A novel energy-efficient actuator system for micro loudspeakers

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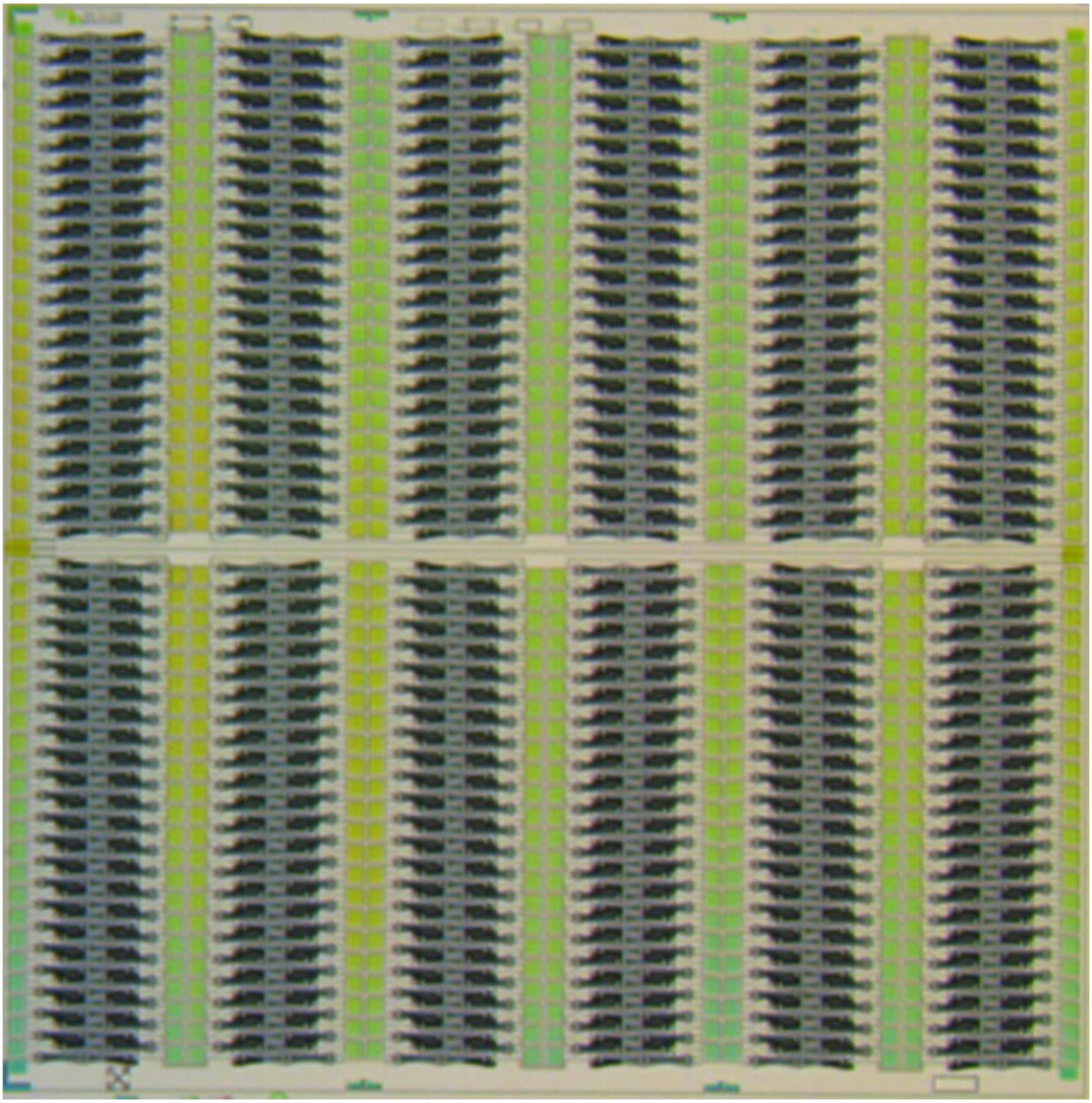


View of the speaker chips from above, showing the otherwise hidden arrangement of the actuators. Credit: Fraunhofer IPMS

We want modern technology to become smaller and more energy-efficient without losing quality. Technical innovation is required to achieve this. For several years, the Fraunhofer Institute for Photonic Microsystems IPMS has been researching a novel energy-efficient actuator system for micro loudspeakers.

The prototype now presented has surpassed expectations: High volume and excellent sound quality meet high energy efficiency in practical tests. The results are now presented in *Microsystems & Nanoengineering*.

The research team led by Dr. Bert Kaiser, Manager Business Unit Monolithically Integrated Actuator and Sensor Systems at Fraunhofer IPMS, has been conducting research for years on a unique actuator system for wireless micro loudspeakers. With an arrangement of three electrodes in a common movable configuration on a beam, the Fraunhofer Institute presented for the first time a symmetrical bending transducer that embodies the push-pull principle and operates at low voltages.

A first modeling approach was already presented in the journal *Microsystems and Nanoengineering* last year. The new paper now shows test results of the first prototype, which have confirmed the predictions from the theoretical approaches.

