

# RESEARCH NEWS

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## Internet of Things

### Speaker technology — energy-efficient micro speakers for in-ear headphones

**In-ear headphones, which are inserted wirelessly into the ear canal, could replace smartphones in the future. A team of researchers from the Fraunhofer Institute for Photonic Microsystems IPMS and Bosch Sensortec GmbH laid the foundation for this with a novel technology for the integrated micro loudspeakers — and received the Joseph von Fraunhofer Prize for it.**

In the beginning, cell phones were only supposed to enable us to make phone calls on the go, but now they combine a bank branch, shopping center, music system, navigation system, television and much more. And the technological development continues: In the future, smart in-ear headphones with a direct internet interface could take the place of smartphones. Basic requirements for this are minimal energy consumption and low construction volume, low power consumption at high sound pressure and low production costs. Microelectromechanical systems, or MEMS for short, are ideal for this purpose. Until now, however, the heart of such in-ear headphones has been lacking: suitable speaker technology. The technologies currently available on the market are not yet suitable for such demanding applications — whether due to the degree of miniaturization, integration capability, cost reduction, production scalability or power consumption at high sound pressures.

#### Micro loudspeaker — functional and economical for the first time

Researchers at the Fraunhofer Institute for Photonic Microsystems IPMS have now taken an important step towards a smart in-ear headphone — and developed its missing heart: mini loudspeakers that can be manufactured using microelectronics technologies and achieve the loudness of 120 decibels required by the market without high power consumption. Dr. Bert Kaiser and Dr. Sergiu Langa from Fraunhofer IPMS and Holger Conrad from Bosch Sensortec GmbH receive the Joseph von Fraunhofer Prize for their development.

#### New approaches to design and drive technology

The development of the mini-speakers succeeded due to two novel scientific approaches: On the one hand, a completely new design of the speaker, which is not based on a vertically deflectable diaphragm as usual, but in which the sound displacing

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elements are located vertically in a silicon chip. On the other hand, a new drive technology for these elements, the nano e-drive actuators, which make sound generation possible in the first place. Both innovations can hardly be separated from each other.

“With the actuator, an electrostatic lever, we solved a fundamental problem: You can realize very large deflections and thus high volumes with it,” says Bert Kaiser. If you apply a voltage, the lever moves — like an electrostatic muscle. In this way, the researchers were able to realize large movements with small gap distances. In his dissertation, Bert Kaiser investigated exactly how this lever had to look in order to move particularly efficiently and with large deflections. The researchers stacked numerous such levers on edge in the chip. The levers form a virtual speaker membrane, however, not on the surface as before but into the volume of the chip. When the levers move in response to a voltage, they force the volume of air out of the chip via an outlet opening, thus generating the sounds. This idea was born from numerous discussions with the institute director of Fraunhofer IPMS, Prof. Harald Schenk as well.

In order to market the loudspeakers, Arioso Systems GmbH was founded in 2019 as a spin-off of the Fraunhofer IPMS and the research work at the Brandenburg University of Technology Cottbus-Senftenberg. Dr. Hermann Schenk also made significant contributions to this success, both in regard to technology and modeling, during his time at Fraunhofer IPMS and later as managing director of the spin-off. Arioso Systems GmbH was in turn acquired by Bosch Sensortec GmbH in the summer of 2022 — with the aim of developing cutting-edge products based on MEMS speaker technology for the global mass market.

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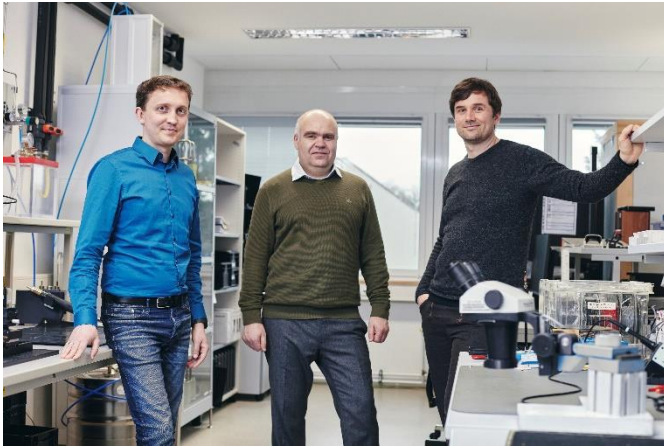
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**Joseph von Fraunhofer Prize**

Since 1978, the Fraunhofer-Gesellschaft has awarded annual prizes to its employees for outstanding scientific achievements that solve practical problems. This year, three prizes each worth 50,000 euros will be awarded to research groups from different institutes.

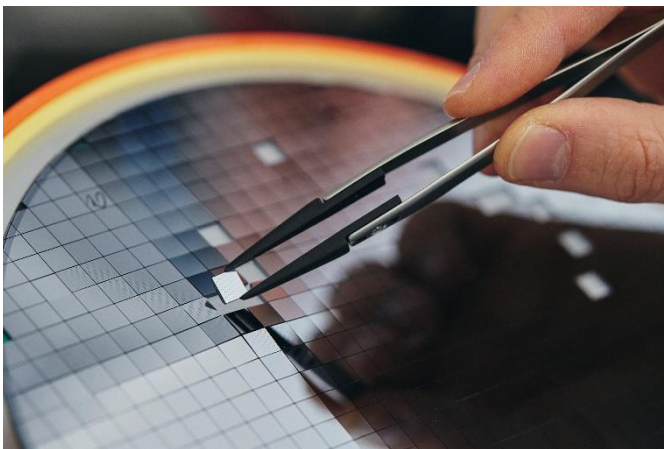


**Fig. 1** The research team: Dr. Bert Kaiser and Dr. Sergiu Langa from Fraunhofer IPMS and Holger Conrad from Bosch Sensortec GmbH (from left to right)

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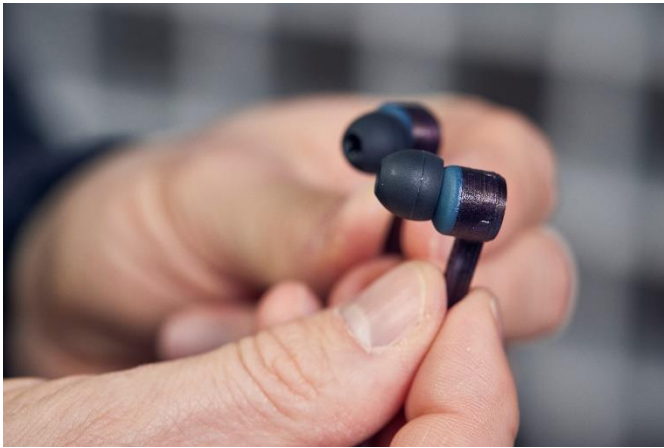
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**Fig. 2** In the innovative mini loudspeaker, the sound-displacing elements are located vertically inside a silicon chip.

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**Fig. 3** Intelligent in-ear headphones with direct Internet interface could replace smartphones in the future.

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