases significantly the performance of the beamforming system. Fig. 1(d) shows the array factor by using true-time delay components. The far-field radiation pattern of the array factor for the frequency band between 10 and 20 GHz clearly shows that the orientation of the main lobe does not vary with the feed signal frequency.

Photonic True-Time Delay Beamforming

Traditionally, feed networks and phase shifters for phased array antennas were realized using electronic components. As ever increasing requirement for performance, severe limitations were observed in electronic devices. For example, copper wires exhibit high losses at high frequencies resulting in a limited bandwidth for the feed signals. Furthermore, electronic beamforming networks have a relatively high weight, thus limiting their use in airborne and satellite systems. Optical components, with key advantages such as immunity to electromagnetic interference (EMI), low loss, small size and light weight, are being considered as a promising alternative for wideband phased array antennas.

True-time delay beamforming based on photonic technologies has been extensively investigated with the systems implemented based either on free-space optics [2] or fiber or guided-wave optics. A true-time delay beamforming system based on free space optics has a relatively large size and heavy weight. Most of the reported systems were implemented based fiber optics. The realization of tunable true-time delays based on a

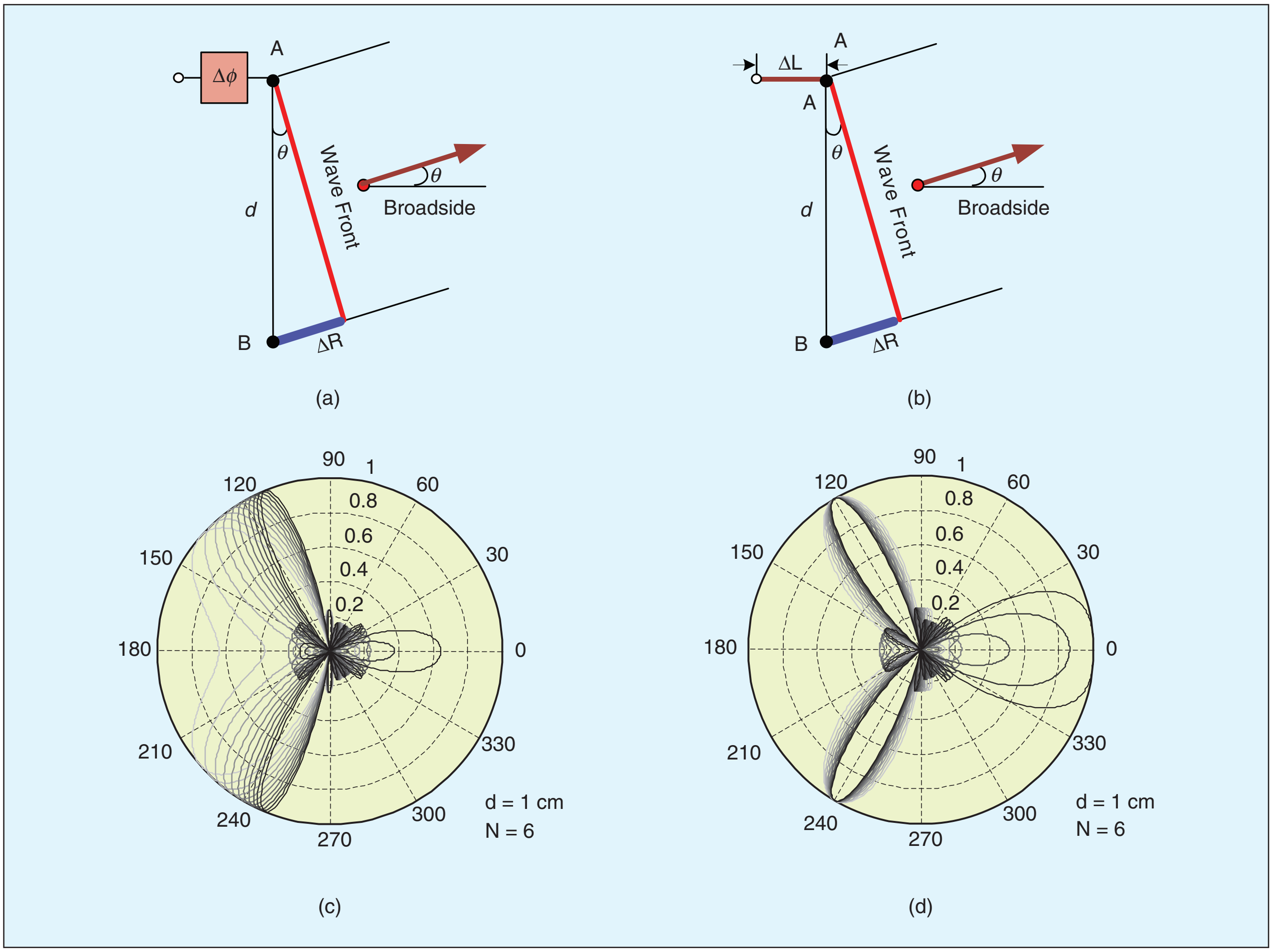

Figure 1. Beam steering (a) using a phase shifter, (b) using a delay line. (c) Beam squint effect for a phased array antenna operating at 10–20 GHz using electronic phase shifters. (d) Array factor of a phased array antenna operating at 10–20 GHz using true-time delay components.

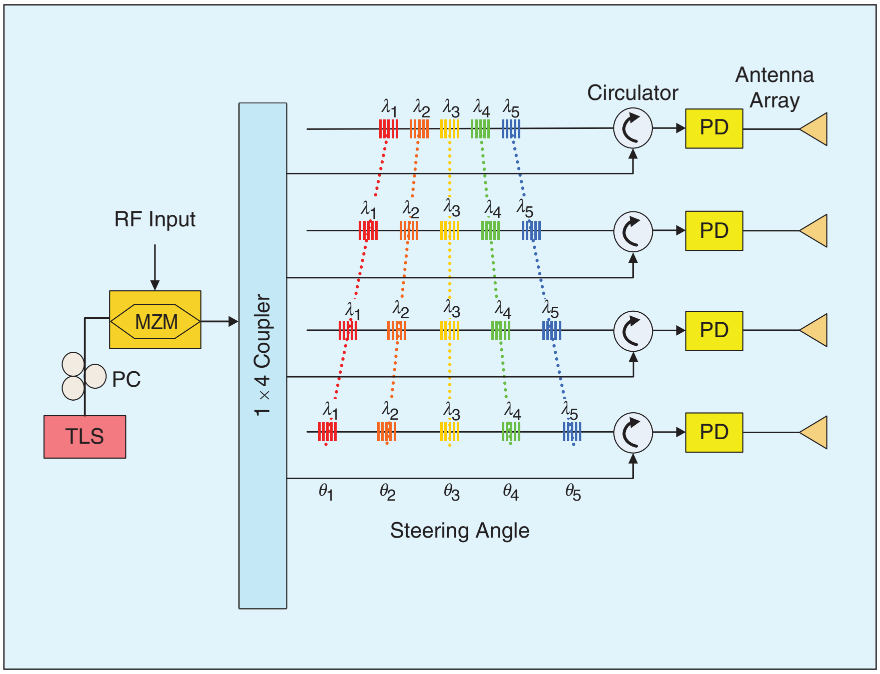

Figure 2. A photonic true-time delay beamforming system based on a FBG prism.

fiber-optic prism consisting of an array of dispersive delay lines was demonstrated in [3]. To reduce the size of the fiber-optic prism, the dispersive delay lines could be replaced by fiber Bragg grating (FBG) delay lines [4]. As an example, a FBG prism consisting of five channels of FBG delay lines is shown in Fig. 2 [5]. As can be seen the beam pointing direction can be steered by simply tuning the wavelength of the tunable laser source (TLS). If the FBG arrays in the delay lines are replaced by linearly chirped FBGs, a true-time delay beamforming system with continuous beam steering capability can be realized [6].

The architecture shown in Fig. 2 can be extended to two-dimensional (2D) beamforming [7] [8]. In [7], a 2D true-time delay beamforming system based on optical micro-electromechanical (MEMS) switches with fiber-optic delay lines connected between cross ports was demonstrated. A 2-bit × 4-bit optical true-time delay for a 10-GHz two-dimensional phased array antenna was implemented by cascading a wavelength-dependent true-time delay unit with a unit time delay of 12 ps in the x-direction and a wavelength-independent true-time delay unit with a unit time delay of 6 ps in the y-direction.

