2009 1 st Colloquium of Optical Science and Technology

Tohoku University Electro-Related GCOE Workshop

10:15-14:00, May 27, 2009
Large Conference Room, Research Institute of Electrical Communications,
Tohoku University

Program

10:15-10:20 **Preface**
Masataka Nakazawa
(Research Institute of Electrical Communications, Tohoku University)

10:20-11:00 **(Invited lecture) Quantum Information Science with Photons on a Chip**
Jeremy L. O'Brien (Centre for Quantum Photonics, University of Bristol)

11:00-11:25 **All-optical phase modulation in waveguide media at ultra-low light levels**
Nobuyuki Matsuda
(Research Institute of Electrical Communications, Tohoku University)

11:25-11:50 **ZnO non-linear optical waveguides**
Yoshio Morales (Graduate School of Engineering, Tohoku University)

11:50-12:30 **(Invited lecture) Axially symmetric, polarized laser beams**
Shunichi Sato (Institute of Multidisciplinary Research for Advanced Materials, Tohoku University)

12:30-14:00 **Buffet Lunch** (Parlor, 1F Building 1)

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Colloquium of Optical Science and Technology, Electro-Related departments, and
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Center of Education and Research for Information Electronics Systems, Tohoku University
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Abstract

Quantum Information Science with Photons on a Chip

Jeremy L. O'Brien

Centre for Quantum Photonics, H. H. Wills Physics Laboratory & Department of Electrical and Electronic Engineering, University of Bristol

We have developed an integrated waveguide approach to photonic quantum circuits [1]. We demonstrate high-fidelity silica-on-silicon integrated optical realizations of key quantum photonic circuits, including two-photon quantum interference with a visibility of 94.8(5)%; a controlled-NOT gate with an average logical basis fidelity of 93.3(2)%; and a path entangled state of two photons, relevant to quantum metrology, with fidelity >92%. We use these devices to demonstrate multi-photon effects relevant to quantum metrology [2], quantum information processing [3], and quantum measurement [4]. The monolithic nature of these devices means that the correct phase can be stably realized in what would otherwise be an unstable interferometer, greatly simplifying the task of implementing sophisticated photonic quantum circuits. We fabricated 100's of devices on a single wafer and find that performance across the devices is robust, repeatable and well understood. Most recently we have demonstrated controlled manipulation of up to four photons on-chip. Finally we discuss the related issue of experimental quantum process discrimination [6].

[1] A. Politi, M. J. Cryan, J. G. Rarity, S. Yu, and J. L. O'Brien, Science 320, 646 (2008)
[2] T. Nagata, R. Okamoto, J. L. O'Brien, K. Sasaki, and S. Takeuchi, Science 316, 726 (2007)
[3] J. L. O'Brien, Science 318, 1567 (2007)
[4] R. Okamoto, J. L. O'Brien, H. F. Hofmann, T. Nagata, K. Sasaki, and S. Takeuchi, Science 323, 483 (2009)
[6] A. Laing, T. Rudolph, and J. L. O'Brien, Phys. Rev. Lett. 102, 160502 (2009)

All-optical phase modulation in waveguide media at ultra-low light levels

Nobuyuki Matsuda

Research Institute of Electrical Communication, Tohoku University

We demonstrate the nonlinear phase shifts in a photonic crystal fiber (PCF) and silicon wire waveguide (SWW) at low light levels. Taking advantage of large optical nonlinearity and managed dispersion of the PCF, we have successfully measured the cross-Kerr phase shift of 10-7 rad. Induced by weak coherent pulses that contain one photon per pulse on average. For the low-loss SWW, nonlinear phase shifts originating from the optical Kerr effect as well as the free carrier dispersion were observed down to a few-photon level.

ZnO non-linear optical waveguides

Yoshio Morales

Graduate School of Engineering, Tohoku University

A scheme of a waveguide for non-linear optical applications is proposed, aimed at obtaining supercontinuum light covering the near infrared spectrum. Wide-bandgap semiconductors were adopted to avoid two-photon absorption at a wavelength of 800nm. From the materials considered, ZnO was chosen. A ZnO thin film was grown on sapphire substrate using the laser molecular beam epitaxy technique, adding a gradient to the film thickness. The thin film's refractive index was measured to ensure the quality of the film. Single-mode conditions and the variation of the group-velocity dispersion parameter were calculated via simulation. Calculations show that the proposed ZnO channel waveguide should prove useful for non-linear applications.

Axially symmetric, polarized laser beams

Shunichi Sato

Institute of Multidisciplinary Research for Advanced Materials, Tohoku University

Light beams whose polarization is axially symmetric to the optical axis are attracting much attention because of their unique features. In this talk, their generation methods and features will be presented.