

X-Band Power Amplifier Modules for Space Applications based on AlGaIn/GaN HEMTs

R. Behtash^{1*}, A. Liero¹, R. Lossy¹, R. Zahn², K. Hirche², J. Würfl¹ and G. Tränkle¹

¹*Ferdinand-Braun-Institut für Höchstfrequenztechnik, Gustav-Kirchhoff-Str. 4, 12489 Berlin, Germany*

²*Tesat-Spacecom GmbH, Gerberstrasse 49, 71522 Backnang, Germany*

Solid-state power amplifiers (SSPAs) are a key component in communications systems. GaAs-transistors in current SSPAs at X-band are expected to be replaced by GaN-based devices, since at a given size GaN-transistors like AlGaIn/GaN-HEMTs can reach considerably higher RF output power levels than GaAs-based devices thanks to their high breakdown-voltage and good thermal conductivity.

In this paper we describe the fabrication and characterization of packaged X-band power amplifier modules on the basis of AlGaIn/GaN-HEMTs. The housing of the devices has been accomplished by using a hermetically sealed package from Kyocera which would be qualified for space applications. Modules with three different transistor sizes have been realized. The largest one consists of two parallel 12x125 μm devices. The gates of the two devices have been connected using an on-wafer resistor whereby the stability of the amplifier has been guaranteed. Additionally on-wafer pre-matching of the devices has been applied in order to simplify the matching of the devices during the measurements. Biased at $V_{\text{DS}}=28$ V the packaged 2x12x125 μm amplifier delivers 10 W saturated output power at 8GHz under continuous wave conditions. The maximum power added efficiency is 35% with a linear gain of 12 dB and 11 dB gain at P_{sat} . The other two amplifier modules consist of a 4x125 μm and of a 12x125 μm device respectively. At 8 GHz and biased at $V_{\text{DS}}= 20\text{V}$ a maximum output power of 1.7 W is measured for the module with the 4x125 μm device along with a maximum power added efficiency of 35 %. The gain is 13 dB in the linear region and 8 dB in saturation. The 12x125 μm module delivers 4.4 W maximum output power with 35 % maximum power added efficiency, again at 8 GHz and $V_{\text{DS}}=20$ V. The amplifier has 12.4 dB linear gain which decreases down to 8.5 dB in saturation.

The transistors in the described modules have been fabricated using AlGaIn/GaN HEMT-structures grown on semi-insulating 2" SiC substrates. Ti/Al/Ti/Au/WSiN has been used for the ohmic contact metallization resulting in a contact resistance of 0.4 Ωmm . MESA-etching was accomplished using a $\text{BCl}_3/\text{Cl}_2/\text{Ar}$ -RIE-process. The electron-beam gates consist of Pt/Ti/Au with a gate length of 0.3 μm . NiCr was sputtered in order to realize on-wafer resistors. Realized 2x125 μm devices have a saturation current of 1.2 A/mm with a maximum transconductance of 211 mS/mm. On-wafer load-pull measurements of the 12x125 μm devices biased at $V_{\text{DS}}= 26\text{V}$ result in 6.3 W maximum output power with 45% power added efficiency at 8 GHz.

In conclusion, power amplifier modules in hermetically sealed packages have been realized. Output powers up to 10 W have been measured under continuous wave conditions showing the great potential of GaN-based transistors as SSPA for space applications.

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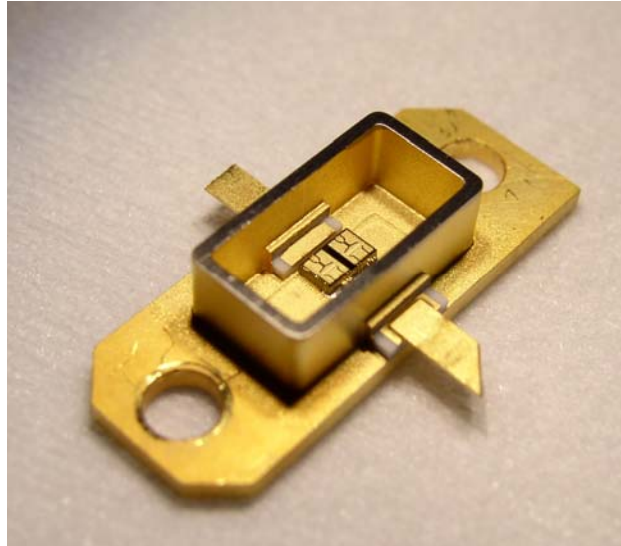


Fig. 1 Picture of the package containing two parallel $12 \times 125 \mu\text{m}$ devices. The package can be hermetically sealed.

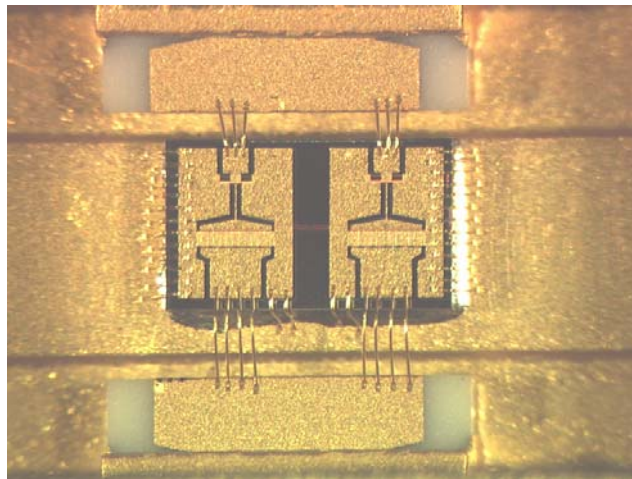


Fig. 2 Picture of the two $12 \times 125 \mu\text{m}$ transistors in the housing. The gates of the two devices are connected with an on-wafer resistor in order to guarantee the stability of the amplifier.

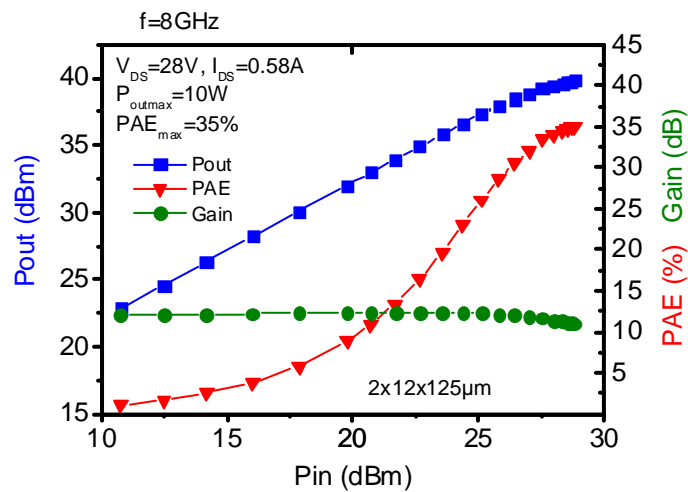


Figure 3 Measured power performance of the packaged $2 \times 12 \times 125 \mu\text{m}$ amplifier at 8 GHz. Biased at 28 V the amplifier delivers 10 W output power with an associated power added efficiency of 35 % under continuous wave conditions. The gain is 12 dB in linear region and 11 dB in saturation.