Team sets new speed record for industry standard optical fiber

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Optical fiber	Randomly coupled 3-core fiber	15-mode fiber	Uncoupled 4-core fiber	55-mode fiber	Current result: Randomly coupled 19-core fiber
Cross-sectional view					
Achieved records	Mar. 2020 Product of data-rate and distance	Dec. 2020 Transmission capacity	May 2022 Transmission capacity	Sep. 2022 Transmission capacity	Mar. 2023 Transmission capacity
Transmission capacity (petabits/s)	0.17	1.01	1.02	1.53	1.7
Transmission distance (km)	2,040	23	51.4	25.9	63.5
Frequency band (terahertz)	9.0	9.6	20	4.6	9.5
Power consumption of MIMO processing	Small	Large	None	Large	Small

Table of fibers. Credit: Macquarie University

An optical fiber about the thickness of a human hair can now carry the equivalent of more than 10 million fast home internet connections running at full capacity.

A team of Japanese, Australian, Dutch, and Italian researchers has set a new speed record for an industry standard optical fiber, achieving 1.7 Petabits over a 67km length of fiber. The fiber, which contains 19 cores that can each carry a signal, meets the global standards for fiber size,

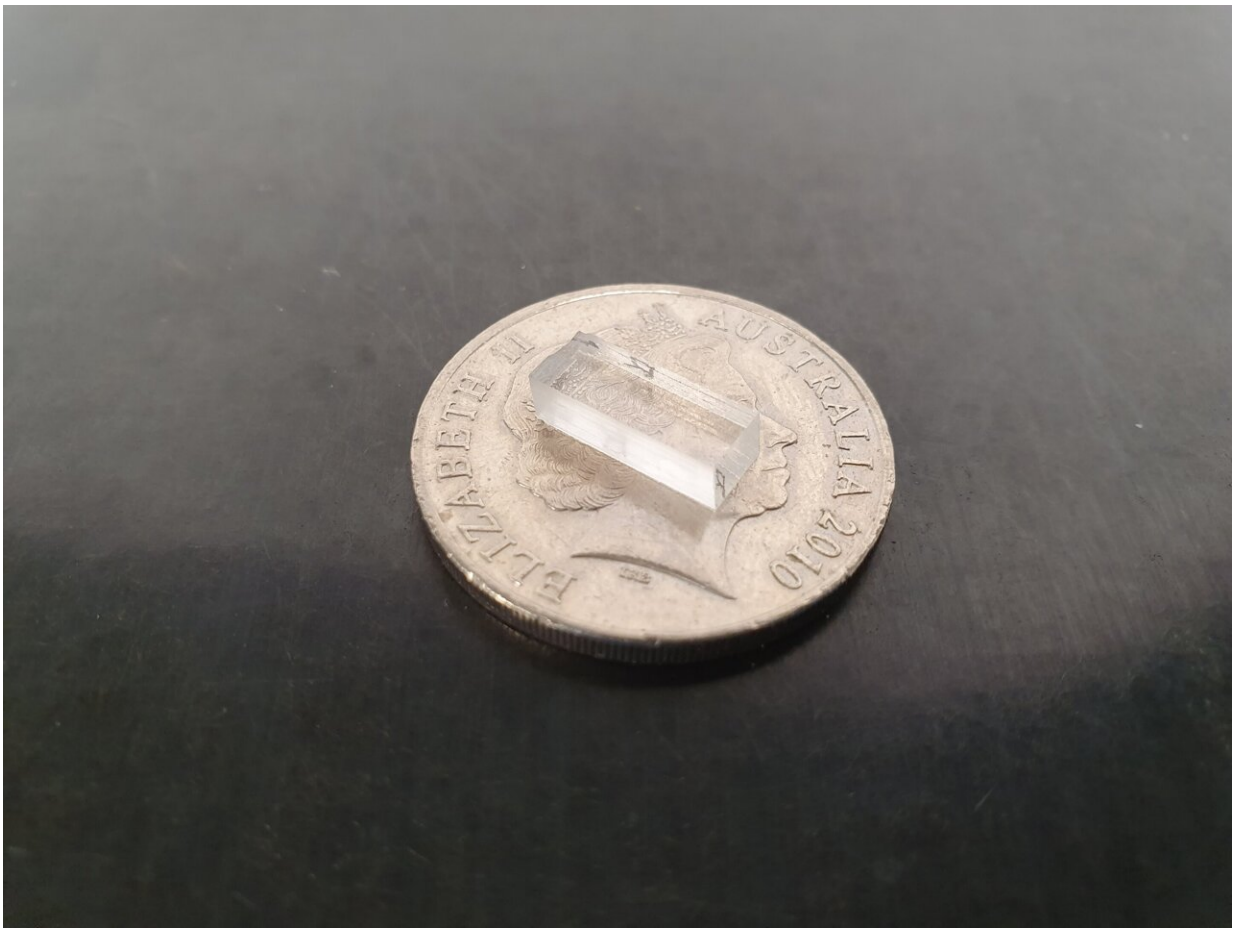
ensuring that it can be adopted without massive infrastructure change. And it uses less digital processing, greatly reducing the power required per bit transmitted.

