D7.6 : Final Report
Publishable summary

Written by	***Responsibility*** + handwritten signature if no electronic workflow tool
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ISSUE	DATE	§ CHANGE RECORDS	AUTHOR
V1.0	02/05/12	Document creation	O. Vendier

TABLE OF CONTENTS

1. PUBLISHABLE SUMMARY OF PROJECT RESULTS

1.1 Reminding project objectives

Reducing size and, in parallel, increasing power capabilities of electronic devices in a spacecraft is of immense importance for the overall performance of any satellite. As the power density increases, it is of critical importance to have packaging technologies available, which can transport the generated heat to the surrounding environment and keep the temperature of the device within its specified limits.
For power packages, it is compulsory to provide at the same time minimized thermal resistance and high protection to all devices and circuits with respect to contaminations, mechanical aggressions, radiations and electromagnetic perturbations.

Gallium Nitride (GaN) technology has recently made a remarkable breakthrough in the world of microwave electronics with the announcement of commercially available transistors from 5W to over 200W at microwave frequencies. Originating from a major industrial transistor vendor in Japan but also from Europe and the US, equipment manufacturers and especially those related to space applications strongly believe that time has now come for a rapid insertion of GaN electronics into their systems.

Apart from the reliability concerns that still need to be addressed specifically for space use, these GaN power transistors will roughly increase power density by more than an order of magnitude for large devices compared to present solutions (from 0.5 W/mm to 5 W/mm for space applications including de-ratings). Consequences will directly impact packaging technology for which the thermal resistance needs to be significantly reduced if the advantages obtained at die level are to be maintained at its highest at the module and equipment level.

The Project AGAPAC, which stands for “Advanced GAN PACkaging”, aims to address this critical challenge for space satellite applications. This item is identified on the ESA roadmap [Ref: ESTEC/AC/418-20, ESA-IPC 2006] for GaN component strategy but is not funded by ESA.

AGAPAC core objective is to establish a space compatible European supply chain for packaging solutions of GaN HEMTs and GaN MMICs to cover the need for GaN-based High Power Amplifiers (HPA) for space applications.

More precisely, the AGAPAC project technical objectives are to :

- extend beyond state-of-the-art for high thermal dissipation composites (up to 600 W/mK) using materials based on diamond solutions as well as on carbon nano-fibres, compatible with hybrid micropackage manufacturing technologies;
- develop a space compatible power hybrid able to withstand up to 150 W of RF power in L band, with minimal junction temperature elevation. Note that power modules used in space commercial flights have a maximum RF power of 40 W in L band.

AGAPAC has also brought together actors and industry from material science (in Spain and Austria), thermal and mechanical analyses (UK and France), with the packaging industry (France), and GaN device manufacturing (Germany) around the needs of major space actors in Europe.

1.2 Description of the work

To realize this project's objectives, the partners have defined sub-objectives that directly relate to 7 workpackages targeting:

- WP1 Requirements and GaN components
- WP2 Thermal and thermo-mechanical simulation and characterization
- WP3 High conductivity material development
- WP4 Package development
- WP5 HPA module assessment
- WP6 Use and dissemination
- WP7 Management

1.3 Main project achievements

AGAPAC is an important project for Europe: the Market for GaN transistors is expected to have a strong growth, with main turnover in 3G base station, satcom and military. This project targets packaging for space applications to enable Europe to maintain a strong position in the highly competitive space industry. Up to 25 high power amplifier packages have been produced by Egide according to TAS design. These packages have been found hermetic according to space standards.

State of the art results have been obtained for L band high power amplifier, putting forward the strong impact of base plate material to be used into RF power modules . Up to 65% power added efficiency with up to 180 W RF power in L band has been obtained with no tunning on several power module using diamond silver base plate material The gain in power added efficiency is about 10 points for same design implemented into CuW standard micropackage.

Tremendous thermal advantage obtained representative high power amplifier implemented onto commercial CuW, Cu/Mo/Cu macro composite and AGAPAC diamond silver produced by Plansee have confirmed the excellent electrical results obtained.

Selection of high thermal conductivity material with other european source than Plansee has been performed with technological and thermal evaluation of the selected material.

2 packages have been proposed and implemented with 2 material base plate coping with Plansee discontinuation of production and patented RF F/T from TAS (AGAPAC FUTURE packages).

In addition to initial project objectives and thanks to ESA support, multipactor test have been implemented with representative test structure supplied by Egide. It shows that RF feedthrough has been tested until 450 W without multipactor discharge.

Preliminary technology assessment of the AGAPAC micropackages have been performed according to TAS standards. No failures could be reported with HPA module mounted into representative SSPA structure after 500 thermal cycles (-55, 125°) showing the robustness of the AGAPAC micropackage vs space environment.

Innovative non destructive testing means such as 3D Xray tomography has been used and have been proven to be useful to determine voids into high power amplifier module.

Lately, the dissemination is being at the level of high quality results obtained by the consortium as AGAPAC will be again present at the main event in the field in Europe (European Microwave Conference in Amsterdam, Oct 2012) and in North America (International microwave symposium in Montreal Canada, June 2012) with many other reported in past years in relevant conferences.

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