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"MEMS-ParAmps" project successfully completed

Wake-Up Receiver with Extended Range

Fraunhofer IPMS and Hamburg University of Technology have completed the "MEMS-ParAmps" project, funded by the German Research Foundation (DFG) and the Fraunhofer-Gesellschaft (FhG). The project focused on a new amplifier chip that increases the sensitivity of wireless sensors without increasing their power consumption.

The Fraunhofer Institute for Photonic Microsystems IPMS completed the collaborative project, "MEMS-Based Parametric Amplifiers for Range Optimization of Wireless Sensor Networks" (MEMS-ParAmps), with the Technical University of Hamburg (TUHH) and the Lusatia-based application partner, Actemium BEA. The project resulted in the development of a generic, energy-efficient platform for battery-powered monitoring applications that combines a wake-up receiver with a novel parametric MEMS amplifier. The project ran from October 1, 2021, to January 16, 2026.

Starting Point and Objectives

Wake-up receivers keep sensor nodes in a constant state of readiness to receive signals without activating the main electronic circuitry. They require very little energy to do so. However, their reception sensitivity is significantly limited, which restricts the achievable radio range. Therefore, the project consortium adopted the approach of connecting a parametric MEMS amplifier in series with the receiver. The team defined target values of up to ten years of battery life and a range of up to one kilometer in open space.

"Until now, you had to choose between long range and long battery life. With our new amplifier chip, though, it's possible to have both," explains Dr. Michael Stolz, project manager at Fraunhofer IPMS.

Technical Results

The project covered the entire development process, from system specification to the design and fabrication of a micromechanically tunable capacitor (MEMS varactor) and its associated drive circuit. A key focus was an energy-efficient voltage pulse generator that can excite the varactor mechanically with approximately 3.3 microjoules per pulse. This corresponds to a tiny fraction of the energy of an LED lamp. Since no commercial measurement systems met the requirements, the project partners also developed their own methodology for dynamic capacitance measurement with a bandwidth of over 10 megahertz to verify the functionality of the component.

Editor

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Protocol Adaptation and Validation

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To ensure that the technology also works in practice, the team adapted an existing wireless communication protocol for large distances between sensors. Together with industry partner Actemium BEA, the subsystems were tested in a simulated laboratory scenario. The central communication platform, consisting of a low-power microcontroller and radio transceiver, was also built and successfully tested. This demonstrated the basic feasibility of the approach at the theoretical and simulation level.

“Adapting the protocol to large distances between nodes was just as important as the hardware itself. Validation in the laboratory scenario showed that the concept can be transferred to the conditions of industrial applications,” says Prof. Dr. Alexander Kölpin, project manager at Hamburg University of Technology.

Application Potential and Integration in Lusatia

The developed MEMS components and circuit concepts have a variety of applications, including low-noise mixers, highly sensitive wake-up receivers, and self-powered sensor nodes. A demonstrator was presented at Sensor+Test in Nuremberg in 2022, 2023, and 2025, as well as at ICC2024 in Cottbus. In September 2024, the demonstrator was on display at the Science Gallery of the Cottbus Innovation Center (IKMZ). The technology is gaining a foothold in Lusatia, as evidenced by a bachelor's thesis submitted as part of the project at BTU Cottbus-Senftenberg.

With the conclusion of the project, the infrastructure for future developments is growing: Cottbus is establishing itself as an important Fraunhofer location. A groundbreaking ceremony on October 1, 2026, marked the start of construction of a new, state-of-the-art office and laboratory building north of BTU Cottbus-Senftenberg's central campus. The building is being developed as part of the structural transformation of the Lusatia region. It will house research groups from Fraunhofer IPMS's Institute Branch “Integrated Silicon Systems” (ISS), as well as other Fraunhofer institutes, Leibniz Association institutions, and the German Aerospace Center (DLR). Together with Brandenburg University of Technology Cottbus-Senftenberg, the new building will form a central component of the Lusatia Science Park, strengthening the region as a high-performance research and innovation hub.

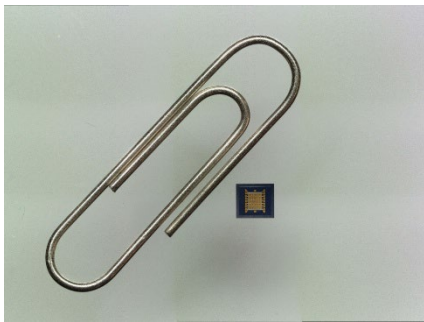
“With the new building, we are consolidating our expertise in Lusatia and creating laboratory environments that will allow us to further develop technologies such as those from MEMS-ParAmps together with regional partners,” says Dr. Sebastian Meyer, head of the Institute Branch ISS of Fraunhofer IPMS.

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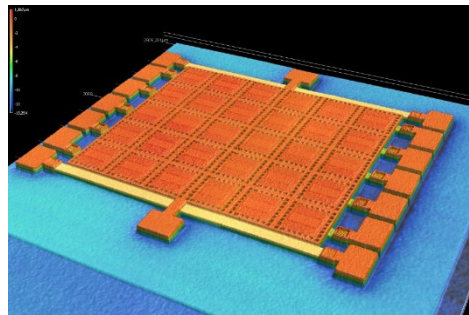
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About Fraunhofer IPMS

Fraunhofer IPMS is a world-renowned research and development service provider specializing in electronic and photonic microsystems. Our technologies are used in industries such as mobility, biotechnology, and medical technology. We are also addressing key future fields, such as quantum technologies and neuromorphic computing. Through our research in green microelectronics, we contribute to a sustainable and resource-efficient world.

Images

5 x 6 varactor array with a resonance frequency of 1 MHz on a 3 x 3 mm² silicon chip
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Laser scanning microscope image of a varactor array with individually addressable elements
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