Macquarie University researchers supported the invention by developing a 3D laser-printed glass chip that allows low loss access to the 19 streams of light carried by the fiber and ensures compatibility with existing transmission equipment.

The fiber was developed by the Japanese National Institute of Information and Communications Technology (NICT, Japan) and Sumitomo Electric Industries, Ltd. (SEI, Japan) and the work was performed in collaboration with the Eindhoven University of Technology, University of L'Aquila, and Macquarie University.

All the world's internet traffic is carried through optical fibers which are each 125 microns thick (comparable to the thickness of a human hair). These industry standard fibers link continents, data centers, mobile phone towers, satellite ground stations and our homes and businesses.

Back in 1988, the first subsea fiber-optic cable across the Atlantic had a capacity of 20 Megabits or 40,000 telephone calls, in two pairs of fibers. Known as TAT 8, it came just in time to support the development of the World Wide Web. But it was soon at capacity.



Macquarie University's optical glass chip feeds data into the ultra high-speed optical fiber. Credit: Macquarie University

The latest generation of subsea cables such as the Grace Hopper cable, which went into service in 2022, carries 22 Terabits in each of 16 fiber pairs. That's a million times more capacity than TAT 8, but it's still not enough to meet the demand for streaming TV, video conferencing and all our other global communication.

"Decades of optics research around the world has allowed the industry to push more and more data through single fibers," says Dr. Simon Gross from Macquarie University's School of Engineering. "They've used

different colors, different polarizations, light coherence and many other tricks to manipulate light."

Most current fibers have a single core that carries multiple light signals. But this current technology is practically limited to only a few Terabits per second due to interference between the signals.

"We could increase capacity by using thicker fibers. But thicker fibers would be less flexible, more fragile, less suitable for long-haul cables, and would require massive reengineering of optical fiber infrastructure," says Dr. Gross.

"We could just add more fibers. But each fiber adds equipment overhead and cost and we'd need a lot more fibers."

To meet the exponentially growing demand for movement of data, telecommunication companies need technologies that offer greater data flow for reduced cost.

The new fiber contains 19 cores that can each carry a signal.

"Here at Macquarie University, we've created a compact glass chip with a wave guide pattern etched into it by a 3D laser printing technology. It allows feeding of signals into the 19 individual cores of the fiber simultaneously with uniform low losses. Other approaches are lossy and limited in the number of cores," says Dr. Gross.

"It's been exciting to work with the Japanese leaders in optical fiber technology. I hope we'll see this technology in subsea cables within five to 10 years."

Another researcher involved in the experiment, Professor Michael Withford from Macquarie University's School of Mathematical and

Physical Sciences, believes this breakthrough in optical fiber technology has far-reaching implications.

"The optical chip builds on decades of research into optics at Macquarie University," says Professor Withford. "The underlying patented technology has many applications including finding planets orbiting distant stars, disease detection, even identifying damage in sewage pipes."

The paper is published in the proceedings of the *Optical Fiber Communication Conference (OFC) 2023*.

More information: Georg Rademacher et al, Randomly Coupled 19-Core Multi-Core Fiber with Standard Cladding Diameter, *Optical Fiber Communication Conference (OFC) 2023* (2023). DOI: 10.1364/OFC.2023.Th4A.4

Provided by Macquarie University