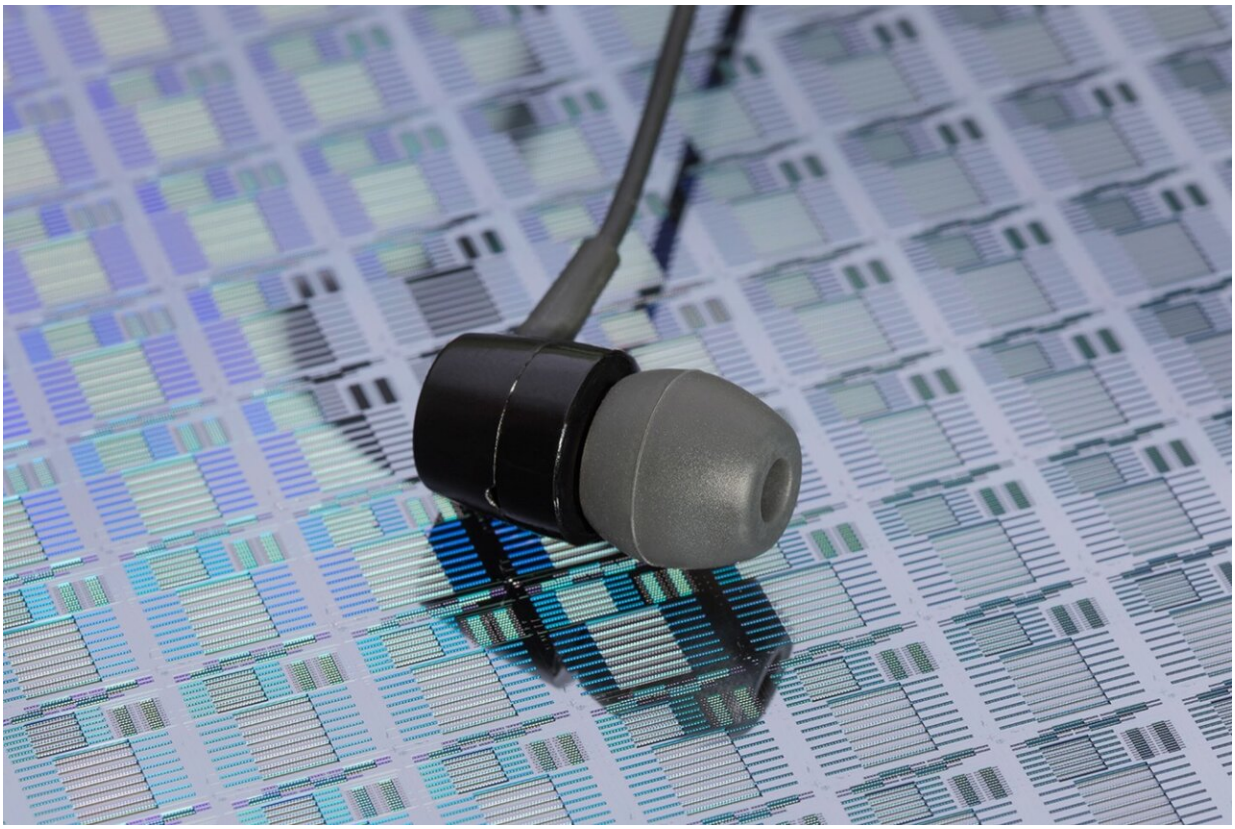
Bert Kaiser reports, "By implementing our novel push-pull actuators in a MEMS micro loudspeaker, we have in particular demonstrated the feasibility of a commercially highly attractive application." The first

balanced micro loudspeaker shows excellent audio reproduction over a wide frequency range of more than nine octaves (10 Hz to 6:3 kHz) with a distortion factor of less than 1.2 %.

"We therefore expect that this electrode configuration will stimulate the development of innovative electrostatic actuators for a wide range of applications. In this context, it is also important to mention that the silicon fabrication technology is compatible with the complementary metal-oxide semiconductor technology," Bert Kaiser added.

The Fraunhofer IPMS micro-speakers also promise great reductions in power consumption and peak current draw. "With the tiny batteries of modern in-ear devices (typically 60 mAh), most of the battery budget is reserved for smart features such as speech recognition and wireless connectivity," Kaiser explains.

This limits the power available to the audio playback system to a small, single-digit milliwatt number. "Micro loudspeakers have to beat this target to be competitive with classic electrodynamic or balanced-armature loudspeakers," says the business unit manager.



The innovative loudspeaker concept is based on the NED technology of Fraunhofer IPMS. Credit: Fraunhofer IPMS

The combination of a comparatively low signal voltage and low actuator capacitance present in Fraunhofer IPMS' micro-speakers allows the micro-speaker to be driven by small, highly efficient actuators connected to a small lithium-polymer or zinc-air battery. The speaker chips have a total electrical capacitance of much less than 1 nF. In comparison, capacitance values of over 20 nF or even 150 nF have been published for piezoelectric systems.

"Our further research on the system will also focus on technology development to reduce the minimum possible gap distances while increasing space utilization," concludes Bert Kaiser.

More information: Bert Kaiser et al, The push-pull principle: an electrostatic actuator concept for low distortion acoustic transducers, *Microsystems & Nanoengineering* (2022). DOI: 10.1038/s41378-022-00458-z

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