Advance Program

Fibers for Lasers, Amplifiers and Nonlinear Applications

Monday, 17 July 2006

Krieghoff

08.45 - 10.30

Session J-PLE: **JOINT PLENARY SESSION**
Session Chairs: Alexandre Pauchard, *id Quantique, Carouge/Geneva, Switzerland*
Siddharth Ramachandran, *OFS Laboratories, Somerset, NJ, USA*

08.45 - 09.00 **Introduction**

J-PLE1 09.00 - 09.45

Quantum Communication in Standard Optical Fibers, N. Gisin*, University of Geneva, Geneva, Switzerland*

BIO: Professor Nicolas Gisin is the director of the<http://www.gap-optique.unige.ch/> Group of Applied Physics of the University of Geneva. He leads a group of about 24 researchers exploring the foundations of quantum mechanics. Prior to joining the University of Geneva, he has held various industrial positions in companies developing both hardware and software. In 1994, he was among the founders of Gap Optique SA, a spin-off developing test and measurement equipment for the optical fiber communication industry. The company was acquired in 1995 by EXFO Electro-optical Engineering of Quebec, Canada.

Prof. Gisin is the author of more than 100 publications in prestigious journals such as Nature and Science, and is cited as an inventor on more than 20 patents. Prof. Gisin holds a PhD in Physics and a Master in Mathematics from the University of Geneva. He has spent one year at the University of Rochester, USA, in a post-doctoral position. He has received a Doctor Honoris Causa degree from the Swiss Federal Institute of Technology in Lausanne.

ABSTRACT: Quantum cryptography, quantum teleportation and experiments on entanglement will be reviewed with special emphasize on the state of the art and the challenges of the 5-10 next years.

J-PLE2 09.45 - 10.30

Future Fun with Fantastic Fibers, W. H. Knox*, University of Rochester, Rochester, NY, USA*

BIO: Wayne H. Knox obtained BS (1979) and PhD degrees (1983) at The Institute of Optics, University of Rochester in Rochester, NY. He went to Bell Labs in Holmdel NJ in 1984 and worked as a Postdoctoral Fellow, was promoted to Member of Technical Staff in 1985 and to Distinguished Member of Technical Staff in 1990. In 1997, he was promoted to Director of the Advanced Photonics Research Department where he was responsible for forward-looking research in a number of areas related to advanced technologies in telecommunications in long-haul, access and Metro networks. He is a Fellow of the Optical Society of America and a Fellow and Life member of the American Physical Society, in 1990 won the National Academy of Sciences W.O. Baker Award for Initiatives in Re and biomedical optics. He was elected to a 2002-2005 term as Director-at-large on the OSA Board of Directors, search. In 1999 he won the Richtmyer Award for Physics teaching from the American Association of Physics Teachers. He has authored over 150 publications and 39 patents, and has chaired many international professional society meetings such as Ultrafast Phenomena, CLEO, Quantum Optoelectronics, Ultrafast Electronics and Optoelectronics, the OSA Annual Meeting, and Nonlinear Optics. He has served on OSA and APS Fellows committees, and was Chair of the 2002 Tyndall Award Committee. In April 2001 he returned to The Institute of Optics as Director and Professor of Optics where he currently carries out a research program in ultrafast science and technology, nonlinear fiber optics and served on the Finance Committee. He serves on several Scientific Advisory Boards. He was appointed to the Board of Directors of the Rochester Regional Photonics Cluster in 2002. In 2004, he won the University of Rochester's Robert B. Goergen award for undergraduate teaching.

ABSTRACT: The great variety of specialty fibers that has become available has already had a significant impact on fiber lasers, amplifiers, and nonlinear devices. In this talk, we review and speculate about some exciting future possibilities.

10.30 – 11.00 **COFFEE BREAK**

REMAINDER OF PROGRAM TO BE HELD IN BORDUAS

11.00 - 12.15

Session MC1: **NOVEL FIBERS FOR HIGH POWER APPLICATIONS**
Session Chair: Siddharth Ramachandran, *OFS Laboratories, Somerset, NJ, USA*

MC1.1 11.00 - 11.30 (Invited)
Large Effective Mode Area Fibers for High Power Lasers and Amplifiers, L. Dong, W. S. Wong and X. Peng*, IMRA America, Inc., Ann Arbor, MI, USA*

Much effort has been spent in recent years trying to scale up peak power of fiber lasers by increasing effective mode area (EMA) of optical fibers while maintaining robust single mode operation. We will report progress on leakage channel fibers for EMA exceeding 1000 micronmeter^2.

