182W L band GaN high power module with 66% power added efficiency based on European technologies

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Abstract

This paper deals with the design, manufacture and test of a high efficiency power amplifier for L-band space borne applications. The circuit operates with a single 36 mm gate periphery GaN HEMT power die allowing both improved integration and performance as compared with standard HPA design in a similar RF power range. A huge effort, dedicated to the packaging environment as well as the device's characterization and modeling, has eased the circuit optimization. Test results demonstrate performance up to 182 W RF output power with an associated 66% PAE under 50 V supply voltage using a single GaN power bar.

INTRODUCTION

Most of the budget constraints driving the design of space borne microwave equipments focus on the power amplifier stage : DC power consumption, thermal management, mass and volume. Although demonstrating very large RF power capability, the TWTA solution [1][2][3] suffers from needing large volume and heaviness in the L/S frequency band. In contrast, the SSPA approach offers advantages of better integration and cost efficiency. In this context, the advent of Wide Band Gap technology, providing transistors with ten times higher power density compared to Gallium Arsenide devices, makes this second option increasingly meaningful [4][5]. Yet this breakthrough comes with new challenges such as the component reliability and proper thermal management in a harsh environment. The optimization of the package environment enables mitigation of the thermal stress hence reliability challenge. This paper demonstrates the essential steps towards the successful test of a breadboard paving the way for future space borne power equipments.

DEMONSTRATOR DEVELOPMENT

Leaning on the 0.5µm GaN HEMT technology from the UMS European foundry, a L band high power amplifier demonstrator, aiming at answering the needs for future navigation systems, has been designed using a single 36mm gate width power bar, then manufactured with either the standard Copper Tungsten package or the alternative AGAPAC solution.

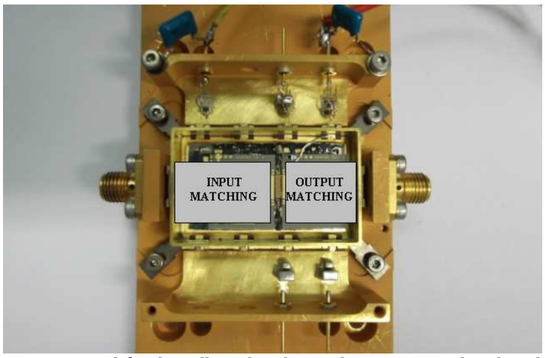

Fig.1 Power amplifier breadboard with novel AGAPAC L-band package

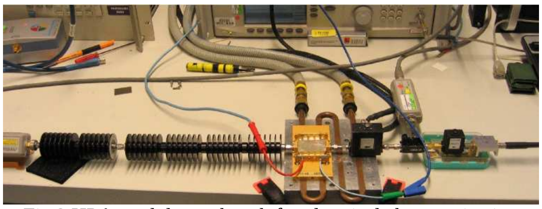
Fig.2 HPA module test bench for electrical characterization

Given the transistor's gate periphery, a dedicated characterization and modelling approach has been proposed so as to conveniently fit both electrical and thermal behaviours of the active device when submitted to high RF power drive.

The amplifier modules test results have confirmed the simulation accuracy and demonstrated the positive impact of the AGAPAC AgCD package versus the standard CuW based solution : 13.2 dB RF gain versus 11.9 dB, reduced 3.3 dB gain compression versus 4.1 dB, 182 W output power versus 138 W, and up to 66.4 % power added efficiency versus 57.9 % have been obtained under continuous wave 1.28 GHz operation.

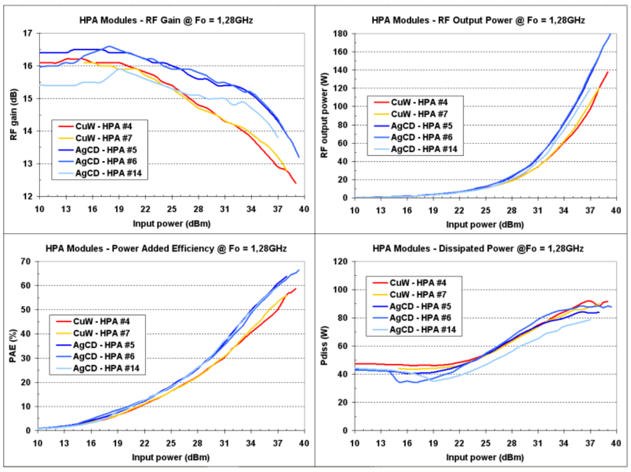

Fig.3 CW mode large signal performance versus package configuration @ F_0 = 1.28 GHz

The benefit brought by the novel solution with regard to the junction temperature management has also been proven with an estimated reduction up to 30 degrees, leaning on the device's thermal modelling. The trend has been confirmed through a preliminary test using a dedicated thermal camera.

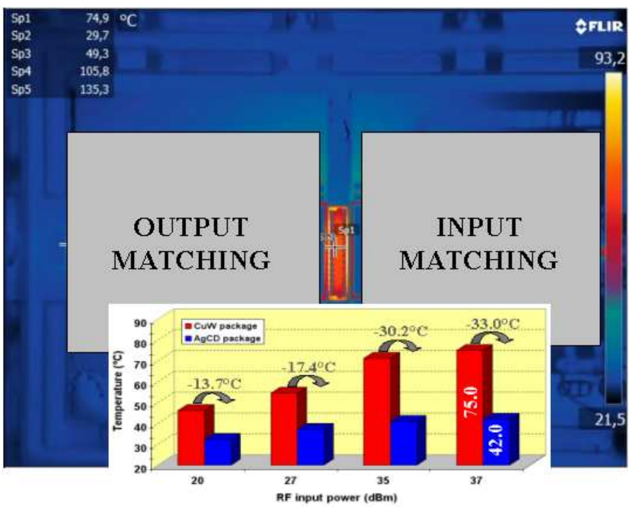

Fig.4 Thermal management performance assessment

CONCLUSIONS

A fully European supply chain has been developed in the frame of AGAPAC project to provide with a space compatible solution for very high power applications at L-band, including the use of very promising wide band gap technology with ten times higher power density capability, with regard to conventional III-V devices, and the design of a customized package. This last is able to cope with much higher constraints in terms of multipactor phenomena and thermal management linked to the power dissipation ability. This solution allows very large GaN components to operate at 5W/mm power density and much improved reliability conditions.

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ACRONYMS

AGAPAC: Advanced GaN Packaging
GaN: Gallium Nitride
HEMT: High Electron Mobility Transistor
HPA: High Power Amplifier
PAE: Power Added Efficiency
SSPA: Solid State Power Amplifier