PRESS RELEASE

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First demonstration of 100 Gbps-class wireless transmission beyond 420 GHz: Toward ultra-high-speed mobile backhaul for 6G

Key points:

- Conventional electronic technologies face limitations in generating high-frequency signals beyond 350 GHz, necessitating new approaches for 6G ultra-high-speed wireless communications.
- Terahertz wireless transmission using a fiber-coupled microcomb achieved a single-channel data rate of 112 Gbps at 560 GHz.
- This work establishes a key technological foundation for ultra-high-speed mobile backhaul and photonic–wireless integrated networks in 6G.

Summary

Wireless communications have achieved higher data rates and larger capacity by increasing carrier frequencies. While millimeter-wave bands are used in fifth-generation (5G) systems, next-generation (6G)(Note 1) communications, expected to be deployed in the 2030s, aim to utilize terahertz waves above 300 GHz. However, beyond 350 GHz, conventional electronic technologies face fundamental limitations in signal generation, including reduced output power and increased phase noise, making stable and high-speed wireless transmission difficult.

To address these challenges, a research team comprising Dr. Yu Tokizane, Dr. Hiroki Kishikawa, Prof. Naoya Kuse, and Prof. Takeshi Yasui of the Institute of Post-LED Photonics (pLED) and the Institute of Photonics and Human Health Frontier (IPHF), Tokushima University; Mr. Takumi Kikuhara of the Graduate School of Sciences and Technology for Innovation, Tokushima University; Visiting Professor Tadao Nagatsuma of pLED, Tokushima University; and Prof. Shintaro Hisatake of Gifu University, developed a microcomb-driven terahertz wireless communication system that combines terahertz wave generation using a fiber-coupled microcomb(Note 2) with high-order modulation techniques. By leveraging the high frequency stability of the microcomb, the researchers generated a low-phase-noise terahertz carrier and demonstrated single-channel wireless transmission at 112 Gbps in the 560 GHz band. This represents a significant increase compared to conventional terahertz communication systems, typically limited to a few to several tens of Gbps.

This work is the first to demonstrate the feasibility of 100 Gbps-class wireless communication beyond 420 GHz, and it provides a key technological foundation for ultra-high-speed backhaul links and photonic–wireless integrated networks in 6G systems.

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Instruction Video by the Yasui Lab., Tokushima University

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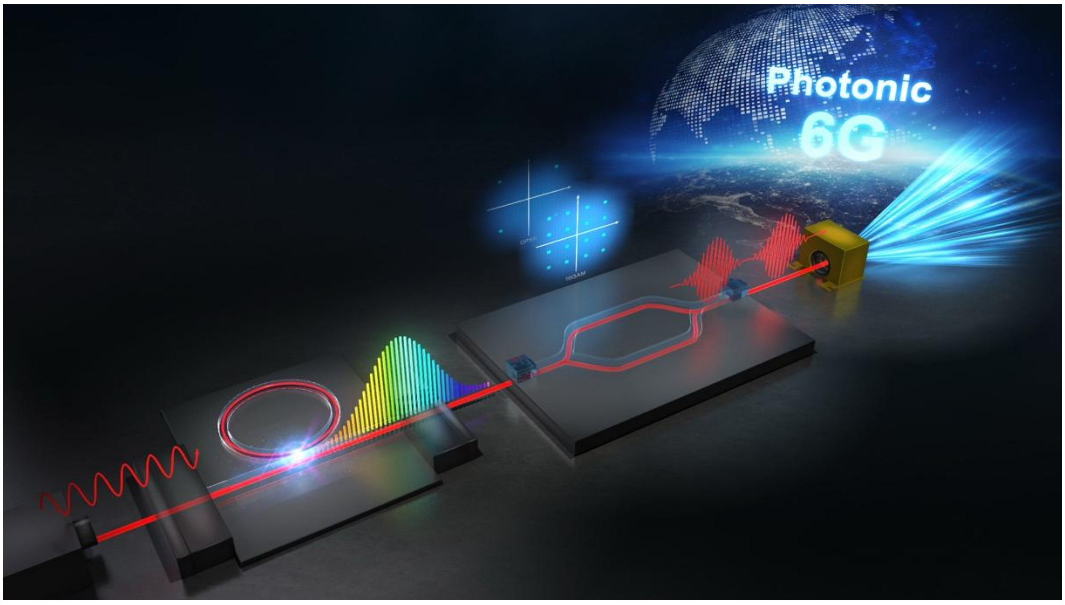


Fig. 1. Conceptual illustration of microcomb-driven terahertz wireless communication.

