Semiconductor Integrated Digital Photonic Devices

Yoshiaki Nakano
Research Center for Advanced Science and Technology, The University of Tokyo
4-6-1 Komaba, Meguro-ku, Tokyo, 153-8904, Japan
nakano@rcast.u-tokyo.ac.jp

Optical communication system technologies are advancing very rapidly, that include dense wavelength division multiplexing (DWDM), high speed optical time division multiplexing (OTDM), optical packet switching, microwave/photonic access link, and photonic internetworking. Although the optoelectronic technologies have been driven by materials and devices research conventionally, the bottle neck at present seems to exist in optical devices. A part of the reasons may be attributed to the fact that the conventional optical devices have been analog devices; the amplification has been possible but the regeneration (resetting signal to noise ratio and timing jitter) has not been possible. In addition no optical buffer memory device has been available besides the fiber delay line. Consequently, sophisticated processing of optical signals has never been possible. What is requested for the next generation is "digital photonic devices" where there is highly nonlinear all-optical response function as well as "optical memory device" that is flexible like the present electronic random access memories.

More specifically, digital functions that are necessary for all-optical networking are ・digital wavelength conversion, ・high speed optical 3R (reshaping, retiming, regeneration) function, ・high speed optical logic gate, and ・high speed optical buffer memory. In order to realize them, one needs very high optical nonlinearity with low optical power. We have been investigating semiconductor digital photonic devices necessary in the next generation photonic data communication infrastructures. In particular, we are looking at carrier-associated optical nonlinearity in semiconductors which is substantial from low optical power and is fast enough if the material is properly designed.

This talk will review our recent effort towards all-optical digital devices and circuits such as digital wavelength converters, optical logic devices, optical flip-flop, and optical buffer memories, that should form fundamentals of the "digital photonics" in the future.