Frontier Science Area

Demonstration of a highly efficient modulator using the organic electro-optic polymer for visible light

NICT has successfully developed a highly efficient optical modulator using the organic electro-optic polymer (hereinafter referred to as EO polymer) for visible light. Conventional EO polymer optical modulators could operate in near-infrared light (wavelength 1,550 nm, etc.), but they couldn't be used for visible light (wavelength 380 nm to 780 nm) because of the large absorption loss at visible light. NICT has developed an EO polymer which has small absorption loss in visible light and a large electro-optic coefficient required for the optical modulator. The demonstrated optical modulator for visible light is smaller and more efficient than the conventional EO polymer optical modulator for near-infrared light.

The growth of global internet traffic has led to the demand for optical networks with high performing technology. NICT is developing the high speeds and low driving voltages optical modulator using EO polymer more than conventional lithium niobate (LN) optical modulator. Compared to LN optical modulators, EO polymer optical modulators have the problem that they can only be used with near-infrared light for optical communications. The EO polymer optical modulator can be applied to scan the light beam at high speed. To use it for display devices such as stereoscopic displays, it must be available in visible light.

In this research, we successfully developed an EO polymer which has low absorption and high electro-optic coefficient in visible light. This result was achieved by NICT's accurate measurement technology and molecular design based on the vast molecular structure library accumulated over many years. By designing the EO molecule structure to be short and rigid to suppress the absorption loss at visible light, this EO polymer has less than 1/20,000 absorption loss than conventional EO polymer and is available for visible light.

NICT designed and fabricated a Mach-Zehnder interferometer structure using microfabrication process. The waveguide size for operating at visible light is necessary to be small than conventional optical modulator for near-infrared light. We have adopted a ridge type waveguide (see Fig.1) which guarantees a single mode even if the width of the waveguide is relatively large. As a result, although high accuracy processing is required, the fabrication tolerance relaxed.

"I will continue to promote research and development of the optical phased array for next-generation display" said KAMADA Shun , researcher of Nanoscale Functional Assembly ICT Laboratory, Advanced ICT Research Institute. We will also aim to develop EO polymers for green and blue other than red, and expand their, applications to full color stereoscopic displays.

This EO polymer optical modulator for visible light is expected to be applied to next generation display devices such as stereoscopic displays and smart glasses.

This achievement was published in the scientific journal "Optics Express" on May 19, 2022.

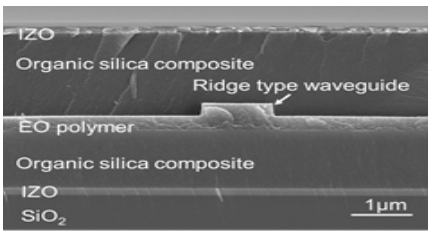

Fig.1 : Cross section of EO polymer optical modulator for visible light. IZO (Indium Zinc Oxide) electrode are placed at the top and bottom of waveguide.

Reference

Shun Kamada, Rieko Ueda, Chiyumi Yamada, Kouichi Tanaka, Toshiki Yamada, and Akira Otomo, "Superiorly low half-wave voltage electro-optic polymer modulator for visible photonics," Optics Express, vol.30, Issue 11, pp.19771-19780, 2022
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