MC1.2 11.30 - 11.45

Acoustical-Optical Fibers for Control of Stimulated Brillouin Scattering, P. D. Dragic*, Neolight Labs LLC, Chicago, IL, USA*

We present recent modeling and experimental results, and a discussion of practical issues on the design and fabrication of SBS-suppressed optical fibers for lasers and nonlinear applications employing fibers without rare earth dopants.

MC1.3 11.45 - 12.00

Bend Resistance of Large-Mode-Area Higher-Order-Mode Fibers, J. M. Fini and S. Ramachandran*, OFS Laboratories, Somerset, NJ, USA*

Higher-order-mode fibers with very large mode area are shown to be naturally resistant to bend induced mode distortion, an important limitation on amplifier fibers. Simulations and measurements display resistance of these fibers to bending.

MC1.4 12.00 - 12.15

A Novel Pump Combiner for High Power Fiber Lasers, T. F. Morse and F. Luo*, Boston University, Boston, MA, USA*

The success of high power double clad optical fiber lasers depends upon the efficient coupling of multimode radiation from high power pump sources, and there are various techniques to accomplish this. In the technique proposed here, the double clad fibers are coiled surrounding a central pump fiber to form a fiber bundle with the pump fiber in the center.

12.15 – 13.30 **LUNCH BREAK**

13.30 - 15.00

Session MC2: **HIGH POWER AMPLIFICATION**
Session Chair: Hanna Hoffman, *Liekki Oy, Lohja, Finland*

MC2.1 13.30 - 14.00 (Invited)

Multi-MW Peak Power, Multi-mJ Pulse Energy Yb-doped Fiber Amplifiers, F. Di Teodoro and C. D. Brooks*, Aculight Corporation, Bothell, WA, USA*

We report on the use of very-large-core (>70μm), Yb-doped photonic crystal fiber technology to efficiently generate pulse energy > 2.2mJ and peak/average power > 2.2MW/21W in an output beam of excellent spatial (M2 < 1.2) and spectral quality at 1.06μm wavelength.

MC2.2 14.00 - 14.30 (Invited)

Pulsed High Power Fiber Laser Systems, A. Malinowski, J. H. V. Price, F. He, P. Dupriez, H. D. Foreman, A. C. Tropper, J. Nilsson and D. J. Richardson*, University of Southampton, Southampton, UK*

The Master-Oscillator Power-Amplifier approach, cladding pumping technology and large mode area fibers provide a route to compact and efficient pulsed fiber laser systems with high beam quality and high output powers.

MC2.3 14.30 - 14.45

Optimization of Ultrafast Chirped-Pulse Amplification with Large Nonlinearity, A. Chong, L. Kuznetsova and F. W. Wise*, Cornell University, Ithaca, NY, USA*

The mechanism of chirped-pulse amplification performance improvement with interplay of nonlinearity and third-order dispersion is successfully interpreted with a simple theoretical model. One can extract design parameters optimizing the output performance according to the model.

MC2.4 14.45 - 15.00

Interplay of Nonlinearity and Gain-Shaping in High-Energy Femtosecond Yb-doped Fiber Amplifiers, L. Kuznetsova, A. Chong and F. W. Wise*, Cornell University, Ithaca, NY, USA*

Spectral shaping in a fiber amplifier in the presence of finite gain bandwidth (~15nm) and large nonlinear phase shifts (up to ~12) is studied numerically and experimentally. Pulses amplified to 30 μJ are dechirped to ~250 fs duration.

15.00 – 15.30 **COFFEE BREAK**

15.30 - 16.45

Session MC3: POLARIZATION EFFECTS AND ULTRASHORT PULSE GENERATION
Session Chair: John M. Fini, *OFS Laboratories, Somerset, NJ, USA*

MC3.1 15.30 - 16.00 (Invited)

Polarization Effects in Polarization-Independent and Polarization Maintaining Fiber Amplifiers, A. R. Grant, P. F. Wysocki and D. P. Holcomb*, Lucent Technologies, Murray Hill, NJ, USA*

Polarization effects in fiber optical amplifiers are described. Theoretical and experimental results for the statistical variation of the polarization extinction ratio (PER) in a PM amplifier are presented. PER variation between units and over temperature is analyzed.

MC3.2 16.00 - 16.15

Generation of Ten-Cycle Pulses from a Yb Fiber Laser, J. Buckley, S. Clark and F. W. Wise*, Cornell University, Ithaca, NY, USA*

We demonstrate the use of a prism-grating sequence to reduce third-order dispersion inside a modelocked Yb fiber laser. 33-fs pulses, the shortest from a fiber oscillator, can be generated with extremely clean profiles.

