Scientists build ultra-high-speed terahertz wireless chip

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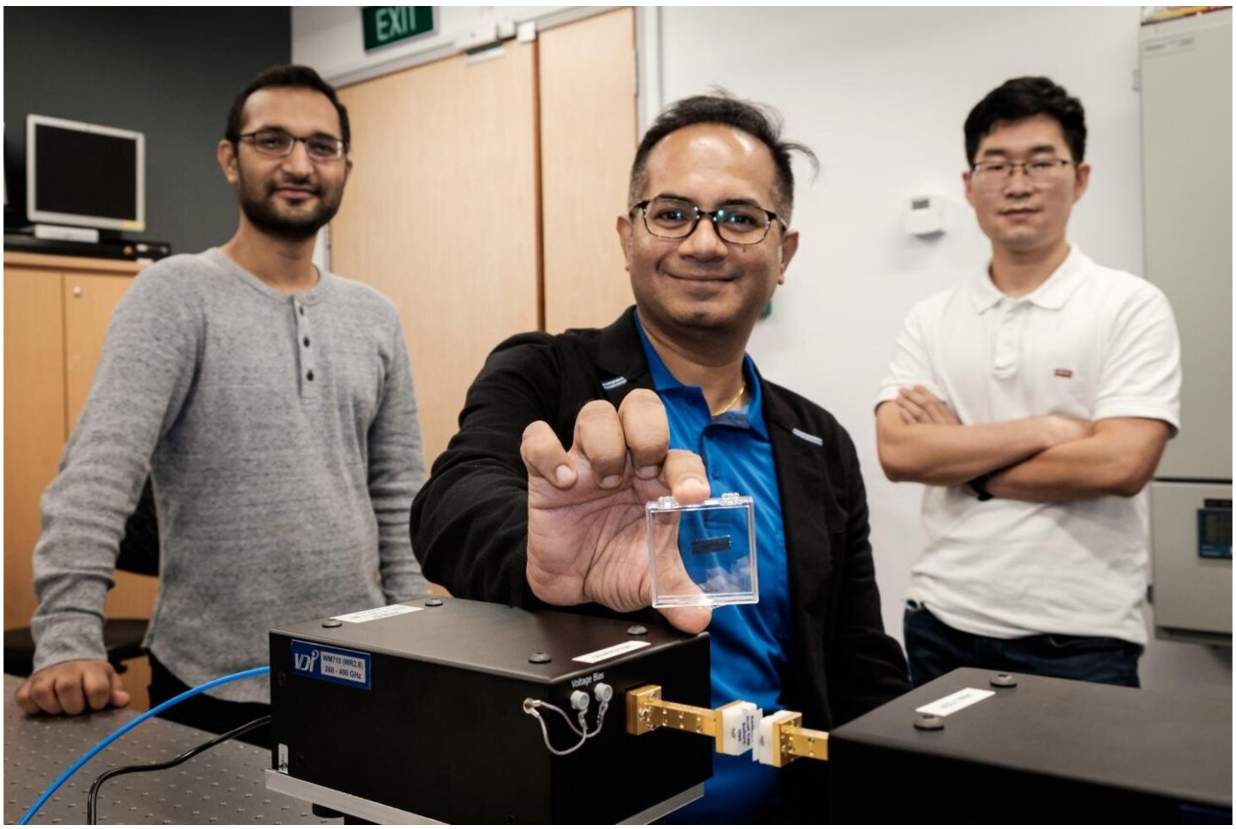


From left: NTU final year PhD student Abhishek Kumar, Assoc Prof Ranjan Singh and postdoc Dr Yihao Yang. Dr Singh is holding the photonic topological insulator chip made from silicon, which can transmit terahertz waves at ultrahigh speeds. Credit: NTU Singapore

To enable data transmission speeds that surpass the 5th Generation (5G) standards for telecommunications, scientists from Nanyang Technological University, Singapore (NTU Singapore) and Osaka University in Japan have built a new chip using a concept called photonic topological insulators.

Published recently in *Nature Photonics*, the researchers showed that their chip can transmit terahertz (THz) waves resulting in a data rate of 11 Gigabits per second (Gbit/s), which is capable of supporting real-time streaming of 4K high-definition video, and exceeds the hitherto theoretical limit of 10 Gbit/s for 5G wireless communications.

