Press Release

Semiconductor technologies for energy-efficient gallium nitride electronics

Gallium nitride plays a key role in greener electronics

A significant reduction in energy consumption and CO_2 emissions through modular and easy-to-integrate GaN power semiconductors – this is the objective of the EU-funded All2GaN project. Forty-five partners from twelve countries are collaborating to unlock the energy-saving potential of gallium nitride (GaN) semiconductors for a broad range of industrial applications. Fraunhofer IZM plays a key role across the value chain: leveraging its internationally recognized expertise in packaging technologies, the institute is developing innovative assembly solutions that are essential for the performance, miniaturization, and sustainability of next-generation GaN electronics.

Gallium nitride is regarded as one of the most promising semiconductor materials for future electronic systems. Compared to silicon, GaN enables higher power densities, lower switching losses, and higher operating frequencies – providing decisive advantages for applications in telecommunications, data centers, e-mobility, renewable energy, and smart grid technologies.

The components developed within the All2GaN project (“Affordable smart GaN IC solutions for greener applications”) are being evaluated in eleven industrial use-case demonstrators to systematically assess their efficiency potential. Across all use cases, the researchers expect to achieve an average reduction in power losses of around 30 percent. In addition, the project aims to establish an integration toolbox that will pave the way for a new generation of modular, easy-to-integrate GaN power semiconductors.

The development of suitable interconnection technologies for printed circuit boards is essential to fully exploit the advantages of gallium nitride in real-world applications. While other project partners are investigating conventional soldering approaches and sintering technologies, the scientists at Fraunhofer IZM are focusing on thermocompression – a process particularly well suited for fine-pitch applications with dimensions below 10 µm.

Nanoporous gold as a game-changer for fine structures and reliable interconnections

A central role is played by the nanoporous gold (NPG) developed at Fraunhofer IZM. It consists of a three-dimensional network of nanoscale gold ligaments created through the selective dissolution of silver from a gold-silver alloy. As the miniaturization of microelectronic systems continues to advance, NPG is increasingly attracting attention as a promising material for next-generation assembly technologies.

NPG is considered a highly promising alternative to conventional joining methods, opening up new possibilities for reliable assembly technologies. It enables solder-free interconnection for direct chip attachment on organic printed circuit boards and, thanks to its sponge-like structure, provides a significantly broader process window than traditional soldering approaches. Its unique deformation behavior allows for highly precise and dependable connections even within extremely confined spaces. At the same time, the porous structure efficiently compensates for relatively large topographical variations between the joining partners. Another major advantage lies in the material's exceptionally large specific surface area, which enables material-bonded interconnections at comparatively low temperatures. This considerably reduces thermal stress on sensitive components.

As a result, nanoporous gold is emerging as a forward-looking material for high-precision applications, particularly in areas where conventional soldering technologies are approaching their physical and technological limitations.

Greater efficiency and sustainability through innovative material and system approaches

In addition to technological innovation, sustainability is a central focus of the project. All2GaN forms part of the European strategy to support the objectives of the Green Deal by developing energy-efficient and resource-saving technologies.