MC3.3 16.15 - 16.45 (Invited)

Comb-like Profiled Fiber Technologies for Synchronized Short Pulse Generation, T. Inoue*, Furukawa Electric Co. Ltd, Ichihara, Chiba, Japan*, S. Takasaka*, Japan Science and Technology Corporation, Kawaguchi, Saitama, Japan*, Y. Mimura, R. Miyabe, N. Kumano*, Furukawa Electric Co. Ltd, Ichihara, Chiba, Japan*, S. Namiki*, National Institute of Advanced Industrial Science & Technology, Tsukuba, Ibaraki, Japan*, M. Sakano and T. Yagi*, Furukawa Electric Co. Ltd, Ichihara, Chiba, Japan*

We review our recent results on optical short pulse generation based on "comb-like profiled fiber (CPF)". Various types of CPF are summarized, where we show that the CPF technologies are suitable for truly practical, externally synchronous, and flexible short pulse generation.

18.30 – 20.00 **WELCOME RECEPTION – BOURDUAS**

Tuesday, 18 July 2006

09.00 - 10.00

Session TuC1: COHERENT COMBINATION I
Session Chair: Erik J. Bochove, *US Air Force Research Laboratory, Kirtland AFB, NM, USA*

TuC1.1 09.00 - 09.30 (Invited)

Coherently Combined High Power Fiber Arrays, M. G. Wickham, J. Anderegg, S. Brosnan, E. Cheung, P. Epp, D. Hammons, H. Komine and M. Weber*, Northrop Grumman Space Technology, Redondo Beach, CA, USA*

A four-element fiber array has demonstrated 470 watts of coherently phased, linearly polarized light. The results of this experiment as well as comparisons to other fiber array approaches will be presented.

TuC1.2 09.30 - 09.45

Self-Synchronous Coherent Beam Combination, T. M. Shay*, US Air Force Research Laboratory, Kirtland AFB, NM, USA*

A completely novel concept for coherent beam combination is presented. The technique completely eliminates the need for a reference beam resulting in a dramatic simplification of electronic coherent beam combination without any compromise in performance.

TuC1.3 09.45 - 10.00

First Experimental Demonstration of Coherent Fiber Array Phase Locking without an External Reference Beam, T. M. Shay*, US Air Force Research Laboratory, Kirtland AFB, NM, USA*, V. Benham*, IIT Industries, Albuquerque, NM, USA*, J. T. Baker*, Boeing Company, Albuquerque, NM, USA*, B. G. Ward*, US Air Force Research Laboratory, Albuquerque, NM, USA*, M. A. Culpepper, A. D. Sanchez*, US Air Force Research Laboratory, Kirtland AFB, NM, USA*, D. E. Pilkington, J. Spring*, US Air Force Research Laboratory, Albuquerque, NM, USA* and R. W. Berdine*, US Air Force Research Laboratory, Kirtland AFB, NM, USA*

Both active and passive fiber arrays were phase locked using two novel phase locking architectures for the first time. The measured phase error was 1/22 of a wave independent of the number of elements locked.

10.00 – 10.30 **COFFEE BREAK**

10.30 - 12.00

Session TuC2: COHERENT COMBINATION II
Session Chair: Thomas M. Shay, *US Air Force Research Laboratory, Kirtland AFB, NM, USA*

TuC2.1 10.30 - 11.00 (Invited)

Coupled Fiber Laser Structures, A. Siegman*, Stanford University, Stanford, CA, USA* and *Multiwave Photonics, Oporto, Portugal*

Arrays of fiber amplifiers or oscillators connected together by optimized couplers appear to provide a promising approach to increased single-mode power output, but also face challenging difficulties in practical implementation. Some of the more promising approaches to fiber arrays will be reviewed, along with their practical difficulties and limitations.

TuC2.2 11.00 - 11.30 (Invited)

Fiber Lasers with Phosphate Photonic Crystal and Multicore Fibers, N. N. Peyghambarian, A. Schuelzgen, L. Li, V. L. Temyanko, J. V. Moloney and H. Li*, University of Arizona, Tucson, AZ, USA*

We have demonstrated near 5W output power from a 3.5cm photonic crystal fiber laser. We will also summarize our findings in coherent combining of emission from 19 active cores of a multi-core fiber laser.