Radio-Over-Fiber and UWB-Over-Fiber

Radio-Over-Fiber

The distribution of radio signals over optical fiber, taking advantage of the low loss and broadband bandwidth of the state-of-the-art optical fibers, has been a topic of interest for the last two decades and some radio-over-fiber (RoF) systems have been deployed for practical applications. Fig. 3 shows RoF networks that are integrated into an optical communications network for broadband wireless access. At a backbone node or a central office, baseband signals are modulated on microwave subcarriers and then modulated on an optical carrier. The signals are sent over optical fibers to base stations. Microwave signals are detected at the base stations and then radiated to free space. For uplink, microwave signals from users are received by microwave antennas at the base stations and then modulated on optical carriers, to send via the same or different optical fibers to the central office. To distribute radio signals over optical fiber a few key issues should be addressed, including 1) the dispersion-induced power fading, 2) the dynamic range and 3) the noise figure of the link. Here the first two issues will be discussed: 1) Single-sideband modulation to combat fiber chromatic dispersion, and 2) increasing dynamic range to avoid interchannel distortion.

Due to the chromatic dispersion, double-sideband modulation is not preferred in a RoF system, especially for transmission of high frequency signals over a long distance, since a double-sideband-modulated microwave signal over fiber will suffer from the chromatic-dispersion-induced power fading. The reason behind the microwave power fading along the fiber is due to the cancellation of the beat signal between the upper sideband and the carrier and the beat signal between the lower sideband and the carrier, since the optical carrier and the two sidebands will travel at different velocities, leading to the phase changes. For a RoF link using an optical fiber with a length of L and a dispersion parameter of D, the power distribution as a function of microwave frequency is given by [9]

$$P(f) = \cos^2\left(\frac{\pi LD}{C}\lambda_C^2 f^2\right) \quad (4)$$

where λ_C is the wavelength of the optical carrier, f is the microwave frequency, C is the light velocity in vacuum.

Fig. 4 shows the microwave power of a double-sideband modulated signal as a function of the microwave frequency in a single-mode fiber of a length of 5 and 10 km. The fiber dispersion parameter is 17 ps/nm.km. Power fading due to the chromatic dispersion is clearly observed.

Although the dispersion can be compensated using a dispersion compensating fiber (DCF) or a linearly chirped FBG, a cost-effective solution is to use single-sideband modulation.

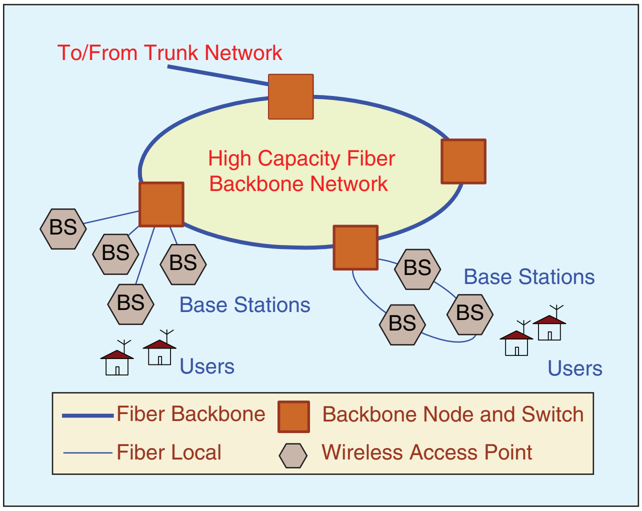

Figure 3. Convergence of wireless and fiber networks.

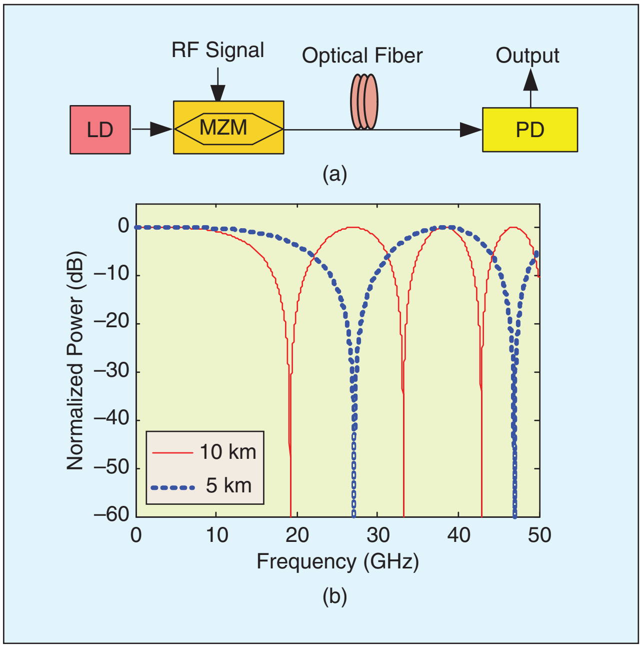

Figure 4. (a) A RoF transmission link. (b) Microwave power as a function of the microwave frequency for a given transmission length.

Fig. 5 shows the implementation of single-sideband modulation using a dual-port MZM [10]. An RF signal is applied to the two RF ports, with one being directly connected to the RF port and the other being phase shifted by 90° and then connected to the second RF port. The output signal will have the optical carrier and one optical sideband.

Single-sideband modulation can also be achieved by using an optical filter, such as an FBG or a ring resonator, to filter out one of the two sidebands [11]. The major problem associated with the approach is that the optical filter should have a narrow bandwidth to effectively suppress one of the sideband. For a microwave signal operating a low frequency (a few GHz), a regular uniform FBG can hardly fulfill this task due to the relatively large bandwidth. The use of a phase-shifted FBG that has an ultra-narrow transmission band can solve this problem [11].

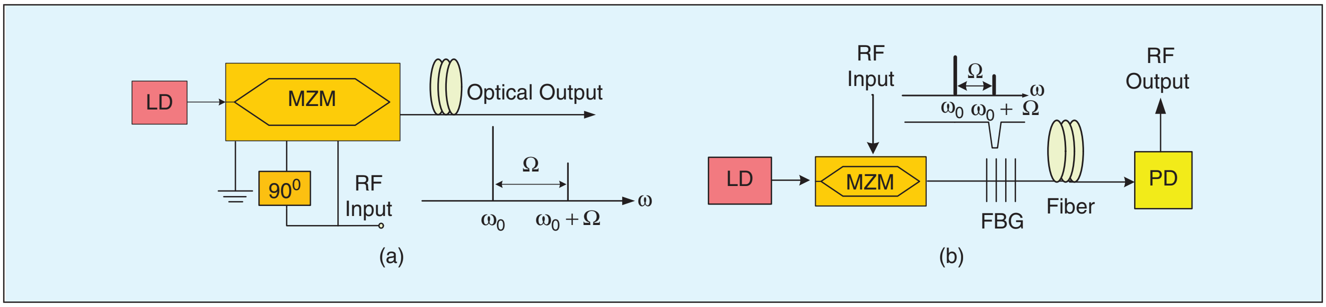

Figure 5. (a) Single-sideband modulation using a dual-port MZM. (b) Single-sideband modulation using an FBG to filter out one of the two optical sidebands.

One of the key performance measures that characterizes the performance of a RoF link is the dynamic range. In a RoF system using direct modulation or external modulation, due to the modulation nonlinearity of a LD or the inherent nonlinearity of the transfer function of a MZM, nonlinear distortions such as harmonic distortions and intermodulation distortions would be generated, which will limit the dynamic range of the RoF link. Various techniques have been proposed to combat the nonlinear distortions. It was reported in [12] that the third-order inter-modulation can be minimized in a direct-modulation-based RoF system by using an optimum bias current to the LD. The use of feed-forward linearization of a directly modulated LD would also provide a distortion cancellation [13]. The distortions of a LD can also be reduced by predistortion [14]. For a RoF system employing an external modulator, the nonlinear distortions caused by the MZM can be reduced by techniques such as predistortion of the RF signals [15] [16] and linearization of the MZM [17] [18]. In addition to the above techniques to reduce the nonlinear distortions, another solution to increase the dynamic range is to reduce the noise floor. It is known that a reduction of the noise floor would increase the spurious-free dynamic range (SFDR). Spurious-free dynamic range is defined as the difference between the minimum signal that can be detected above the noise floor and the maximum signal that can be detected without distortions (third-order intermodulation terms). In a RoF link, the SFDR is limited by several noise sources, including the optical phase-induced intensity noise, shot noise and relative-intensity noise (RIN). For a RoF link that uses independent light sources with very narrow line width, the phase-induced intensity noise is small and can be neglected. Therefore, the dominant noise sources are the shot noise and the RIN, both are associated with the average received optical power at the PD. The shot noise and the RIN powers are linearly and quadratically proportional to the received optical power. Therefore, a solution to increase the SFDR is to reduce the average received optical power. The reduction of shot noise and the RIN to improve the dynamic range of an RoF link has been proposed, such as intensity-noise cancellation [19], optical carrier filtering [20], low-biasing of a MZM [21]–[24], coherent detection [25], and optical PM-IM conversion using an FBG-based frequency discriminator [26].