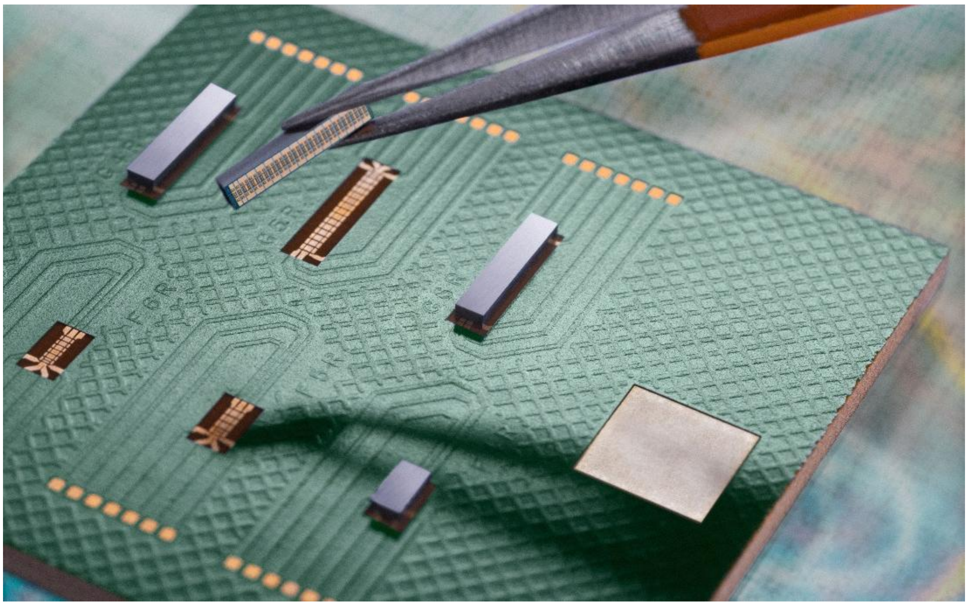
GaN-based circuits can make a direct contribution to reducing energy consumption by minimizing power losses. At the same time, advanced packaging approaches – such as the use of nanoporous gold – enable more material-efficient integration while also extending component lifetime.

The projected energy-saving potential is substantial: with the widespread adoption of GaN-based circuits, around 86 TWh of energy could be saved annually within the EU alone over the long term. This corresponds to approximately 43 megatons of CO_2 emissions per year. On a global scale, the savings potential could reach 218 megatons of CO_2 annually – roughly equivalent to the yearly emissions of a medium-sized industrialized nation such as Spain.

The All2GaN project runs from May 1, 2023, to October 30, 2026, and is funded with a total budget of €60 million under the Chips Joint Undertaking (Grant Agreement No. 101111890). This includes €4.81 million provided by the German Federal Ministry of Research, Technology and Space (BMFTR) and €40,000 from the Free State of Thuringia.

Project partners

Infineon Technologies Austria AG, Fronius International GmbH, Kompetenzzentrum für Automobil- und Industrieelektronik, Silicon Austria Labs GmbH, Graz University of Technology, Technische Universität Wien, IMEC, MindCet, Thermo Fisher Scientific, Brno University of Technology, Aalborg University, Blue World Technologies ApS, AIXTRON SE, CE-LAB GmbH, Chemnitzer Werkstoffmechanik, Fraunhofer Gesellschaft zur Förderung der angewandten Forschung, Heraeus Electronics GmbH & Co. KG, Infineon Technologies AG, IMS Chips, IMST GmbH, NanoWired GmbH, NaMLab gGmbH, Technical University Chemnitz (TUC), Foundation for Research and Technology-Hellas (IESL-FORTH), Applied Micro Electronics "AME" B.V., Nexperia BV, Signify, Delft University of Technology, Eindhoven University of Technology, Delta Electronics (Norway) AS, NanoDesign, ltd., Slovak University of Technology in Bratislava, 4fores – For Optimal Renewable Energy Systems S.L., IKERLAN, Mondragon Goi Eskola Politeknikoa, PREMIUM, Universidad Politécnica de Madrid, Alixlabs, Chalmers University of Technology, Ericsson Research, RISE Research Institutes of Sweden AB, SweGaN AB, Attolight AG, Corintis SA, Ecole Polytechnique Fédérale de Lausanne



The researchers tested various interconnection pitches to evaluate the reliability of NPG for different chip sizes and contact pad geometries of the GaN chips © Fraunhofer IZM/Volker Mai

The **Fraunhofer-Gesellschaft**, headquartered in Germany, is one of the world’s leading organizations for applied research. Founded in 1949, the Fraunhofer-Gesellschaft currently operates 75 institutes and research units throughout Germany. Its nearly 32,000 employees, predominantly scientists and engineers, work with an annual business volume of 3.6 billion euros; 3.1 billion euros of this stems from contract research.

The **Fraunhofer Institute for Reliability and Microintegration IZM** is one of the world's premier research institutions for electronics packaging. With its dedication to developing miniaturized, high-reliability electronics in cutting-edge lab facilities, the institute works to maintain the competitive edge of Germany and Europe.

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