TuC2.3 11.30 - 11.45

Spatial and Temporal Stability of an N-Core Evanescently Coupled Fiber Amplifier Ring, E. J. Bochove*, US Air Force Research Laboratory, Kirtland AFB, NM, USA*

Spatial-temporal stability of an array with neighbor interaction is shown to be mainly determined by the sign of the imaginary part of the interaction constant and resonant nonlinear refraction.

TuC2.4 11.45 - 12.00

Joint Supermode and LP01 Passive Mode Selection in an Array of Large Mode Area Fiber Lasers using a Compact Self Fourier Cavity, E. J. Bochove*, US Air Force Research Laboratory, Kirtland AFB, NM, USA* and C. J. Corcoran*, Corcoran Engineering, Inc., Newton, MA, USA*

We demonstrate the possibility of simultaneous passive mode selection of the in-phase array mode of LP01 fiber modes with high mode discrimination.

12.00 – 13.30 LUNCH BREAK

13.30 - 15.00

Session TuC3: Femtosecond Fiber Lasers
Session Chair: Martin E. Fermann, *IMRA America, Inc., Ann Arbor, MI, USA*

TuC3.1 13.30 - 14.00 (Invited)

High-Energy Femtosecond Fiber Lasers based on Self-Similar Pulse Evolution, F. W. Wise*, Cornell University, Ithaca, NY, USA*

Theoretical and experimental advances in high-energy femtosecond fiber lasers will be reviewed. A new kind of pulse-formation based on self-similar propagation allows substantial increases in pulse energy compared to prior fiber lasers.

TuC3.2 14.00 - 14.30 (Invited)

Recent Advances in Pulsed Fiber Lasers Passively Mode-Locked by Carbon Nanotubes, Y.-W. Song*, University of Tokyo, Tokyo, Japan*, S. Y. Set*, Alnair Labs, Tokyo, Japan* and S. Yamashita*, University of Tokyo, Tokyo, Japan*

We review our recent works on passively mode-locked lasers functioned by Carbon nanotubes. Researches are focused on the diversified structures of the nanotube mode-lockers as well as the ultrashort laser cavity configurations for telecom applications.

TuC3.3 14.30 - 15.00 (Invited)

Applications of Higher Order Modes in Optical Fibers to Femtosecond Pulses, J. W. Nicholson*, OFS Laboratories, Somerset, NJ, USA*

Higher order modes in optical fiber present unique possibilities in terms of designing fibers for femtosecond pulse applications. A large mode area fiber using higher order modes with an effective area of 2100 micron^2 is shown to be an effective pulse compressor.

15.00 – 15.30 COFFEE BREAK

15.30 - 17.15

Session TuC4: Slow Light and Fiber Gratings
Session Chair: Benjamin J. Eggleton, *CUDOS, University of Sydney, NSW, Australia*

TuC4.1 15.30 - 16.00 (Invited)

Slow Light via Stimulated Brillouin Scattering in Optical Fibers, Z. Zhu, A. M. C. Dawes and D. J. Gauthier*, Duke University, Durham, NC, USA*

Optical-fiber-based slow-light techniques are reviewed. Slow light via stimulated Brillouin scattering (SBS) in optical fibers is discussed and recent progress in achieving broadband SBS slow light for high data-rate systems is presented.

TuC4.2 16.00 - 16.30 (Invited)

Chiral Fiber Gratings, V. I. Kopp, V. M. Churikov, J. Singer, N. Chao, G. Zhang, D. Neugroschl and A. Z. Genack*, Chiral Photonics, Clifton, NJ, USA*

A custom optical fiber is designed for a sub-decibel loss, single-mode-maintaining coupling between standard low numerical aperture (NA) fibers and high NA fibers used to fabricate chiral fiber gratings or fibers for nonlinear applications.

TuC4.3 16.30 - 16.45

Optimization of a Continuous Phase-Only Sampling for 81-Channel Fiber Bragg Gratings, H. Li, M. Li, K. Ogusu*, Shizuoka University, Shizuoka, Japan*, Y. Sheng*, Universite Laval, Quebec, QC, Canada* and J. E. Rothenberg*, Northrop Grumman Space Technology, Redondo Beach, CA, USA*

A novel phase-only sampling function capable of producing up to 81-channel FBG with excellent channel uniformity and high in-band energy efficiency is proposed. With the conventional phase-mask writing technique, an 81-channel FBG is experimentally demonstrated.

