All-Organic Optical Logic Gates from Photochemically Switchable Interconnected Microcavities

Hendra,[1] Akihide Takeuchi,[1] Hiroshi Yamagishi,[1] Osamu Oki,[1] Masakazu Morimoto,[2] Masahiro Irie,[2] and Yohei Yamamoto[1]

[1] Department of Materials Science, Faculty of Pure and Applied Sciences, University of Tsukuba, 1-1-1 Tennodai, Tsukuba, Ibaraki 305-8573, Japan

[2] Department of Chemistry, Rikkyo University, 3-34-1 Nishi-Ikebukuro, Toshima, Tokyo 171-8501, Japan

Organic materials have recently received increasing attentions in optoelectronics because of their light weight, high flexibility, compositional diversity, and easy processability. These organic materials are advantageous for realizing flexible optical and optoelectronic devices such as light-emitting diodes, thin-film solar cells, and optical fibers. Particularly, fully organic optical circuits that can be operated entirely by light is highly anticipated for high-speed and long-distance data communication and processing. However, devices so far invented largely rely on inorganic materials and lithographic techniques. For instance, optical logic gates have been realized with optical waveguides in silicon thin wires and optical circuits that combine micro-optical resonators.[15] These optical gates require state-of-the-art advanced microfabrication techniques, which are unapplicable to fully organic devices. An alternative candidate toward this end is an organic microdevice that incorporate photofunctional molecules. Previously, we reported that physically contacted polymer microspheres doped with different organic fluorescent dyes are optically coupled with each other and exhibit cavity-mediated energy transfer. Molecular fluorescence in a sphere is transmitted to the adjacent spheres with a diameter (d) of several micrometers, which is far longer than conventional Förster-type resonant energy transfer process (< 10 nm). Recently, Chandrasekar et al. reported a related work on dye-doped polymer coupled-resonator optical waveguide (CROW), where linearly and L-shaped CROW can transfer light efficiently. However, further functionalization of the spheres, such as a switching operation, rather than the simple light transmission, has not yet been achieved with organic self-assembled microdevices.

In this presentation, we demonstrate a prototype of a fully organic micro-optical switch consisting of multiple microsphere resonators and an optical fiber. Analogous to an electric logic gate (Figure 1), the microspheres individually work as optical source, drain, and gate. The source sphere, upon optical input, emits fluorescence and illuminates the gate sphere through the optical fiber. The gate sphere, when it is turned on, convert the optical signal to the output sphere. This signal conversion can be switched off by photochemically modulating an organic dye in the gate sphere. All-organic optical switch will be an important step forward to a realization of flexible photonics logic circuits.[1]

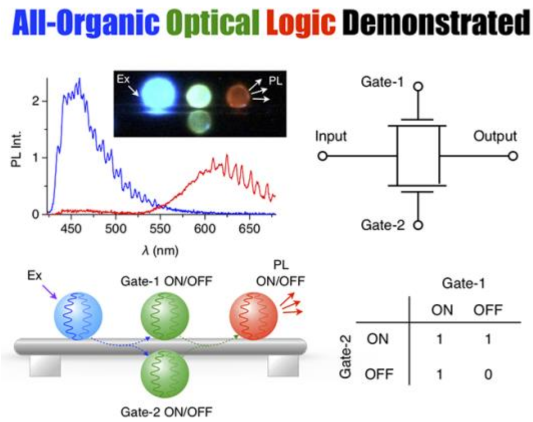

Figure 1. Schematic representations of an optical OR gate using four fluorescent microsphere resonators put on a polystyrene optical microfiber. The green-fluorescence from two spheres on the middle of the optical gate is photochemically switchable upon UV/vis photoirradiation.

KEYWORDS: *Microspheres, microfiber, whispering gallery mode, energy transfer*

Reference: [1] Hendra *et al*., *Adv. Funct. Mater*. **2021**. (DOI: 10.1002/adfm.202103685)