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RESEARCH NEWS

Mobile communication of the future

Power amplifiers for 5G made of gallium nitride

The wireless data transmission via mobile communication is reliable and affordable. However, data volume per user is rising exponentially. Causes are not only the continuously growing number of smartphones, but also trends as car-to-car (C2C) or machine-to-machine (M2M) communication – cars and machines need to communicate in high speed with each other. From 2020 the 5G mobile standard is aiming to transmit data rapidly and energy-efficiently. For that purpose Fraunhofer is developing new power amplifiers based on the semiconductor gallium nitride.

At least 8 billion wireless devices are currently linked via mobile communication worldwide*. Chatting with friends and the family, watching videos while on the road, playing online or simply surfing the Internet can be done without problems and is affordable. However, will this still be the case if the number of users is rising and therefore data volume keeps increasing? "We are at a turning point", says Dr. Rüdiger Quay of the Fraunhofer Institute for Applied Solid State Physics IAF in Freiburg (Germany). "So far, it is mainly humans who are communicating with each other using mobile communication devices. In the future, cars, devices, or production machines will join the networks." However, real-time radio communication is necessary for visions such as Industry 4.0 or autonomous driving. Maximum data rates of 10 gigabits per second are needed and thus targeted. However, today's 4G LTE mobile standard is designed for 300 megabits per second and does not support real-time transmission. Surfing the Internet on your mobile device is comparatively slow with an average peak data rate of 50 megabits per second. For this reason, wireless carrier and network equipment providers are working jointly with researchers on the more powerful 5G. The new cellular network standard will enable the live transmission of high-quality video.

Developing technology for higher radio frequencies

The base stations are an important component in the cellular network. They are the bottleneck through which all data must pass. The Fraunhofer IAF has special knowledge on how to widen this bottleneck. The researchers are developing power amplifiers that are able to send more data more quickly and above all more efficiently through the cellular network. "New power amplifiers provide the necessary radio frequencies over which the data is transmitted", Quay explains. As a first step, additio-

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nal radio frequencies of up to 6 gigahertz are freed up for 5G. Currently, LTE is limited to 2.7 gigahertz.

"Higher frequencies mean faster data transmission, but unfortunately also less available power for the transmitters", says Quay. For this reason, the scientists are manufacturing transistors and microchips that are only a few square millimeters in size out of the semiconductor material gallium nitride (GaN). "Due to its special crystal structure, the same voltages can be applied at even higher frequencies, leading to a better power and efficiency performance", says Quay. Within the EU project Flex5Gware, the Institute is already successfully testing prototypes up to frequencies of 6 gigahertz.

For every transmitted bit, the wireless transmission of data consumes power. "That alone makes up about 15 percent of our cellular invoice", Quay explains. Each bit of information requires a certain, constant amount of power in the radio transmission. In comparison to today, 200 times more bits should be transmitted with a similar amount of energy. That means 200 times the power requirement. "For the sake of sustainability, the power efficiency of the cellular communication must be increased substantially for 5G", says Quay. But currently, the base stations are only able to transmit high data rates with a very high energy expenditure. The root cause is that they transmit the radio waves into the air – without knowing where the users are located. However, with new electronically steerable antennas and GaN-based power amplifiers, the information reaches the receivers with pinpoint accuracy and a much lower energy bill. Equipped with the technology of the researchers from Freiburg, the antennas of the base station electronically aim at the receiver. "They work like the human ear: We know from which direction noises are coming from without turning our head", explains the physicist.

The raw materials for GaN are available in large quantities. Nitrogen can be taken from the air, and gallium is a waste product in metal working. GaN is an important component of blue and white LEDs. The success of this light technology has contributed to the production of GaN becoming ever more cost-effective. Today, the power savings during operations exceed the production costs, in comparison to silicon, of the still more expensive GaN.

*Source: Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2015-2020 White Paper

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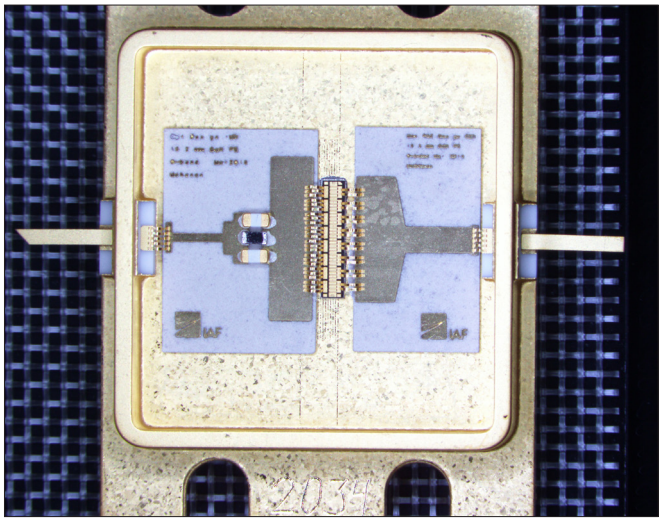
Flex5Gware
In the EU-funded Flex5Gware project, the Fraunhofer Institute for Applied Solid State Physics IAF in Freiburg is doing research jointly with companies such as Nokia, Intel, and Ericsson on new types of hardware and software for 5G networks. The project is running until 2017. In Europe, 5G is supposed to be widely available by the next European Soccer Championship in 2020.

Website: http://www.flex5gware.eu/



The power amplifier of the Fraunhofer IAF transmits at a frequency of 5.8 gigahertz. These frequency is needed for the new 5G mobile radio standard. The centrally placed gallium nitride (GaN) semi-conductor circuits are the central part of the packaged power amplifier. © Fraunhofer IAF | Picture in color and printing quality: www.fraunhofer.de/en/press