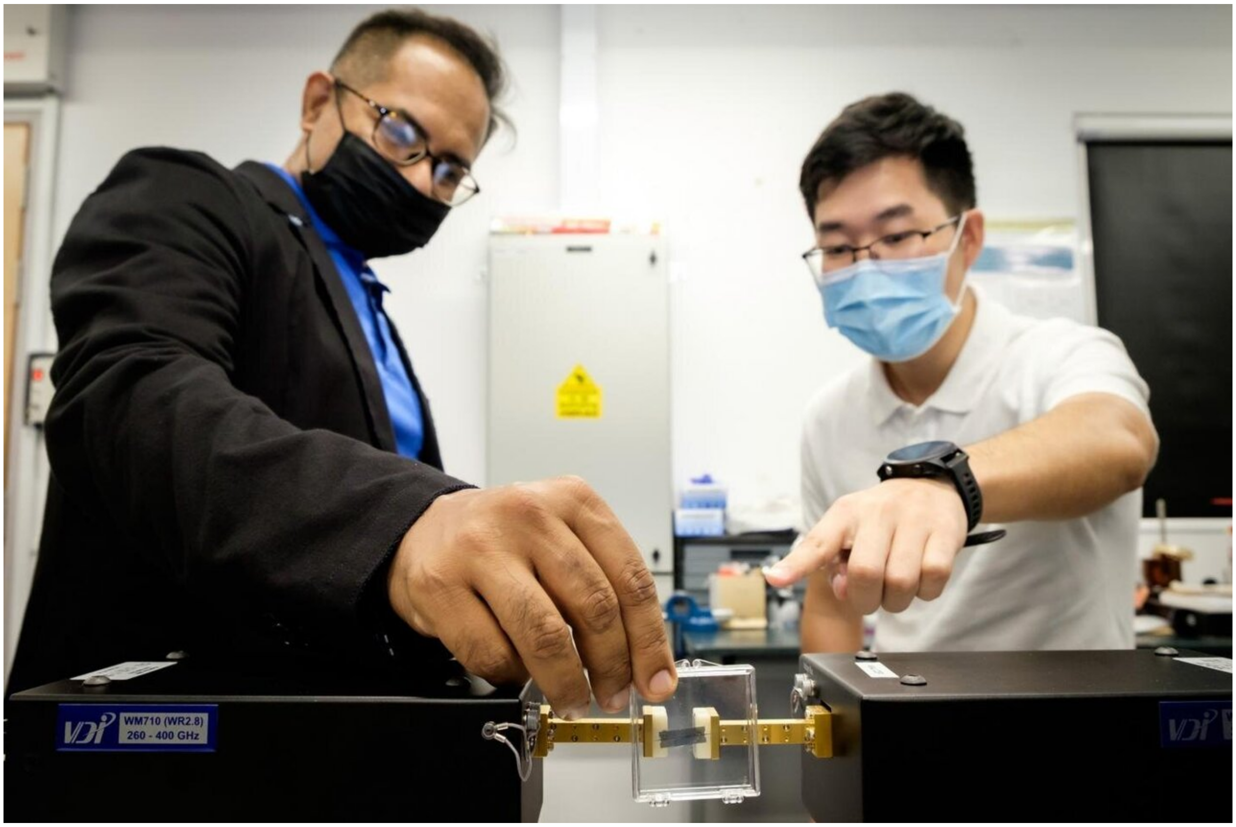
THz waves are part of the electromagnetic spectrum, in between infrared light waves and microwaves, and have been touted as the next frontier of high-speed wireless communications.

However, fundamental challenges need to be tackled before THz waves could be used reliably in telecommunications. Two of the biggest issues are the material defects and transmission error rates found in conventional waveguides such as crystals or hollow cables.

These issues were overcome using Photonic Topological Insulators (PTI), which allows light waves to be conducted on the surface and edges of the insulators, akin to a train following railroads, rather than through the material.

When light travels along photonic topological insulators, it can be redirected around sharp corners and its flow will resist being disturbed by material imperfections.

By designing a small silicon chip with rows of triangular holes, with small triangles pointing in the opposite direction to larger triangles, light waves become 'topologically protected.'



From left: NTU physicist Assoc Prof Ranjan Singh and first author of the paper Dr Yihao Yang discussing future experiments with their new photonic topological insulator terahertz chip Credit: NTU Singapore

This all-silicon chip demonstrated it could transmit signals error-free while routing THz waves around 10 sharp corners at a rate of 11 gigabits per second, bypassing any material defects that may have been introduced in the silicon manufacturing process.

Leader of the project, NTU Assoc Prof Ranjan Singh, said this was the first time that PTIs have been realized in the terahertz spectral region, which proves the previously theoretical concept, feasible in real life.

Their discovery could pave the way for more PTI THz interconnects—structures that connect various components in a circuit—to be integrated into wireless communication devices, to give the next generation '6G' communications an unprecedented terabytes-per-second speed (10 to 100 times faster than 5G) in future.

"With the 4th industrial revolution and the rapid adoption of Internet-of-Things (IoT) equipment, including smart devices, remote cameras and sensors, IoT equipment needs to handle high volumes of data wirelessly, and relies on communication networks to deliver ultra-high speeds and low latency," explains Assoc Prof Singh.

"By employing THz technology, it can potentially boost intra-chip and inter-chip communication to support Artificial intelligence and cloud-based technologies, such as interconnected self-driving cars, which will need to transmit data quickly to other nearby cars and infrastructure to navigate better and also to avoid accidents."

This project took the NTU team and their collaborators led by Professor Masayki Fujita at Osaka University two years of design, fabrication, and testing.

Prof Singh believes that by designing and producing a miniaturized platform using current silicon manufacturing processes, their new high-speed THz interconnect chip will be easily integrated into electronic and photonic circuit designs and will help the widespread adoption of THz in future.

Areas of potential application for THz interconnect technology will include data centers, IOT devices, massive multicore CPUs (computing chips) and long-range communications, including telecommunications and wireless communication such as Wi-Fi.

More information: Yihao Yang et al. Terahertz topological photonics for on-chip communication, *Nature Photonics* (2020). DOI: 10.1038/s41566-020-0618-9

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