Information communication technologies, Smart devices

Development of compact diplexers based on a silicon chip

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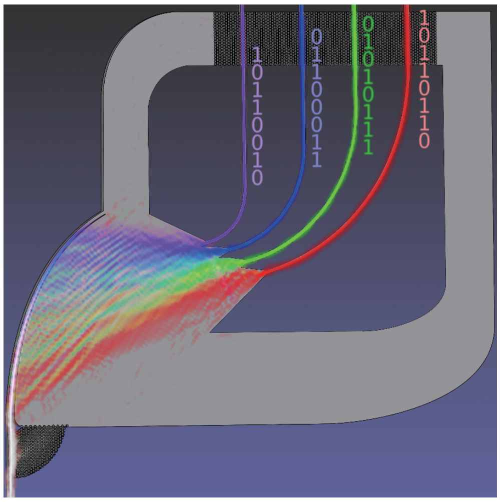
Abstract

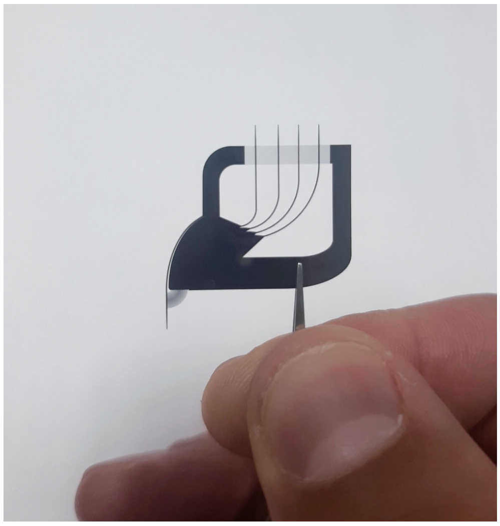
People around the world are increasingly using mobile devices to access the internet and the number of connected devices is multiplying exponentially. Soon machines will be communicating with each other in the Internet of Things which will require even more powerful wireless networks able to transfer large volumes of data fast. Terahertz waves are a portion of the electromagnetic spectrum that has a raw spectral bandwidth that is far broader than that of conventional wireless communications, which is based upon microwaves. A new design of ultra-small silicon chip called a multiplexer will effectively manage terahertz waves which are key to the next generation of communications: 6G and beyond. The developed terahertz multiplexers, which are economical to manufacture, will be extremely useful for ultra-broadband wireless communications. The multiplexer is made from pure silicon for terahertz-range communications in the 300-GHz band. To control the great spectral bandwidth of terahertz waves, a multiplexer, which is used to split and join signals, is critical for dividing the information into manageable chunks that can be more easily processed and so can be transmitted faster from one device to another. The shape of the chips is the key to combining and splitting channels so that more data can be processed more rapidly.

Significance of the research and Future perspective

A typical four-channel optical multiplexer might span more than 2000 wavelengths. This would be about two meters in length in the 300-GHz band. Our device is merely 25 wavelengths across, which offers dramatic size reduction by a factor of 6000. The developed multiplexer covers a spectral bandwidth that is over 30 times the total spectrum that is allocated in Japan for 4G/LTE, the fastest mobile technology currently available and 5G which is the next generation, combined. As bandwidth is related to data rate, ultra-high-speed digital transmission is possible with the new multiplexer. Our four-channel multiplexer can potentially support an aggregate data rate of 48 Gbit/s, equivalent to that of uncompressed 8K ultrahigh definition video being streamed in real-time. To make the entire system portable, we will integrate this multiplexer with resonant tunneling diodes to provide compact, multi-channel terahertz transceivers. The present modulation scheme was quite basic; terahertz power was simply switched on and off to transmit binary data. More advanced techniques are available that can squeeze even higher data rates towards 1 Terabit/s into a given bandwidth allocation. The developed multiplexer can be mass-produced, just like computer chips, but much simpler. So large-scale market penetration is possible. This would enable applications in 6G and beyond, as well as the Internet of Things, and low-probability-of-intercept communications between compact aircraft such as autonomous drones.



Schematic of the integrated multiplexer, showing broadband terahertz wave being split into four different frequencies, where each is capable of carrying digital information.



Photograph of the silicon multiplexer.

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