Research background and history

Wireless communications have achieved higher data rates and larger capacity by increasing carrier frequencies. While millimeter-wave bands are used in fifth-generation (5G) systems, next-generation (6G) communications, expected to be deployed in the 2030s, aim to utilize terahertz frequencies above 300 GHz. In particular, frequencies beyond 350 GHz offer extremely wide bandwidths for ultra-high-speed transmission. However, conventional electronic technologies face fundamental limitations in this regime, including reduced output power and increased phase noise, making it difficult to realize stable and high-speed wireless communication. Therefore, new approaches capable of generating stable and high-quality signals are required.

Against this background, the research team focused on photonic technologies as an alternative to electronic approaches, particularly on microcombs, a type of optical frequency comb. They have been developing terahertz signal generation and wireless communication systems based on microcombs (microcomb-driven terahertz communication or Photonic 6G[Note 3]). Microcombs exhibit high frequency stability and low phase noise, and their wide mode spacing enables the generation of high-quality terahertz carriers, making them a promising technology for terahertz wireless communication. However, in frequency ranges beyond 350 GHz, it has remained challenging to simultaneously achieve stable signal generation and high-order modulation for high-speed data transmission, limiting the realization of practical wireless communication systems.

In this study, the team aimed to overcome these technical challenges and demonstrate 100 Gbps-class wireless communication beyond 350 GHz.

Research content and results

In this study, we first developed a microcomb device based on a fiber-coupled microresonator to realize a compact and stable terahertz signal source. By directly bonding an optical fiber to a silicon nitride microresonator using optical adhesive, we eliminated the need for precise optical alignment using optical microscopes and multi-axis stages, which are typically required in conventional setups. This approach enabled significant miniaturization of the system (Fig. 2). Furthermore, this configuration greatly improved the temporal stability of the optical coupling efficiency and allowed the use of high-power pump light. As a result, stable long-term operation was achieved, establishing a platform for low-noise and highly stable terahertz signal generation.

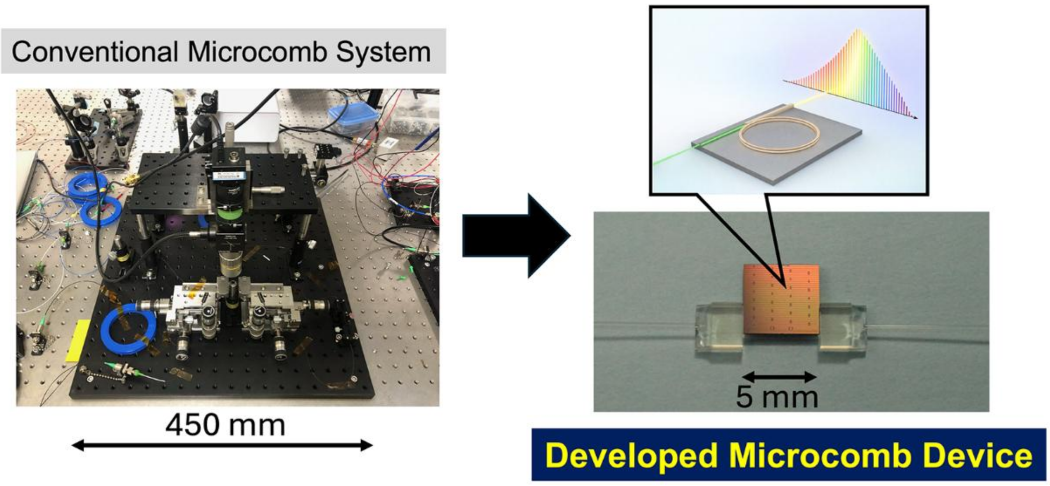
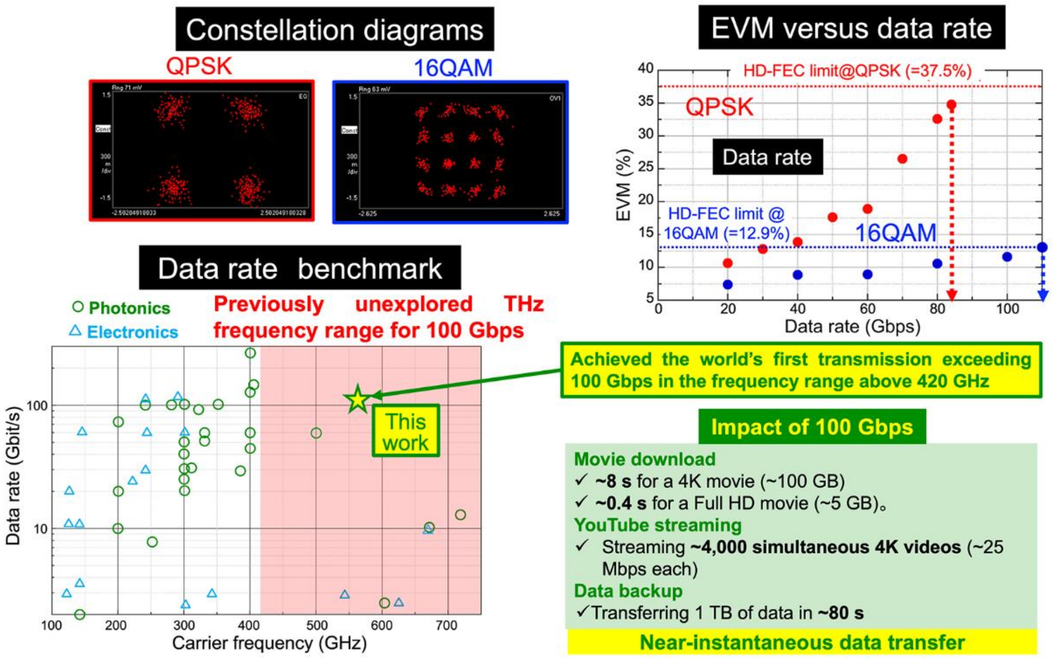


