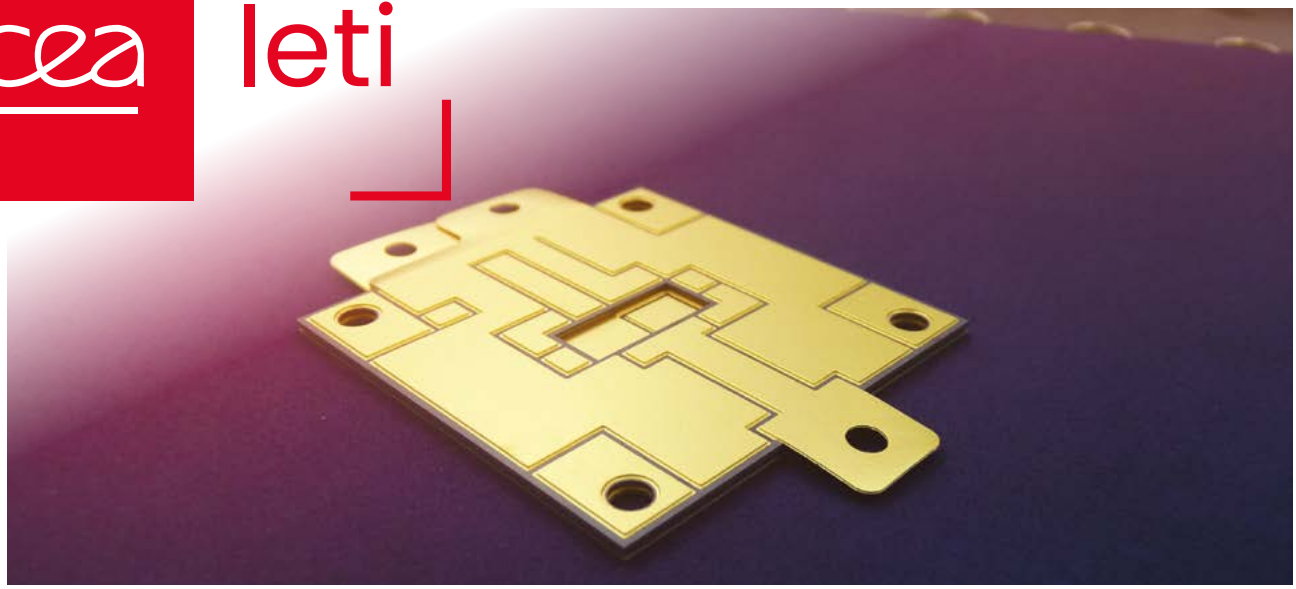


3D integration for power modules

3D integration and enhanced electrical performances for power systems

What is it?

Today's advanced power modules are intended to unleash the full potential of wide-band gap semiconductor like GaN or SiC devices. They are designed to reduce and/or balance parasitic inductances and capacitances, and improve heat transfer, while optimizing both cost and reliability. This is achieved in various ways including size reduction, 3D integration, new joint materials and double side cooling.

The benefits of 3D & advanced technologies for power modules are multiple:

- Higher switching speed and switching frequency
- Higher efficiency
- Greater reliability
- Reduction of overall size and weight allowing a better system integration and lower cost
- Operation under harsh conditions

Applications

3D and advanced technologies support energy transition across a wide range of applications:

- **Mobility**: automotive, transportation (train, drones, etc.), airborne systems and space
- **Energy conversion**: wind turbine, PV, storage
- **Robotic & IT**: UPS and data center, unmanned aerial vehicles, USB-C PD, exoskeletons for industrial applications

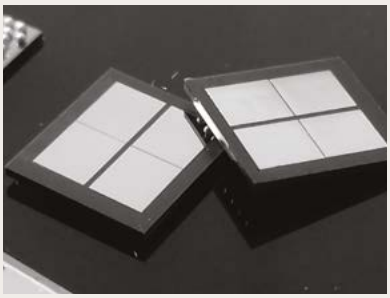
Work performed in the frame of the IRT Nanoelec consortium.

Main Publications

- EPE 2019: Integrated GaN ICs, development and performance
- CIPS 2018: Towards Wafer Level 3D Power Integration
- ESTC2016: Design of a GaN HEMT based Inverter Leg Power Module for Aeronautic Applications

What's new?

CEA-Leti's developments extend from low-volume wafer production in clean rooms to complete module design, assembly and testing. Dies can be processed to receive the appropriate pad finishing (Cu, NiAu, SAC, etc.) in our 10 000 m² R&D clean room facility. Different technologies are offered ranging from Fan-Out Wafer Level Packaging (FO-WLP) to ceramic substrates.



Power DMOS, 3D stack on CMOS driver
System in Package (SiP) embedding 4 power dies flip-chipped in a H-bridge configuration for low voltage automotive application. Transistors are located right on the gate driver to optimize switching operation and reduce size. *Work funded by EPPL Eniac project.*

3D GaN module, double side cooling
System in package embedding both active and passive devices between two ceramic substrates by silver sintering for high voltage automotive application. The current loop's 3D form enables this architecture to provide double-side cooling and lower power loop inductance (3 nH for half bridge).
These outcomes highlight the superior performances achieved by using WBG devices in conjunction with advanced packaging.
Technology developped on aPSI3D packaging concept.

What's next?

We are currently working on:

- Compatibility of GaN devices with embedded organic packaging
- 3D ceramic packages
- Silver-sintering process
- Wafer-level high voltage passivation and pad finishing (thick copper, bump, etc.)
- FO-WLP power

Interested in this technology?

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