UWB-Over-Fiber

As defined in Part 15 of the Federal Communications Commission (FCC) regulations [27], a UWB impulse signal should have a fractional bandwidth larger than 20% or a 3-dB bandwidth of at least 500 MHz. The UWB spectral mask defined by the FCC is shown in Fig. 6. As can be seen, the frequency band assigned to UWB indoor communications systems extends from 3.1 GHz to 10.6 GHz, with a bandwidth of 7.5 GHz centered at 7 GHz. The power density must be smaller than –41.3 dBm/MHz. Due to the low power density regulated by the FCC, the wireless transmission distance is limited

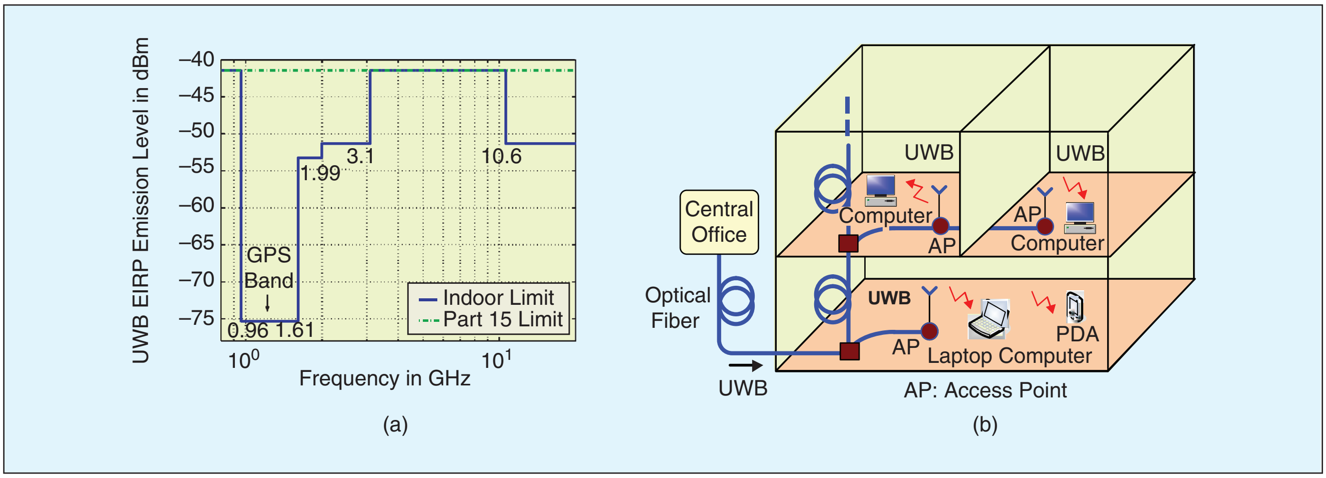

Figure 6. The UWB spectral mask defined by the FCC for UWB indoor communications. (b) UWBoF system for broadband indoor wireless access.

to a few to tens of meters. Such a short-range communications network can only operate in a standalone mode. To increase the area of coverage and to integrate the local UWB environment into fixed wired networks or wireless wide-area infrastructures, UWB signals are to be distributed using wired line such as coaxial cable or optical fiber. Thanks to the low loss and broad bandwidth of the state-of-the-art fiber, the distribution of UWB signals over fiber, or UWB-over-fiber (UWBoF) [28], is considered a promising solution. Fig. 7 shows a UWBoF system for broadband indoor wireless access. In the system, UWB signals are generated and encoded in the central office and distributed over optical fiber to the access points. At the access points, the UWB signals in the optical domain are converted to the electrical domain and then radiate to the free space. For upstream signal transmission, considering the low data-rate nature of upstream transmission, a simple and mature wireless communication technique, such as a wireless local-area network (LAN), would be used. Therefore, the entire UWBoF system would be operating in a hybrid mode to take advantage of the high-data rate feature of UWB technique for downstream signal distribution and the low cost of a mature wireless communication technique for upstream transmission.

In addition to the distribution of UWB signals over optical fiber, it is also desirable that UWB signals are generated directly in the optical domain, without the need of extra optical-electrical and electrical-optical conversions, to fully exploit the advantages provided by optics [29]. Fig. 7 shows a technique to generate UWB pulses based on phase modulation and PM-IM conversion using a FBG [30]. At the phase modulator, a Gaussian pulse is modulated on the optical carrier. By tuning the wavelength of the optical carrier to locate at the left or right linear slope of the FBG transfer function, a UWB monocycle pulse with opposite polarity is generated.

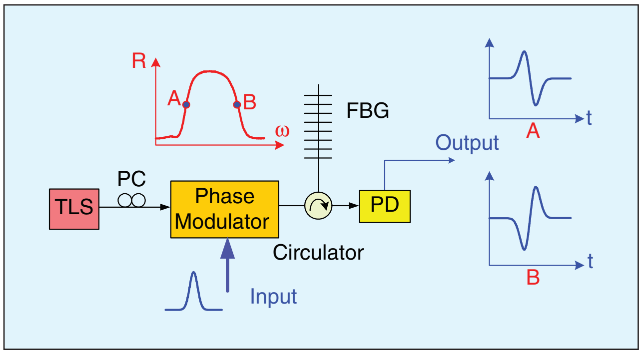

Figure 7. UWB pulse generation based on phase modulation and PM-IM conversion.

To practically deploy an UWBoF system, it is of great importance to reduce the cost. A solution is to integrate UWBoF systems into the existing wired optical access networks. Gigabit passive optical network (GPON) according to ITU-T G.984 has been widely deployed in parts of the U.S. and Europe. Meanwhile, Ethernet PON (EPON) according to the Ethernet-First-Mile standard or IEEE 802.3ah is broadly deployed in Japan and Korea. However, both GPON and EPON are based on time-division multiple access (TDMA) technology, providing services to *N* users by use of passive 1:*N* power splitters with an aggregate bit rate, so they cannot meet the requirements of future access network evolution regarding aggregated bandwidth, attainable reach and allowable power budget. Therefore, there is a worldwide consensus that the current time-division multiple access (TDMA) passive optical network would evolve toward wavelength division multiplexing PON (WDM-PON) [31]–[33]. Therefore, it is of great interest to integrate an UWBoF system into

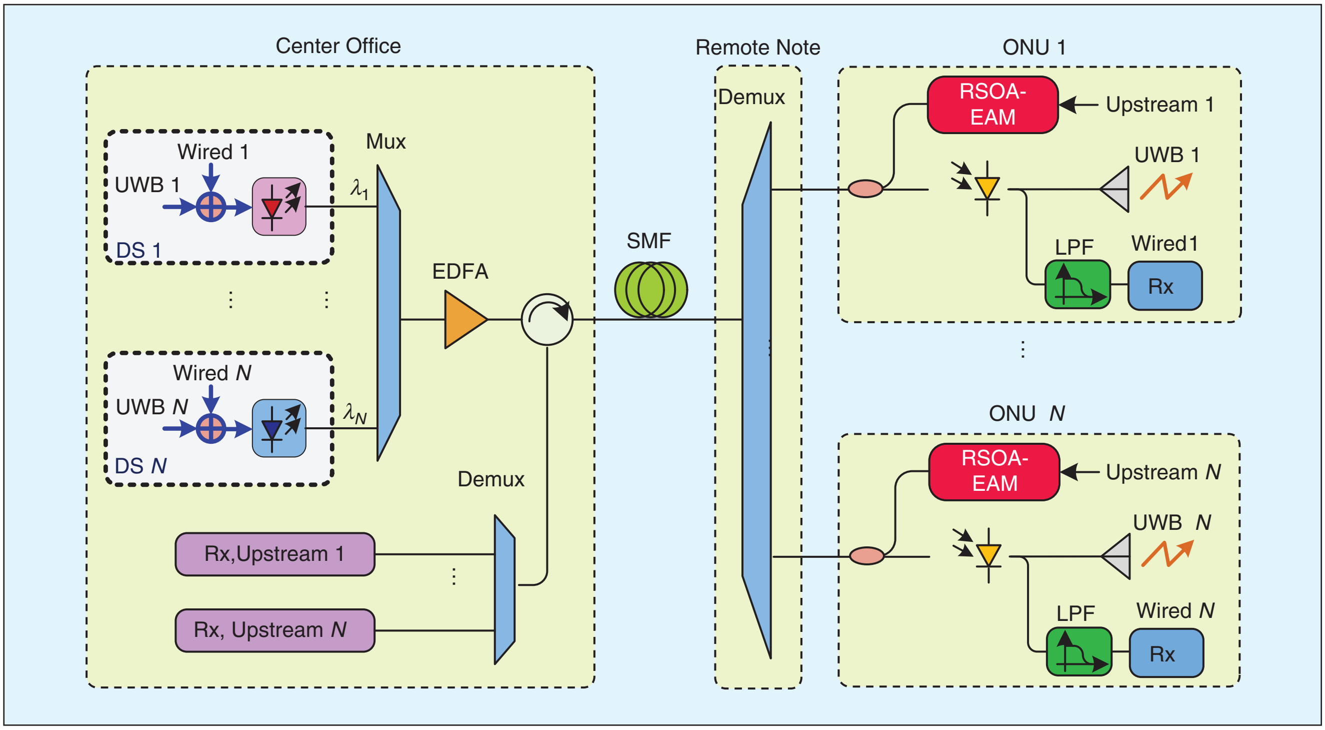

Figure 8. UWB over WDM-PON. The system is designed to provide UWB services without affecting the existing wired services.