Fig. 2. Fiber-coupled microcomb device and experimental setup.

Next, we constructed a terahertz wireless communication system using the fiber-coupled microcomb. Two optical carriers with high stability and high signal-to-noise ratio were generated via injection locking of the microcomb, and high-order modulation formats (QPSK and 16QAM) were applied in the optical domain. The modulated signals were then converted into a 560 GHz terahertz wave through photomixing and transmitted wirelessly. At the receiver, the signal was recovered using heterodyne detection with a sub-harmonic mixer. As a result, wireless transmission rates of 84 Gbps with QPSK and 112 Gbps with 16QAM were achieved, demonstrating 100 Gbps-class communication beyond 420 GHz (Fig. 3). This is the first demonstration of 100 Gbps-class wireless transmission in the unexplored frequency range beyond 420 GHz.



Achieved the world's first transmission exceeding 100 Gbps in the frequency range above 420 GHz

Impact of 100 Gbps

Movie download
- ✓ **~8 s** for a 4K movie (~100 GB)
- ✓ **~0.4 s** for a Full HD movie (~5 GB)。

YouTube streaming
- ✓ Streaming **~4,000 simultaneous 4K videos** (~25 Mbps each)

Data backup
- ✓Transferring 1 TB of data in **~80 s**

Near-instantaneous data transfer

Fig. 3. Experimental results demonstrating high-speed terahertz wireless transmission.

Future developments

This work demonstrates the feasibility of 100 Gbps-class wireless communication in the terahertz regime beyond 350 GHz, establishing a key technological foundation for ultra-high-speed mobile backhaul and photonic–wireless integrated networks in 6G systems. Looking ahead, further reduction of the phase noise of microcombs will improve signal quality and enable the use of higher-order modulation formats, paving the way for even higher data rates and larger capacity. In addition, extending the practical transmission distance will require selecting frequency bands with lower atmospheric absorption, increasing terahertz output power, and employing high-gain antennas. By combining these approaches, the practical deployment of terahertz wireless communication is expected to accelerate, contributing to next-generation communication infrastructure.

Terminology

(Note 1) Next-generation mobile communication (6G)

In next-generation mobile communications (sixth-generation mobile communication, 6G), which is expected to be deployed in the 2030s, terahertz waves above 300 GHz are anticipated to be used as wireless carriers. 6G is expected to meet several key requirements, including ultra-high-speed and high-capacity communication, ultra-low latency, extended coverage, ultra-reliable communication, low power consumption and cost efficiency, as well as massive connectivity and integrated sensing.

(Note 2) Fiber-coupled microcomb

A microcomb is a highly discrete multi-spectral structure in which multiple optical frequency modes are arranged at equal intervals like the teeth of a comb. It enables the generation of ultrahigh-frequency optoelectronic signals with significantly higher quality than those obtained using conventional electronic approaches. In addition, microcombs can be mass-produced using semiconductor fabrication processes, making them promising for future miniaturization, simplification, and cost reduction.

In the fiber-coupled configuration used in this study, an optical fiber is directly bonded to the microresonator, enabling highly stable and reproducible optical coupling. This approach eliminates the need for precise optical alignment required in conventional systems and offers significant advantages for practical implementation.

(Note 3) Photonic 6G

"Photonic 6G" is a registered trademark of Tokushima University (Registration No. 6537005).

Acknowledgments

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Reference

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Authors	Yu Tokizane, Hiroki Kishikawa, Takumi Kikuhara, Miezel Talara, Yoshihiro Makimoto, Kodai Yamaji, Yasuhiro Okamura, Kenji Nishimoto, Eiji Hase, Isao Morohashi, Atsushi Kanno, Shintaro Hisatake, Naoya Kuse, Tadao Nagatsuma, and Takeshi Yasui
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Related patents

We have filed three related Japanese patent applications.

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