TuC4.4 16.45 - 17.15 (Invited)

Generation of Vortices in Optical Fiber Via Acousto-Optic Interaction, H. P. Lee, P. Z. Dashti and F. Alhassen*, University of California - Irvine, Irvine, CA, USA*

We show that orbital angular momentum of the acoustic vortex can be transferred to a circularly polarized fundamental optical mode to form a stable optical vortex in the fiber carrying orbital angular momentum.

Wednesday, 19 July 2006

09.00 - 10.00

Session WC1: NOVEL FIBERS AND DEVICES
Session Chair: Frank W. Wise, *Cornell University, Ithaca, NY, USA*

WC1.1 09.00 - 09.30 (Invited)
Bi-based Fibers for Amplifiers and Nonlinear Applications, N. Sugimoto, T. Hasegawa, T. Nagashima and S. Ohara*, Asahi Glass Co. Ltd., Yokohama, Kanagawa, Japan*

500-fs pulse amplification without spectrum broadening can be achieved using bismuth based EDF. On the other hand, highly nonlinear fiber (1350 $W^{-1}km^{-1}$) can be obtained using high refractive index bismuth based glass.

WC1.2 09.30 - 09.45

Broadband Emission from Glass-Clad Chromium Doped Fiber, J.-C. Chen*,* K.-Y. Huang, C.-N. Tsai, Y.-S. Lin*, National Sun Yat-sen University, Kaohsiung, Taiwan, R.O.C.* and S.-L. Huang*, National Taiwan University, Taipei, Taiwan, R.O.C.*

A Cr-doped fiber with a YAG-silica core generates an 1140-nm emission with a 3-dB bandwidth of 406 nm. It is resulted from both Cr^{3+} and Cr^{4+} ions where the latter is enhanced by CaO side deposition.

WC1.3 09.45 - 10.00

Microspheres-Fiber Laser, H. A. Abdeldayem and J. Buris*, NASA Goddard Space Flight Center, Greenbelt, MD, USA*

Doped silica microspheres are used to build a novel, rugged, and tunable laser system. The microspheres are adhered to a fiber by a refractive index matching glow and pumped from one end of the fiber.

10.00 – 10.30 COFFEE BREAK

10.30 - 12.00

Session WC2: NONLINEAR EFFECTS
Session Chair: Jinendra K. Ranka, *MIT Lincoln Laboratory, Lexington, MA, USA*

WC2.1 10.30 - 11.00 (Invited)

Optimization of Low Noise Continuum Generation from Femtosecond Fiber Lasers, J. Jiang, S. Drissler and D. J. Jones*, University of British Columbia, Vancouver, BC, Canada*

We will discuss our work on development of low noise femtosecond frequency combs generated by fiber lasers that are suitable for optical frequency metrology, optical waveform synthesis and other applications.

WC2.2 11.00 - 11.15

Dispersion Decreasing Photonic Crystal Fiber for UV-Enhanced Supercontinuum Generation, A. Kudlinski, A. George and J. C. Knight*, University of Bath, Bath, UK*

We have fabricated a photonic crystal fiber with a continuously decreasing zero-dispersion wavelength along its length. It has been used to generate an ultraviolet-extended supercontinuum from a nanosecond pump source at 1.064 μm.

WC2.3 11.15 - 11.30

Wavelength Conversion in Highly Nonlinear Single Mode As_2Se_3 Chalcogenide Fiber, V. G. Ta'eed, L. Fu, M. D. Pelusi, M. Rochette, I. C. M. Littler, *CUDOS, University of Sydney, Sydney, NSW, Australia*, D. Moss, *University of Sydney, Sydney, NSW, Australia* and B. J. Eggleton, *CUDOS, University of Sydney, NSW, Australia*

We establish design criteria for pump-probe devices in two photon absorbing materials and demonstrate low-power wavelength conversion over 10nm in 1m of single mode As_2Se_3 fiber through cross-phase modulation with only 1.4dB system penalty at BER=10^{-9}.

WC2.4 11.30 - 12.00 (Invited)

Parametric Devices in High-Confinement Optical Fibers, S. Radic, *University of California - San Diego, La Jolla, CA, USA* and C. J. McKinstrie, *Lucent Technologies, Holmdel, NJ, USA*

The operation and performance of one- and multiple-pump parametric devices is reviewed. Fundamental impairments limiting the high-gain parametric amplifiers are addressed and recent mitigation techniques are described in detail. Parametric translator designs that use highly nonlinear fiber and photonic crystal fiber are compared. The implications in practical applications including banded translation, amplification, regeneration and temporal management are outlined.

END OF PROGRAM