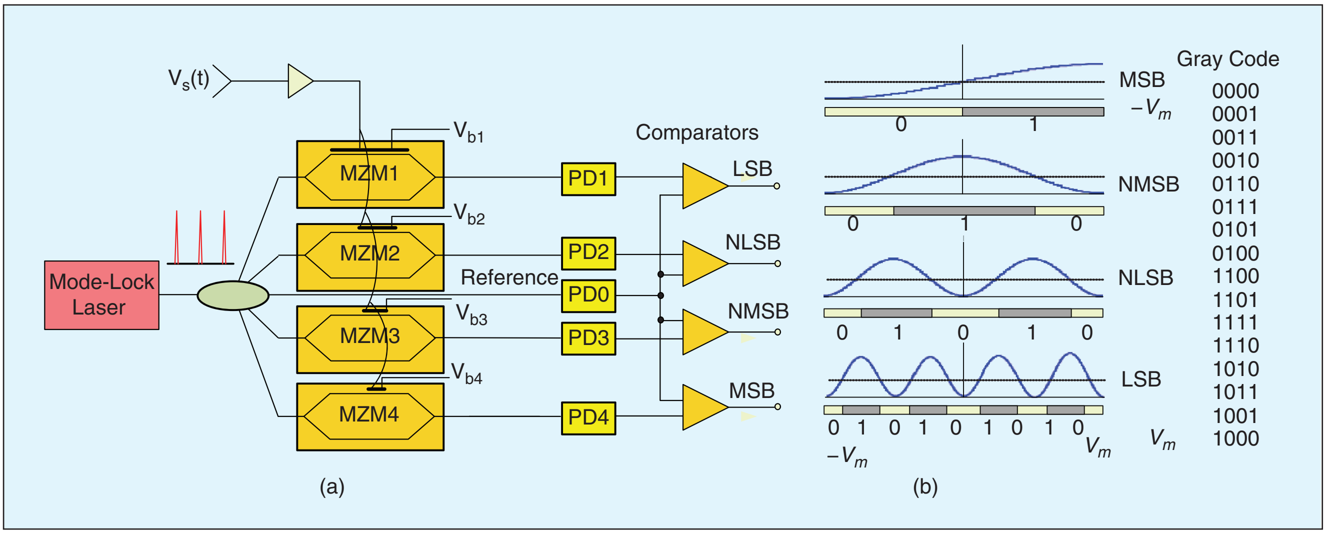

Figure 9. A 4-bit analog-to-digital converter using an array of MZMs with each modulator having an electrode length that is twice that of its nearest more significant bit. (a) The schematic of the system, (b) Gray code produced at the outputs of the comparators.

a WDM-PON network. Fig. 8 shows a UWB over WDM-PON network [34].

For downstream transmission, at the center office, a UWB signal and a baseband wired signal are combined at an electronic power combiner and then modulated on a single wavelength at a MZM. The wired signal should have a spectrum in the range of 0–3.1 GHz. Since a UWB signal, based on the spectral mark defined by the FCC, would have a spectrum in the range of 3.1–10.6 GHz, the two signals could coexist without spectral interference. The optical signal at the output of the MZM is then transmitted through a length of single-mode fiber to an optical network unit (ONU), where the optical signal is first detected by a PD and then split into two paths. In one path, the electrical signal is sent to a UWB antenna. Since a UWB antenna has a spectral response covering a range of 3.1–10.6 GHz, it can be used to act as a bandpass filter to block the wired signal. An UWBoF link is thus established. In the other path, the UWB signal is filtered out by a low-pass filter, and only the wired signal is obtained. As a result, an optical link for the wired signal transmission is implemented.

For upstream transmission, to simplify the base station, the optical carrier used for downstream transmission can be reused, which can be achieved by using a reflective semiconductor optical amplifier (RSOA). As can be seen, part of the downstream signal is tapped and sent to the RSOA. At the RSOA, the downstream signals are erased due to the gain saturation of the RSOA and the upstream signal is modulated on the same optical carrier.

In Fig. 8, the UWB signals at the central office are generated electronically and then multiplexed with the wired baseband signals. Recently, an approach to the simultaneous generation and transmission of UWB signals in the optical domain was demonstrated, which simplifies the overall system [35].

Photonics Analog-to-Digital Conversion

Analog-to-digital conversion (ADC) is essential for many applications where analog signals are digitized for processing using digital signal processing circuits. Although there is a significant progress in ADC, the sampling speed of the state-of-the-art electronics is still limited. In the last few decades, the use of optical techniques to achieve photonic ADC has attracted great interest thanks to the technological breakthrough in mode-lock laser sources, which can produce ultra-narrow and high-repetition-rate optical pulses with a timing jitter significantly below that of an electronic pulse generator. The use of optical sampling would have an added advantage of small back-coupling.

Fig. 9(a) shows a photonic analog-to-digital converter proposed by Taylor [36][37], in which an array of MZMs was used, with the input analog signal being symmetrically folded by the MZMs with each MZM having an electrode length that is twice that of its nearest more significant bit (NMSB), leading to a doubled-folding frequency, as shown in Fig. 9(b). The folding property in the transfer function imposes a requirement that the half-wave voltage of the MZM at the least significant bit (LSB) should be 2^N times lower than that of the MZM at the most significant bit (MSB), where N is the number of bit, which is difficult to realize with currently available photonics technology.

A recent solution to implement a photonic analog-to-digital converter using an array of MZMs with identical half-wave voltages was demonstrated [38]. The system architecture is identical to the one shown in Fig. 9(a), except that the MZMs are differently biased such that the transfer functions of the MZMs are laterally shifted, which leads to the generation of a linear binary code to represent the analog input signal. The operation principle is shown in Fig. 10. For an analog-to-digital converter with four channels, the four MZMs are biased with their transfer functions shifted laterally with a uniform phase spacing of $\pi/4$, as shown in Fig. 10(a). The outputs from the comparators with a threshold level as half of the full scale are shown in Fig. 10(b). The quantized values of the signal at the output of the 4-channel analog-to-digital converter are shown in Fig. 10(c). Other system structures using MZMs with identical half-wave voltages including the optical folding-flash

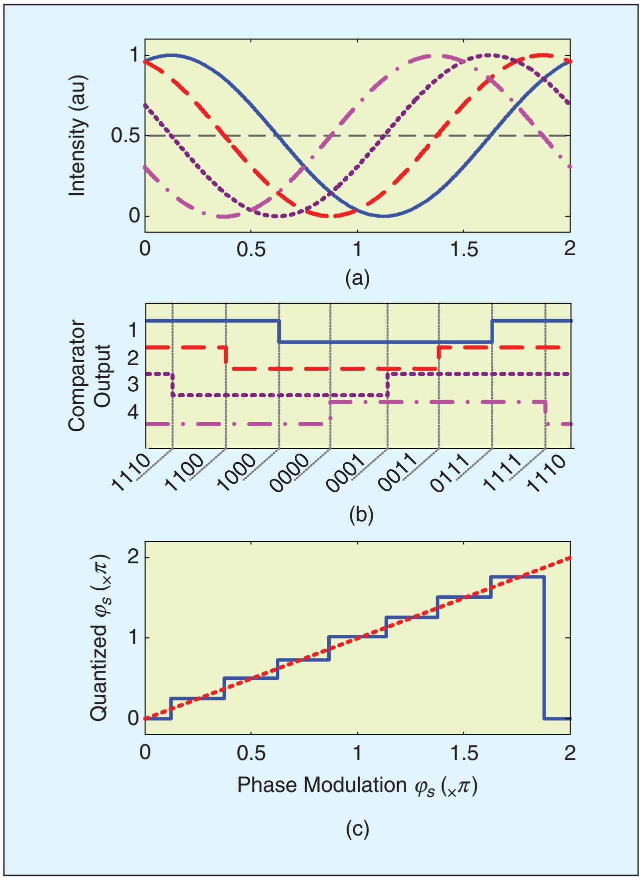

Figure 10. A 4-channel photonic analog-to-digital converter using MZMs with identical half-wave voltages. (a) The transfer functions of the four Mach-Zehnder modulators; (b) *The linear binary code* at the outputs of the comparators; (c) Quantized value (solid line) v.s. the input phase modulation (dotted line).

ADC [39] and the cascaded phase modulator-based ADC [40] were also demonstrated.

