12th Optoelectronics and Communications Conference/16th International Conference on Integrated Optics and Optical Fiber Communication (OECC/IOOC2007)
Technical Digest, July 2007, Pacifico Yokohama

10E1-1 (Invited)

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Photonic Device Breakthrough for New Generation Optical Communications

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Abstract

Recent results on photonic device research are introduced which are conducted as a research theme in MEXT funded project of Priority Areas named INGOC, i.e., Innovation for New Generation Optical Communications.

1. Introduction

A number of subscribers who can access to the networks with a bandwidth of 10 Mb/s or higher exceeded 25 millions at September 2006 in Japan[1]. Among the broadband access such as ADSL, FTTH and CATV, fiber optic version (FTTH) has shown a stronger growth rate than the other schemes. A positive feedback between the growth of the high volume contents, such as movies, pictures, and music, and the growth of the broadband access capability has led to the strong increase in the information traffic. The trend seems to continue and to be further enhanced, because transition of the contents toward those with the higher quality, such as high-density TV(HDTV) and in a future Super Hi-Vision[2] will likely to appear. This situation will induce strong motivation to realize networks with an extraordinary higher performance. Although photonics has been contributing to construct global information and communication networks through the technological breakthrough of optical fiber communications since 1970's, extensive efforts are still required to cope with the issues where two to three orders of magnitude increase in the network performance is anticipated. As one of the efforts, a new project named INGOC, Innovation for New Generation Optical Communications has started since 2005. The conceptual image is depicted in Fig. 1 with the project logo mark. It is a project funded by MEXT (Ministry of Education, Culture, Sports, Science and Technology) as a Grant-in-Aid for Scientific Research on Priority Areas. In this talk, recent results are introduced on the photonic device research in this project.

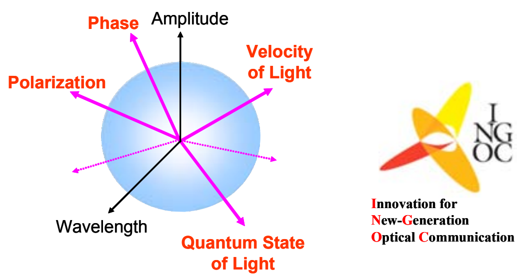

Fig.1 The conceptual image of the project

2. About the Project

The project consists of three research groups and an executive committee. The purpose is to create a new area of science and technology and to achieve innovation for the transmission and the signal processing for the future optical communication networks through breakthrough of photonic devices. In this project, we would like to explore new functions of light which have not been yet fully utilized. Among them are phase, polarization, quantum state of light, light velocity and so on. Twelve principal research topics are divided into the three research groups, i. e., A01: Function Innovation Group, A02: Structure Innovation Group and A03: Integration Innovation Group. These names do not look popular. In a more usual way, they can be called fundamental, device and system-oriented research groups for A01, A02 and A03, respectively.

3. Photonic Device Breakthrough

As examples of photonic device breakthrough in our project, the principal research topics are shown schematically in Figs. 2 and 3. In A01, several approaches have been tried to explore the potential of light toward the new generation optical communication. Twin photons with cross-polarization state were generated using a Ti: LiNbO3 waveguide with domain-inverted grating pumped by a semiconductor laser[3]. Single photon and photon-pair generation were achieved with an InAs quantum dot covered by GaNAs[4]. Slow light effects in a photonic crystal waveguide with a chirped structure was investigated to apply to an optical buffer memory[5]. Ultra-fast optical non-linearity of optical fibers was utilized to produce ultra-short pulse and very wide continuum spectrum[6].

In A02, emphasis is laid on photonic device innovation. Waveguide ring resonators were utilized to devise a multi-wavelength multi-port wavelength selective switching circuit for RODAM applications[7]. A widely tunable dispersion compensator was realized by combining a unique hollow waveguide with MEMS technology[8]. Ultra-fast all-optical switching was demonstrated in InGaAs/AlAs/AlAsSb multi-quantum well structure by using inter-sub-band transition[9]. A variety of optical devices such as tunable filters and reflectors were fabricated by exploiting MEMS technology[10].

4. Concluding Remarks

Due to the limited space, the research themes of the candidates for the photonic device breakthrough in our project are only briefly described in this paper. In the talk, the latest results of these themes will be addressed in addition to those of system oriented topics such as digital coherent optical receiver[11], multi-port optical spectrum analyzer[12], and all-optical signal processing and buffer memory[13][14].

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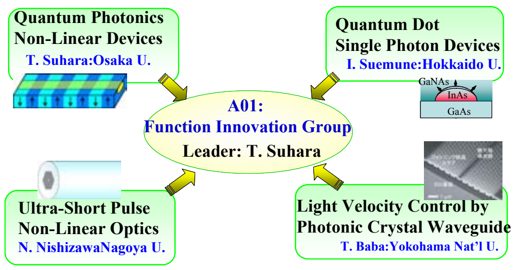

Fig. 2 Principal research topics of A01 group

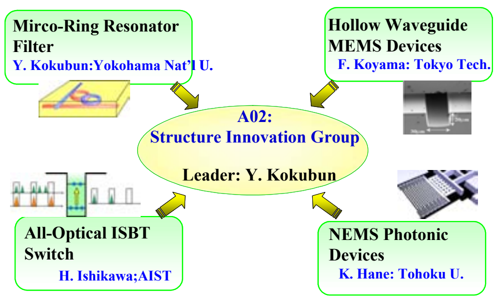

Fig. 3 Principal research topics of A02 group