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PRESS RELEASE (2025/01/07)

Beyond 5G, accelerating the world of ultra-high-speed optical data transmission

Researchers develop a new ultrahigh-speed optical modulator that can operate at more than 10 times the speed of current devices

Fukuoka, Japan—Kyushu University researchers have successfully developed an ultrahigh-speed optical modulator that can operate at more than 10 times the speed of current devices. This modulator was made thanks to a new method the team developed that allowed them to grow thin films of ferroelectric crystals on silicon substrates.

Optical communication technology is the bedrock of our modern internet. Thousands of kilometers of fiberoptic cable are laid across the globe, providing the data needed for our modern digital age. Transferring that data is done using light, hence the need for fiberoptic material that can contain said light between major distances.

"Optical fiber traffic is rapidly increasing year by year, and the need for devices and systems capable of faster transmission is growing. Devices called optical modulators are critical for this future," explains Professor Shiyoshi Yokoyama of Kyushu University's Institute for Materials Chemistry and Engineering and who led the study published in *communications materials*. "Optical modulators are devices that help generate high-speed signals from optical fibers. They can convert or change things like the intensity, phase, or frequency of the light using electrical signals."

One of the biggest hurdles in making ultrahigh-speed optical data transmission is in finding the right materials capable of providing such speeds. Today, optical modulators are being built from semiconductors, inorganic crystals, and even polymers. Yokoyama and his team focused on a type of material called ferroelectric crystals, a material that exhibit spontaneous electrical polarization.

"These materials have high electro-optic effects and are prime candidates to be optical modulators. However, it has been difficult to form them into the thin films necessary for use in optical devices," continues Yokoyama. "Thankfully, our team was able to develop a method that to grown ferroelectric crystals on thin films of silicon."

The material, that the team is call PLZT, was developed into an optical modulator that was 2.5 mm in length. Following tests, they found that their new ferroelectric modulator exhibited modulation of up to 170 Gbps—an operating 10 times higher than existing devices—and a transmission rate of more than 300 Gbps using a four-level pulse modulation.

The team hopes their research can be utilized in future optical network transmissions technologies, as well as support future 6G technologies and optical quantum computers.

"The demand for higher data speeds in optical fiber communications will continue to grow, and data centers will require higher density signal transmissions and processing. I expect our new optical modulator will contribute to this continually expanding industry," concludes Yokoyama.

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For more information about this research, see "Ultra-fast perovskite electro-optic modulator and multi-band transmission up to 300 Gbit s^{-1}," Jiawei Mao, Futa Uemura, Sahar Alasvand Yazdani, Yuexin Yin, Hiromu Sato, Guo-Wei Lu, and Shiyoshi Yokoyama, *communications materials*, https://doi.org/10.1038/s43246-024-00558-5

About Kyushu University

Founded in 1911, Kyushu University is one of Japan's leading research-oriented institutes of higher education, consistently ranking as one of the top ten Japanese universities in the Times Higher Education World University Rankings and the QS World Rankings. The university is one of the seven national universities in Japan, located in Fukuoka, on the island of Kyushu—the most southwestern of Japan's four main islands with a population and land size slightly larger than Belgium. Kyushu U's multiple campuses—home to around 19,000 students and 8000 faculty and staff—are located around Fukuoka City, a coastal metropolis that is frequently ranked among the world's most livable cities and historically known as Japan's gateway to Asia. Through its VISION 2030, Kyushu U will "drive social change with integrative knowledge." By fusing the spectrum of knowledge, from the humanities and arts to engineering and medical sciences, Kyushu U will strengthen its research in the key areas of decarbonization, medicine and health, and environment and food, to tackle society's most pressing issues.

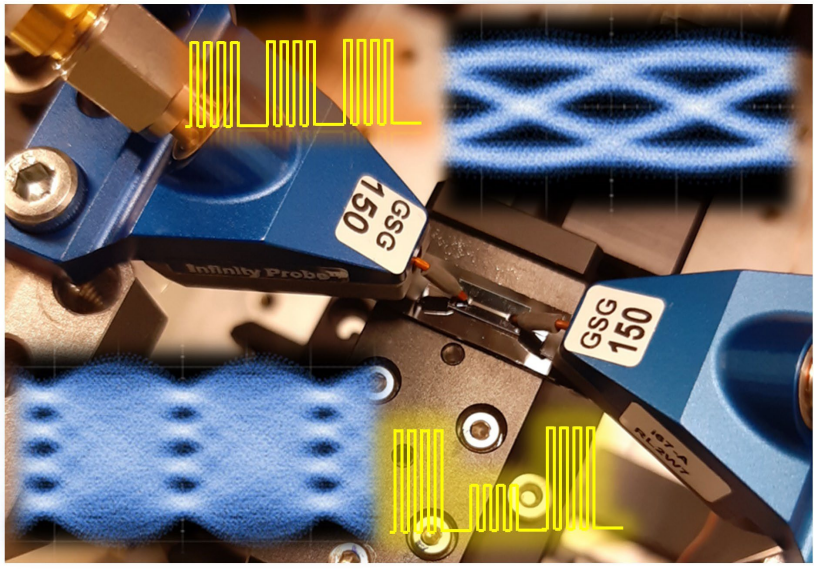

Fig. 1. High-speed optical transmission experiment using PLZT optical modulator. Between the two probes you can find the PLZT optical modulator developed by the research team. The modulator is 2.5 mm in length. The waveform demonstrates the results from the two tests conducted on the optical modulator: on-off-keying method (top) and four-level pulse-amplitude-

modulation method (bottom). The four-level pulse-amplitude-modulation method can double the transmission rate by using pulse signals. (Kyushu University/Yokoyama Lab)

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