Conclusion

An overview about photonic true-time delay beamforming, radio-over-fiber and UWB-over-fiber and photonics analog-to-digital conversion was presented. The key significance of implementing these functions using photonics is the broadband width, high speed and low loss, which may not be achievable using electronics. Some of the techniques have been commercialized [41]. For example, Photonic Systems Inc. has developed a family of microwave photonic links operating over 40 GHz, offering various levels of bandwidth, noise figure and dynamic range. Pharad has developed a comprehensive family of optimized performance RF photonic transceivers for high dynamic range and low loss RF signal over optical fiber transport. OEwaves has developed ultra low phase noise microwave sources based optoelectronic oscillators for high-frequency and high performance applications. Compared with the electronic counterpart, the commercialization of microwave photonics techniques is still limited, due to the lack of photonic integrated circuits. The recent activities in photonic integrated circuits [42] would be expected to have an important impact on the development and implementation of future microwave photonics systems for both civil and defense applications.

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News

Call for Nominations

2013 John Tyndall Award

Nominations are now being accepted for the **John Tyndall Award**, which will be presented at OFC/NFOEC 2013. The deadline for nominations is **10 August, 2012.**

This award, which is jointly sponsored by the IEEE Photonics Society and the Optical Society, is presented to a single individual who has made outstanding contributions in any area of lightwave technology, including optical fibers and cables, the optical components employed in fiber systems, as well as the transmission systems employing fibers. With the expansion of this technology, many individuals have become worthy of consideration.

The nomination form, award information and a list of previous John Tyndall recipients are available on the Photonics Society web site:

http://www.photonicssociety.org/award-info
http://www.photonicssociety.org/award-winners

Call for Nominations

IEEE Photonics Society 2013 Young Investigator Award

Nominations for **Young Investigator Award** are now being solicited for submission to the Photonics Society Executive Office. The deadline for nominations is **30 September, 2012.**

The nomination form, awards information and a list of previous recipients are available on the Photonics Society web site:

http://www.photonicssociety.org/award-info
http://www.photonicssociety.org/award-winners

The **Young Investigator Award** was established to honor an individual who has made outstanding technical contributions to photonics (broadly defined) prior to his or her 35th birthday. Nominees must be under 35 years of age on Sept. 30th of the year in which the nomination is made. The award may be presented either at the Optical Fiber Communications Conference (OFC), or the Conference on Lasers and Electro-Optics (CLEO), to be selected by the recipient.

Careers and Awards

IEEE photonics SOCIETY
Transforming science into technology™

Effective 2012, nomination deadlines for the IEEE Photonics Society Awards are listed as follows:

Award	**Nomination deadline**
Distinguished Lecturer Awards	February 16
Aron Kressel Award	April 5
Engineering Achievement Award	April 5
Quantum Electronics Award	April 5
William Streifer Scientific Achievement Award	April 5
Distinguished Service Award	April 30
Graduate Student Fellowship	May 30
John Tyndall Award	August 10
Young Investigator Award	September 30

IEEE PHOTONICS SOCIETY 2012–13 Distinguished Lecturers

The Distinguished Lecturer Awards are presented to honor interesting speakers who have made recent significant contributions to the field of lasers and electrooptics. The Distinguished Lecturers speak at Photonics Society Chapters worldwide. Please contact your local chapter to see when one of the Lecturers will be speaking in your area. A list of current Photonics Society Chapter Chairs is available on the Photonics Society web site (http://www.photonicssociety.org/chapters).

This year's Lecturers are:

Wood-Hi Cheng, National Sun Yat-Sen University, Kaohsiung, Taiwan

Topic of Lecture: The Art and Science of Packaging Photonic Devices and Modules

Andrew D. Ellis, Photonic Systems Group, University College Cork, Cork, Ireland

Topic of Lecture: Ultra High Capacity Optical Transmission Systems

Simon Poole, New Business Ventures, Finisar, Australia

Topic of Lecture: Confessions of a Serial Entrepreneur: 30 Years of Photonic Start-ups in Academia and Industry

Linshan Yan, Southwest Jiatong University, Chendu, Sichaun, China.

Topic of Lecture: Polarization in Fiber Optics

Below is the bio data on the two newly elected Distinguished Lecturers for the period 2012–2013, Simon Poole and Andrew D. Ellis

Dr. Simon Poole is an engineer/entrepreneur with over 30 years experience in photonics in research, academia and industry. He obtained his PhD from Southampton University in 1987 and was a member of the team that invented the Erbium-Doped Fiber Amplifier (EDFA) in 1985. In 1988 he moved to Australia and founded the Optical Fiber Technology Centre (OFTC) and subsequently Australian Photonics Cooperative Research Centre (APCRC) at the University of Sydney where he was director of the Sydney Node from 1991 to 1995. The APCRC grew to over 150 researchers and led to 15 start-ups which raised a total of over $250m in Venture Capital funding.

In 1995, Dr. Poole led the first spin-off company from the APCRC, Indx Pty Ltd which manufactured Fiber Bragg Gratings (FBGs) for optical communications. Indx was acquired by Uniphase Corporation (now JDS Uniphase) for $US6m and subsequently grew to over 300 people with exports of over $100m pa. After leaving JDSUniphase in late 2000 he worked as a venture partner with KPLJ Ventures before co-founding Engana Pty Ltd in September 2001.

As Engana's CEO Dr. Poole raised $13m in VC funding and oversaw the development and launch of Engana's market-leading Dynamic Wavelength Processor line of Wavelength Selective Switches in early 2005. The company, now Finisar Australia, employs 280 people in Sydney and a similar number in China, with annual sales of Wavelength Selective Switches of >$100m pa.

In 2008, Dr. Poole started a new group within Finisar, the New Business Ventures Group, to generate new, high value added businesses using the principles of Open Innovation. The first business within this group was the highly successful WaveShaper range of Programmable Optical Processors which already has sales of over $6m pa.

Dr. Poole is a Fellow of the IEEE in 2001 and is also a Fellow of the Institute of Engineers Australia (FIEAust), a Senior Member of the Institute of Engineering and Technology (SMIET) and a Chartered Engineer (CEng). He has published over 150 refereed papers in journals and international conferences as well as filing 7 patents, including the initial patent on the EDFA.

Title of Talk: Confessions of a Serial Entrepreneur: 30 Years of Photonic Start-ups in Academia and Industry

Every company – even the largest household names such as Google or Apple or even IBM - begins life as a start-up. Drawing on experience gained from Dr. Poole's extensive start-up history, this presentation will look at how some of the companies and research groups in which Dr. Poole has been involved got started, what they did and how they subsequently developed and thrived. The presentation aims to inspire researchers who are considering how to commercialize their research to take the next steps and move out of the research lab and into the brave new world of commercialization.

Dr. Simon Poole is an engineer/entrepreneur with over 30 years experience in photonics in research, academia and industry. He has been involved in numerous successful start-ups in both Academia and industry and is renowned for both his contribution to the technology of photonics as well as the companies he has founded.

Careers and Awards (cont'd)

Dr. Andrew Ellis was born in Underwood, England in 1965 and gained a BSc in Physics with a minor in mathematics from the University of Sussex, Brighton, England in 1987. He was awarded his PhD in Electronic and Electrical Engineering from The University of Aston in Birmingham, Birmingham, England in 1997 for his study on All Optical Networking beyond 10 Gbit/s.

He previously worked for British Telecom Research Laboratories as a Senior Research Engineer investigating the use of optical amplifiers and advanced modulation formats in optical networks and the Corning Research Centre as a Senior Research Fellow where he led activities in high speed optical component characterization. Currently, he heads the Transmission and Sensors Group at the Tyndall National Institute in Cork, Ireland, where he is also a member of the Department of Physics, University College Cork. He is also an adjunct Professor of Electronic Engineering at Dublin City University, and a founder of the Dublin based start-up Pilot Photonics. He research interests include all optical OFDM, optical and electrical signal processing, the mechanisms limiting capacity in optical communication systems, and the application of photonics to sensing.

Dr. Ellis is a member of the Institute of Physics and the Institute of Engineering Technology, and is a Chartered Physicist. He is an Associate Editor of Optics Express and acts as a reviewer for IEEE Journal of Lightwave Technology, Photonics Technology Letters and Journal of Selected Topics in Quantum Electronics. He has published over 150 journal papers and over 24 patents in the field of Photonics.

Title of Talk: Ultra High Capacity Optical Transmission Systems

With the remorseless growth in demand for telecommunication services, the capacity of optical fiber links first exceeded the capabilities of electronics, requiring the introduction of wavelength division multiplexing, and is now approaching a fundamental limit. This limit is due to a trade-off between the familiar Shannon limit at low signal powers, and nonlinear effects at high powers. Before considering the implications of the capacity crunch when demand finally hits this limit, this lecture will review the technological achievements which took the industry from its first commercial service with the Dorset (UK) police in 1975 through to the 10 Tbit/s systems of today.

