Introducing the Researcher ❶

Assistant Professor Takasumi Tanabe focuses on the development of photonic circuits, which will save the energy than electronic circuits.

Developing Optical Microresonators to pave the way to realize Photonic Circuits

Toward a super energy-efficient society

By using photons instead of electrons, photonic circuits can extremely decrease the power consumption of machinery and equipment. Optical microresonators are indispensable for putting these photonic circuits to practical use, with which we can store light like a memory, release stored light whenever needed like a transistor or a switch, and change characteristics of light.

Takasumi Tanabe

Optical microresonators indispensable to optical circuits

Perhaps you have been surprised by the heat when touching your notebook PC power adapter or the rear of a TV set. The fact is, electrical appliances, regardless of their functions, are releasing wasted heat as part of the electricity they consume. For example, even gold, which has excellent electrical conductivity, exhibits some resistance, not zero, and generates Joule heat responding to the resistance when electricity is passed. In other words, by simply passing a current the electric circuit loses heat energy proportional to its electrical resistance.

“Electronic circuits are bound to generate heat. But photonic circuits are totally different. Light, when passed through glass, causes no loss like Joule heat. Theoretically, photonic circuits work without loss,” explains Assistant Professor Takasumi Tanabe.

Capable of significantly reducing energy consumption compared with ordinary electronic circuits, expectations are high for photonic circuits as a solution to major issues facing our modern society, such as conservation of energy and reduction of CO_2 emissions.

With all advantages and no apparent shortcomings, but optical circuits actually come with their problems as well. One of them is the development of a device that can confine light in one place. Negatively charged electrons can be kept in place by taking advantage of the force of plus and minus attracting each other. But light does not have electric charges as electrons do. So we need to contrive an alternative method for stopping light in one place.

“An optical microresonator is known as a device to keep light in one place. The development of this particular device is essential for putting photonic circuits to practical use. If we can confine light in one place, then it will become possible to use this optical device as a memory. We can also use the same device as a switch or a transistor by manipulating the confined light. Among several approaches attempted in this study, I used photonic crystal technology to confine light and succeeded in running an logic circuit concerning computer memory.”

Practical application, first . . .

Having obtained positive results from a series of his studies, Dr. Tanabe took up the challenge of practical application of photonic circuits from this spring. His research theme is the development of an optical microresonator using silica, the main constituent of glass, as the raw material.

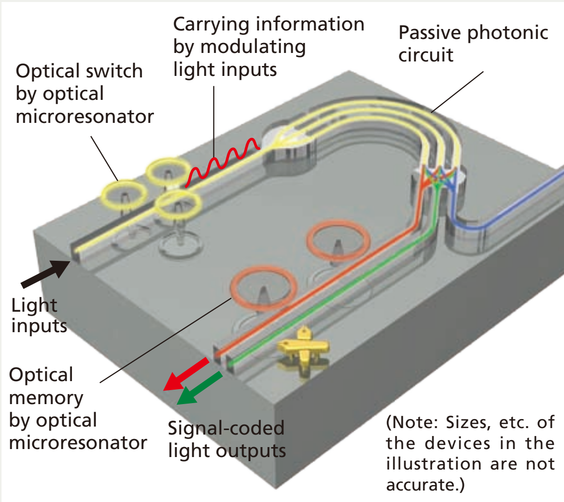
“There are several reasons for choosing silica as the raw material for my optical microresonator. First occurring to my mind was silica's high compatibility with existing optical devices. Silica is an attractive material from the application viewpoint.”

Devices required for a photonic circuit include the optical fiber cable and the planar lightwave circuit. Of these, passive devices such as those used for transmission of light signals and those for information branching are approaching the level of practical use. And many of these devices are silica-based. In short, if we succeed in developing an optical microresonator with silica, we can integrate into one chip such active devices as the optical memory, optical switch and optical transistor as well as existing passive devices, thus enabling an photonic integrated circuit to be created with ease.

Furthermore, silica, when compared with silicon which is the raw material often used for photonic crystals, has different characteristics such as smaller optical nonlinear coefficients and faster nonlinear transition speeds. By using silica, it is also possible to ascertain the influence that a difference in materials exercises on device functions.

Dr. Tanabe expressed his hopes saying, “The use of silica as the raw material enables us to re-examine, across the board, issues peculiar to the whole photonic integrated circuit including peripheral equipment, rather than the optical microresonator as a single device. I think the results and issues identified in this process will go a long way to further photonic crystal and other photonic circuit studies.”

(Reporter & text writer: Kaoru Watanabe)



Basic structure of the photonic integrated circuit

Optical devices made of silica glass are arranged on the silicon substrate. The disk-like devices in the upper left are optical microresonators, in which light is trapped. With optical microresonators, it is possible to vary refractive index according to the intensity of incident light, enabling the particular optical microresonator to operate as an optical switch or an optical transistor. The device in the upper right is a passive device for branching light signals. When light signals are sent from the optical switch and/or optical transistor to this optical device, it can sort out the signals by wavelength or split the signals.