Scientists work on an alternative to carry data

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Professor Franko Küppers in the optical laboratory. Credit: Katrin Binner

Installing new optical fibres is expensive. So network operators want to make better use of their existing capacities. A new type of laser diode from Darmstadt could help. It has now been put into practice with the industry.

Light floods through the extensive office windows on the sixth floor of the Hans Busch Institute at the Technische Universität Darmstadt. Franko Küppers is at his desk, holding a gleaming grey fibre as fine as a hair up to the sun. Light flows through these fibres as well, although not for lighting, but to carry data.

Light as a communication medium has occupied the thoughts of this electrical engineering professor for a long time. He knows the unrivalled strength of optical fibres: thousands of gigabytes shoot through them every second. On the other hand, the copper cables which nowadays often still span the so-called "last mile" to the households, only transmit data at a thousandth of this rate.

As the former head of a respective research department at Deutsche Telekom, Küppers knows well what is hindering the spread of optical fibres. New infrastructure costs a lot of money. So network operators try to make better use of their existing capacities. A well-known way of doing this is so-called multiplexing, which combines up to 80 signals and simultaneously directs them though a single optical fibre. Think of it as a sort of inverted prism. This normally splits a beam of white light into its component colours. It also works in reverse: if beams of different colours enter the prism, it combines them to make a beam of white. As different signals can be carried by means of different coloured light, it is possible to combine more information in a white beam than it would be in a beam of a component colour.

"Multiplexing was the key innovation, as without it, neither the broadband internet we know today nor the mobile internet would be possible", enthuses Küppers. His team from the Department of Electrical Engineering and Information Technology has crucially improved this technology, thus opening up a "vast market", as the researcher puts it. A joint Turbo for the broadband network project involving the team from Darmstadt and three industrial companies and sponsored by the Federal

Ministry of Education and Research (BMBF), recently got the technology ready for field tests.

The key part came from Darmstadt: A microelectro-mechanical system (MEMS), integrated with a laser diode, to which it gives a new and unusual feature. Laser diodes usually emit light of a specific wavelength. They inject light pulses of this colour into the optical fibres. In optical multiplexing, you need up to 80 different laser diodes of different colours. This is because each information channel transmits with a different light wavelength. "This causes a lot of expense", says Küppers.

Because for one thing, it requires extremely precise manufacturing to ensure that the diode emits exactly the required wavelength. "There are a lot of rejects", acknowledges Küppers. There must also be spare diodes available for all 80 channels.

Like a stringed instrument

Küppers is now offering an alternative – a laser diode that can be tuned in wavelength. The wavelength emitted by the diode can be chosen anywhere within a certain range. The advance can be compared to a stringed instrument. Previously, so to speak, guitars never used to have frets, so every string could only produce a single sound. The Darmstadt invention provides the frets, and thus the opportunity to elicit many sounds from every string.

Rejects are reduced. The wavelength can be changed on the finished product, so the standard that has to be maintained during production is not ridiculously strict. "It is also no longer necessary to keep 80 different spare parts available", adds Küppers. A further advantage of the new diodes: "Networks can be more flexible", says Küppers. Even during operation, it is possible to change the wavelength in a matter of seconds. The bandwidth of each colour channel can be constantly adapted to meet current needs. "So optimum use is made of the total bandwidth of the optical fibre", stresses Küppers.

The basic idea behind the Darmstadt technique is simple. Imagine that a laser is like a tube with a mirror at each end, between which light is reflected to and fro. The distance between the two mirrors, rather like the length of a string, determines the colour of the light emitted by the laser. Julijan Cesar and Sujoy Paul, who are studying for their doctorates at Küppers' Institute, show how it works in the cleanroom laboratory: Put a movable mirror at one end of a conventional laser diode. This consists of a highly reflective membrane of silicon oxide and silicon nitride, about a tenth of a millimetre in diameter. Four supports resembling spider's legs hold it parallel above the surface of the actual diode. "If you direct a low current through these little legs, they expand and the mirror moves a bit further away from the surface of the diode", explains Küppers. This change in the distance shifts the default wavelength used in optical fibres of 1,550 nanometres (millionth of a millimetre) by up to 100 nanometres. The technical jargon calls this technique: Vertical-Cavity Surface-Emitting Lasers, or VCSEL for short.

A laboratory prototype has now been developed by the Darmstadt team, together with an industrial consortium. "We enjoyed a very close collaboration",enthused Küppers. And it was worth it. The new technology now achieves an extremely fast data rate of around 12 gigabits per second. "We also found it a particular challenge to keep the wavelength adjustment stable for operation", explains Küppers. The joint project has developed a prototype that is suitable for mass production, and it is to be tested in the industrial environment of one of the partners.

The consortium will then be able to open up a vast market. The backbone of the internet consists of optical fibres. "But optical fibres are also used for data transmission in computing and data centres, which are becoming increasingly important in this age of cloud computing", realises Küppers. It may well be that an invention from Darmstadt will soon become part of the basic internet configuration.

Provided by Technische Universitat Darmstadt

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