Membership Section

Benefits of IEEE Senior Membership

There are many benefits to becoming an IEEE Senior Member:

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New Senior Members

The following individuals were elevated to Senior Membership Grade thru March:

James A. Bain
Muhannad S. Bakir
Mikhail Belkin
Szeming Cheng
Javier Del Ser
Nitin K. Goel
Masashi Hotta
Markus Jung
Kazutoshi Kato
Jung-Won Kim
Emmanouil Kriezis
Hai-Feng Liu
Paolo Navaretti
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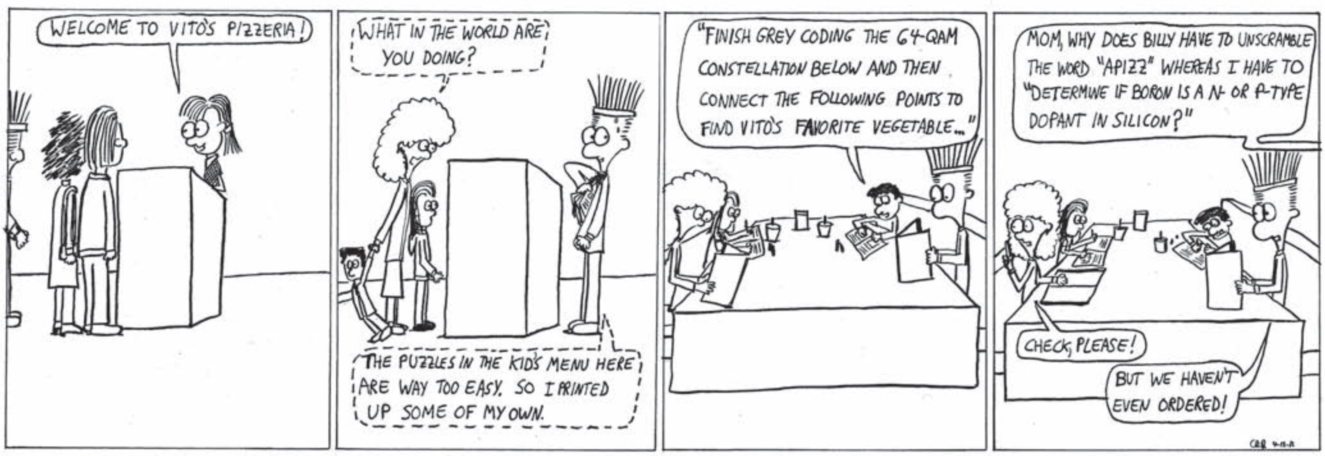

Conference Section

Recognition at OFC/NFOEC 2012

The Optical Fiber Communication Conference and Exposition (OFC), and the National Fiber Optic Engineers Conference (NFOEC) was held on 4–8 March, 2012 at the Los Angeles Convention Center, Los Angeles, California, USA. Recognition was made at the Plenary Session to the following recipients.

John Bowers received the 2012 John Tyndall Award "for pioneering research in hybrid-silicon lasers and photonic integrated circuits." This award is jointly sponsored by the Photonics Society, OSA and endowed by Corning Inc. (From left to right) Hideo Kuwahara (Photonics Society President), Philip H. Bucksbaum (OSA Vice President), John Bowers and Ming-Jun Li (Corning, Incorporated).

The 2012 Young Investigator Award was presented to William Green "for contributions in CMOS integrable, highly scaled, Silicon Nano-Photonics, and pioneering Silicon Photonics for mid-infrared applications and non-linear-optics."

Photonics Society members who have been elevated to the grade of IEEE Fellows: (From left to right) Hideo Kuwahara (Photonics Society President), Jianping Yao, Ashok Krishnamoorthy, Yuichi Matsushima, Tetsuya Mizumoto, and Ping-Kong Wai.

IEEE Photonics Society Co–Sponsored Events - 2012

PVSC June 3 - 8, 2012
2012 Photovoltaic Specialists Conference
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OECC July 2 - 6, 2012
The 17th Opto-Electronics and Communications Conference
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Busan, Korea
http://www.oecc-2012.org/

ICTON July 2 - 6, 2012
The 14th International Conference on Transparent Optical Networks
University of Warwick
Coventry, United Kingdom
http://www.itl.waw.pl/icton2012

ICCE August 1—3, 2012
Fourth International Conference on Communications and Electronics
Saigon Morin Hotel
Hue, Vietnam
http://www.hut-icce.org/

IPRM August 27—30, 2012
Compound Semiconductor Week
24th International Conference on Indium Phosphide and Related Materials
University of California
Santa Barbara, CA
http://csw2012.ece.ucsb.edu

NUSOD August 28—31, 2012
12th International Conference on Numerical Simulation of Optoelectronic Devices
Chinese Academy of Science
Shanghai, China
http://www.nusod.org/2012/

PS September 11—14, 2012
2012 International Conference on Photonics in Switching
Palais des Congrès
Corsica Island, France
http://www.ps2012.net

ECOC September 16—20, 2012
38th European Conference on Optical Communication
RAI Congress Centre
Amsterdam, The Netherlands
http://www.ecoc2012.org

OFS—22 October 15—19, 2012
22nd International Conference on Optical Fiber Sensors
China Hall of Science and Technology
Beijng, China
http://www.ofs-22.org

2012 IEEE PHOTONICS SOCIETY CONFERENCE CALENDAR 2012

Optical Interconnects Conference
20-23 May, Eldorado Hotel and Spa, Santa Fe, NM, USA
www.oi-ieee.org

Summer Topicals Meeting
Pre-Registration Deadline: 8 June 2012
9-11 July, Renaissance Seattle Hotel, Seattle, WA, USA
www.sum-ieee.org

Optical MEMS & Nanophotonics Conference
Pre-Registration Deadline: 6 July 2012
6-9 August, The Banff Centre, Banff, Alberta, Canada
www.mems-ieee.org

9th International Conference on Group IV Photonics
Pre-Registration Deadline: 27 July 2012
29-31 August, Holiday Inn on the Bay, San Diego, CA, USA
www.gfp-ieee.org

Avionics, Fiber-Optics & Photonics Conference
Pre-Registration Deadline: 10 August 2012
11-13 September, Courtyard By Marriott, Cocoa Beach, FL, USA
www.avfop-ieee.org

IEEE Photonics Conference
Paper Submission Deadline: 18 May 2012
23-27 September, Hyatt Regency San Fransico Airport, Burlingame, CA, USA
www.ipc-ieee.org

International Semiconductor Laser Conference
Pre-Registration Deadline: 7 September 2012
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- Optical Interconnects
- Optical Networks & Systems
- Photodetectors, Sensors, Systems & Imaging
- Photonics Integration & Packaging
- Photonic Materials Science & Technology
- Semiconductor Lasers

Plenary Speakers

Ashok Krishnamoorthy
Oracle, USA
"Driving VCSELs and silicon photonic optical interconnects to brutal area and energy efficiencies for future computing systems"

Takao Someya
University of Tokyo, Japan
"Large-area, Flexible, Organic Photonics and Electronics"

Martin Wegener
Karlsruhe Institute of Technology (KIT), Institute of Applied Physics, Germany
"3D Photonic Metamaterials and Transformation Optics"

Eli Yablonovitch
UC Berkely, USA
"The Opto-Electronic Physics That Just Broke the Efficiency Record in Solar Cells"

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Conference Section (cont'd)

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Associate Secretary: **Prof. Gert von Bally**, Centrum für Biomedizinische Optik und Photonik, Universitätsklinikum Münster, Robert-Koch-Straße 45, 48149 Münster, Germany; Ce.BOP@uni-muenster.de

2–5 July 2012
8th International Conference on Optics-photonics Design and Fabrication "ODF'12"
St.-Petersburg, Russia
Contact: M. Letunovskaya
phone: +7(812)457 18 87
fax: +7(812)457 18 87
odf12@gmail.com
http://odf2012.ru/

4–6 July 2012
ICO Topical Meeting: 12th Conference of the International Society on Optics Within Life Sciences "OWLS 12"
Genoa, Italy
Contact: Alberto Diaspro
phone: +39-010.71.781.503
fax: +39-010-72.03.21
alberto.diaspro@iit.it
http://www.owls2012.org/

2–5 November 2012
5th International Photonics and Optoelectronics Meetings (POEM 2012)
Wuhan, China
Contact: Xiaochun Xiao, Qingming Luo
phone: +86-27-87792227, 87792223
fax: +86-27-87792224
xiaoxc@mail.hust.edu.cn
qluo@mail.hust.edu.cn


Pre-Registration Deadline:
8 June 2012
Summer Topicals
9-11 JULY 2012
Photonic Next Generation Communication Systems and Novel Devices
TOPICS:
Space Division Multiplexing for Optical Systems and Networks
Co-Chairs:
Lynn Nelson, AT&T, USA
John Fini, OFS Laboratories, USA
David Richardson, University of Southampton, UK
High Power Semiconductor Lasers
Co-Chairs:
Gary Smith, MIT Lincoln Laboratory, USA
Paul Crump, Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik, Germany
Optical Wireless Systems and Applications
Co-Chairs:
Gee-Kung Chang, Georgia Institute of Technology, USA
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Montana State University, USA

