平成 21 年度第 1 回 光科学談話会

東北大学電気・情報系グローバルCOEワークショップ

2009 年 5 月 27 日（水） 10:15~14:00
東北大学電気通信研究所　大会議室

プログラム

10:15-10:20 はじめに
中沢正隆（東北大学電気通信研究所）
Preface
Masataka Nakazawa (*Research Institute of Electrical Communication, 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 光導波路媒質における極微弱光レベルでの全光位相変調
松田信幸（東北大学電気通信研究所）
All-optical phase modulation in waveguide media at ultra-low light levels
Nobuyuki Matsuda (*Research Institute of Electrical Communication, Tohoku University*)

11:25-11:50 ZnO 非線形光導波路
モラレス芳男（東北大学大学院工学研究科）
ZnO non-linear optical waveguides
Yoshio Morales (*Graduate School of Engineering, Tohoku University*)

11:50-12:30 （**招待講演**）軸対称偏光レーザービーム
佐藤俊一（東北大学多元物質科学研究所）
(Invited lecture) Axially symmetric, polarized laser beams
Shunichi Sato (*Institute of Multidisciplinary Research for Advanced Materials, Tohoku University*)

12:30-14:00 昼食（1 号館 1 階　談話交流室）
Buffet Lunch

共催
東北大学電気通信研究所・電気・情報系光科学談話会
東北大学電気・情報系グローバルCOEプログラム
後援
日本学術振興会　先端研究拠点形成事業

講演要旨

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)

光導波路媒質における極微弱光レベルでの全光位相変調
All-optical phase modulation in waveguide media at ultra-low light levels

松田信幸 (Nobuyuki Matsuda)
東北大学電気通信研究所
Research Institute of Electrical Communication, Tohoku University

We demonstrate the nonlinear phase shifts in a photonic crystal fiber (PCF) and a 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 非線形光導波路
ZnO non-linear optical waveguides

モラレス芳男 (Yoshio Morales)
東北大学大学院工学研究科
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.

軸対称偏光レーザービーム
Axially symmetric, polarized laser beams

佐藤俊一 (Shunichi Sato)
東北大学多元物質科学研究所
Institute of Multidisciplinary Research for Advanced Materials, Tohoku University

偏光が光軸に対して対称に分布した光ビームは、従来の光ビームには無い新しい特徴を有していることが明らかにされつつある。本講演では、その発生方法や特徴について述べる。
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.