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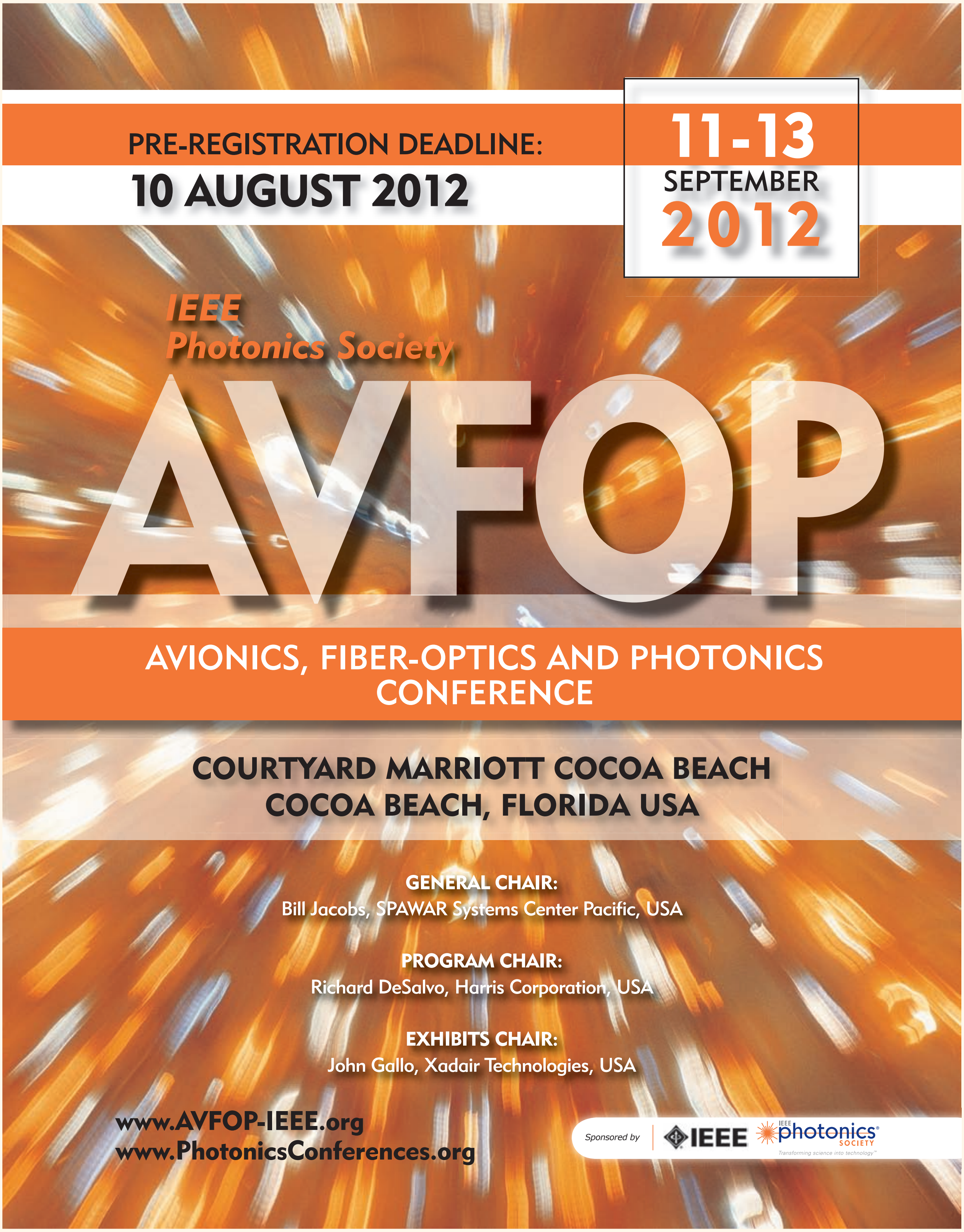
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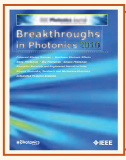

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Call for Papers

Announcing an Issue of the IEEE *JOURNAL OF SELECTED TOPICS IN QUANTUM ELECTRONICS* on Optical Interconnects for Data Centers

Submission Deadline: June 1, 2012

Moore's Law scaling of CMOS technology continues and microprocessor performance is expected to continue to increase with parallel processing of many cores on-chip. The future high performance computers (HPC) and Data Centers implemented with these processors will require terabytes/sec of bandwidth for processor to processor and processor to memory. It is expected to be increasingly difficult to meet the high-bandwidth density, low-latency, and low-energy communication requirements of these future large data centers and terascale computing systems using conventional electrical interconnects. Optical devices and optical interconnects could overcome these limitations. A significant amount of research work is being carried out in the development of optical interconnects, for computer backplane, chip-to-chip as well as on-chip optical interconnections through innovative multichip module component packaging as well as integration of photonic components with CMOS. At the same time research in computer architecture, and circuit design using optical networks is also being pursued. ***IEEE Journal of Selected Topics in Quantum Electronics*** invites manuscript submissions in the area of photonics and optical interconnect technology to meet the future interconnect requirements of the Data Center and High Performance Computing. Technical areas include but are not limited to:

- Networking architectures based on optical interconnect.
- Dynamic packet routing and switched optical network architectures
- Optically enabled functionalities for data centers
- Infiniband, and PCI Express implemented with optical interconnects.
- Low energy optical interconnect technology
- 3D stack integration, 3D optical interconnect methods
- Optical interconnect architectures to memory
- Novel nanophotonic integration methods
- Photonics heterointegration techniques
- Optical sources, detectors and waveguide device integration with CMOS
- Optical PCB, MCM, Chip-to-chip, intra-chip and Free-Space Interconnection;
- Optical microbench & Passive Alignment Technology;
- Limits of optical technologies and comparison to conventional solutions

The Guest Editors for this issue are **Ian Young**, Intel, USA; **Keren Bergman**, Columbia University, New York, USA; **Vladimir Stojanovic**, Massachusetts Institute of Technology, MA, USA; **Ashok Krishnamoorthy**, Oracle, CA, USA.

The deadline for submission of manuscripts is **June 1, 2012; preprints of accepted manuscripts will be posted in the IEEE Xplore website within 2 weeks after authors have correctly uploaded their final files** in the Scholar One Manuscripts "Awaiting Final Files" queue. **Final page proofs of accepted papers will be posted online in IEEE Xplore ideally within 6 weeks after the author has uploaded their Final Files, if there are no page proof corrections.** Hardcopy publication of the assembled Issue is scheduled for **March/April of 2013.**

Online Submission is Mandatory at: http://mc.manuscriptcentral.com/pho-ieee. Please select the Journal of Selected Topics of Quantum Electronics Journal from the drop down menu. Contributed papers should be up to eight pages in length, and invited up to 12 pages. Beyond that, a charge of $220 per page applies. All submissions will be reviewed in accordance with the normal procedures of the Journal.

For inquiries for this Special Issue, please contact:
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Call for Papers

Announcing an Issue of the IEEE *JOURNAL OF SELECTED TOPICS IN QUANTUM ELECTRONICS* on Nanoplasmonics

Submission Deadline: August 1, 2012

The last decade has seen an explosion of research interest linking plasmons to various disciplines in physics, chemistry, biology, engineering, material science, thin film technology, optics, nanosciences, etc. Nanoplasmonics aims at investigating and controlling light on length scales comparable or below the wavelength of operation, possibly down to tens of nanometers and on femtosecond time scales. Control is achieved with individual metallic nanostructures, specifically tailored to increase effective light-matter interactions by providing large local field enhancements or by slowing down propagation. The ***IEEE Journal of Selected Topics in Quantum Electronics*** invites manuscript submissions ranging from fundamental studies to applications of nanoplasmonics. Technical areas include but are not limited to:

- Plasmonic nanoparticles
- Light-matter nanoscale interaction and nanoantennae
- Low-loss doped semiconductors with plasmonic properties
- Subwavelength metallic surfaces
- Scattering and amplification of surface plasmons
- Quantum plasmonics
- Optical metamaterials
- Advanced nanomaterials, flexible and non-planar metasurfaces
- Novel nanofabrication and calculation methods for plasmonics
- Nonlinear and ultrafast plasmonics
- Infrared and terahertz plasmonics
- Ultra-compact photonic devices
- Plasmonics for photovoltaics
- Plasmonics for advanced microscopy and spectroscopy
- Plasmonics for biomedical applications
- Optical interconnects at subwavelength scales

The Primary Guest Editor for this issue is **Hatice Altug**, Boston University, Boston, MA, USA, and the Guest Editors are **Andrea Alù**, University of Texas, Austin, TX, USA, **Philippe Lalanne**, Institut d'Optique Graduate School, Bordeaux, France, **Stefan Maier**, Imperial College London, London, UK, and **Din Ping Tsai**, National Taiwan University, Taipei, Taiwan.

The deadline for submission of manuscripts is **August 1, 2012. Preprints of accepted manuscripts will be posted on the IEEE Xplore website within 2 weeks of authors correctly uploading their final files** in the Scholar One Manuscripts "Awaiting Final Files" queue. **Final page proofs of accepted papers are normally posted online in IEEE Xplore within 6 weeks of authors uploading their final files, if there are no page proof corrections**. Hardcopy publication of the issue is scheduled for **May/June of 2013**.

All submissions will be reviewed in accordance with the normal procedures of the Journal.

For inquiries for this Special Issue, please contact:
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The following supporting documents are required during manuscript submission at http://mc.manuscriptcentral.com/pho-ieee (please select the Journal of Selected Topics in Quantum Electronics from the drop down menu).

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Call for Papers

Announcing an Issue of the IEEE *JOURNAL OF SELECTED TOPICS IN QUANTUM ELECTRONICS* on Semiconductor Lasers

Submission Deadline: November 1, 2012

The ***IEEE Journal of Selected Topics in Quantum Electronics*** invites manuscripts that document the current state of the art in **Semiconductor Lasers**. Technical areas include but are not limited to:

- high-speed VCSELs and edge-emitting lasers
- low energy/bit lasers
- Vertical External Cavity Surface Emitting Lasers (VECSELs)
- novel high power laser schemes
- short pulse sources
- micro- and nanolasers
- short wavelength and visible lasers
- quantum dot/wire lasers
- photonic crystal lasers
- lasers on new semiconductor materials
- tunable lasers
- lasers in photonic and electronic integrated circuits
- quantum cascade, interband and mid-IR lasers
- THz lasers
- coupled semiconductor lasers
- semiconductor ring lasers
- lasers in microwave photonics
- synchronization of chaotic lasers, laser dynamics
- SOA and LED topics closely related to lasers
- new applications of semiconductor lasers

The Primary Guest Editor for this issue is **Luke F. Lester**, University of New Mexico, USA, and the Guest Editors are **Sze-Chun Chan**, City University of Hong Kong, China, **Vassilios Kovanis**, Air Force Research Laboratory, USA, **Tomoyuki Miyamoto**, Tokyo Institute of Technology, Japan, and **Stephen Sweeney**, University of Surrey, UK.

The deadline for submission of manuscripts is **November 1, 2012. Preprints of accepted manuscripts will be posted on the IEEE Xplore website within 2 weeks of authors correctly uploading their final files** in the Scholar One Manuscripts "Awaiting Final Files" queue. **Final page proofs of accepted papers are normally posted online in IEEE Xplore within 6 weeks of authors uploading their final files, if there are no page proof corrections.** Hardcopy publication of the issue is scheduled for **July/August 2013.**

All submissions will be reviewed in accordance with the normal procedures of the Journal.

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3) MS Word document with full contact information for all authors as indicated below: Last name (Family name), First name, Suffix (Dr./Prof./Ms./Mr.), Affiliation, Department, Address, Telephone, Facsimile, Email.

Call for Papers

Announcing an Issue of the IEEE *JOURNAL OF SELECTED TOPICS IN QUANTUM ELECTRONICS on Numerical Simulation of Optoelectronic Devices*

Submission Deadline: December 1, 2012

The ***IEEE Journal of Selected Topics in Quantum Electronics*** invites manuscript submissions in the area of **Numerical Simulation of Optoelectronic Devices**. The purpose of this issue of JSTQE is to document the current state of the art and the variety of leading-edge work in this field through a collection of original papers. Papers are solicited on theory, modeling, simulation, and analysis of modern optoelectronic devices including materials, fabrication and application. Optoelectronic devices are based on the interaction of photons and electrons, including laser diodes, light emitting diodes, optical modulators, optical amplifiers, solar cells, photodetectors, and optoelectronic integrated circuits. Validation of theoretical results by measurements is desired.

The Primary Guest Editor for this issue is **Joachim Piprek**, NUSOD Institute, USA, and the Guest Editors are **Enrico Bellotti**, Boston University, USA; **Seoung-Hwan Park**, Catholic University of Daegu, South Korea; **Bernd Witzigmann**, University of Kassel, Germany; **Beat Ruhstaller**, Fluxim AG, Switzerland.

The deadline for submission of manuscripts is **December 1, 2012. Preprints of accepted manuscripts will be posted on the IEEE Xplore website within 2 weeks of authors correctly uploading their final files** in the Scholar One Manuscripts "Awaiting Final Files" queue. **Final page proofs of accepted papers are normally posted online in IEEE Xplore within 6 weeks of authors uploading their final files, if there are no page proof corrections.** Hardcopy publication of the issue is scheduled for **September/October 2013.**

All submissions will be reviewed in accordance with the normal procedures of the Journal.

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Announcing a Special Issue of the IEEE/OSA Journal of Display Technology on Solid State Lighting

Submission Deadline: 1 SEPTEMBER 2012

The IEEE / OSA Journal of Display Technology (JDT) invites manuscript submissions for a special issue in the area of solid state lighting. The purpose of this issue of JDT is to document recent advances in the physics, simulation, material, and device physics of high efficiency solid state lighting technology, covering both inorganic and organic light-emitting diodes. Broad technical areas include (but are not limited to):

- **Materials, Device, Simulation, and Physics of III-Nitride and III-V Light-Emitting Diodes**
  - new substrate technology and epitaxy method for achieving high-efficiency light-emitting diodes
  - semi-/non-polar and polar III-Nitride quantum wells LEDs with large optical matrix elements
  - physics and solutions for addressing efficiency-droop in light-emitting diodes
  - novel concept for light extraction efficiency enhancement in light-emitting diodes
  - reliability and quality of white light emitted by solid-state lighting devices
  - novel white LEDs and broadband light-emitting diodes
  - surface plasmon and photonic crystal light-emitting diodes
  - thermal management and modeling in visible light-emitting diodes and laser devices
- **Materials, Device Technology, and Physics of Organic Light-Emitting Diodes**
  - novel concept for light extraction efficiency
  - high efficiency organic materials for OLEDs in all visible spectral range
  - white light generation and device reliability in organic light-emitting diodes
  - flexible OLEDs for lighting and display technologies
  - solution based processing and other techniques for low cost fabrication
  - materials / components and packaging for OLEDs
  - manufacturing technology and modeling

The Guest Editors for this issue are **Prof. Nelson Tansu**, Lehigh University (Bethlehem, PA, USA); **Prof. Qibing Pei**, University of California – Los Angeles (Los Angeles, CA, USA); and **Prof. Franky So**, University of Florida (Gainesville, FL, USA).

The deadline for submission of manuscripts is **September 1st 2012** and publication is tentatively scheduled for the **February 2013** issue. Manuscripts should conform to requirements for regular papers (up to 8 double-column, single-spaced journal pages in length, keywords, biographies, etc.). All submissions will be reviewed in accordance with the normal procedures of the Journal. The IEEE Copyright Form should be submitted after acceptance. The form will appear online in the Author Center in Manuscript Central after an acceptance decision has been rendered.

For all papers published in JDT, there are voluntary page charges of $110.00 per page for each page up to eight pages. Invited papers can be twelve pages in length before overlength page charges of $220.00 per page are levied. The length of each paper is estimated when it is received. Authors of papers that appear to be overlength are notified and given the option to shorten the paper.

Authors may opt to have figures displayed in color on IEEE Xplore at no extra cost, even if they are printed in black and white in the hardcopy edition. Additional charges will apply if figures appear in color in the hardcopy edition of the Journal. Manuscripts should be submitted electronically through IEEE's Manuscript Central: http://mc.manuscriptcentral.com/leos-ieee. Be sure to select **"2012 Solid State Lighting Special Issue"** as the Manuscript Type, rather than "Original Paper." This will ensure that your paper is directed to the special issue editors. IEEE Tools for Authors are available online at: http://www.ieee.org/organizations/pubs/transactions/information.htm

Inquiries can be directed to Lisa Jess, Publications Coordinator, IEEE Photonics Society Editorial Office, l.jess@ieee.org (phone +1-732-465-6617; fax +1 732 981 1138).


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Photonics Society Mission Statement

Photonics Society shall advance the interests of its members and the laser, optoelectronics, and photonics professional community by:

- providing opportunities for information exchange, continuing education, and professional growth;
- publishing journals, sponsoring conferences, and supporting local chapter and student activities;
- formally recognizing the professional contributions of members;
- representing the laser, optoelectronics, and photonics community and serving as its advocate within the IEEE, the broader scientific and technical community, and society at large.

Photonics Society Field of Interest

The Field of Interest of the Society shall be lasers, optical devices, optical fibers, and associated lightwave technology and their applications in systems and subsystems in which quantum electronic devices are key elements. The Society is concerned with the research, development, design, manufacture, and applications of materials, devices and systems, and with the various scientific and technological activities which contribute to the useful expansion of the field of quantum electronics and applications.

The Society shall aid in promoting close cooperation with other IEEE groups and societies in the form of joint publications, sponsorship of meetings, and other forms of information exchange. Appropriate cooperative efforts will also be undertaken with non-IEEE societies.


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