SERENA H2020 PROJECT: Workshop #2: GaN-on-Si for mm-wave applications

The SERENA project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 779305.

Rémy Leblanc

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SERENA

gan-on-Silicon Efficient mm-wave euRopean systEm iNtegration plAtform

SERENA WEBINAR

WITH SPEAKERS FROM:

SAVE THE DATE!

SIGN UP NOW!

Heterogeneous Integration for High Performance mmWave Electronics

28.10.2021, 3-4pm

This workshop will cover requirements and design aspects of the system and its semiconductor components with an emphasis on mmWave heterogeneous integration. Using results from SERENA the system aspects, as well as the RF and thermal design of components and packages will be illustrated base on an em-bedding packaging technology.

UWE MAAß (FRAUNHOFER)

KRISTOFFER ANDERSSON (EAB)

FRANZ DIELACHER (IFAT)

SIGN UP NOW!

GaN-on-Si for mm-wave applications

04.11.2021, 3-4pm

This workshop will cover GaN-on-Si processes and design tools for mm-wave applications as well as GaN-on-Si substrates for RF and mm-wave applications. Another focus will be on 60 nm GaN-on-Si based mm-wave amplifiers for RF sensing and wireless communication.

RÉMY LEBLANC (OMMIC)

MARIANNE GERMAIN (SOITEC)

ROBERT MALMQVIST (FOI)

SIGN UP NOW!

Multi-physical modelling for active antenna transmitter systems

11.11.2021, 3-4pm

During this seminar, speakers from TU Berlin and Chalmers University of Technology, will discuss how thermal, electric, and electromagnetic hardware effects will influence the performance of millimeter wave communication transmitters and communication systems. Both theoretical and experimental studies will be included to illustrate typical applications of the methods discussed.

CHRISTIAN FAGER (CHALMERS)

THOMAS KUEHNE (TUB)

Webinar Outline, workshop #2

Welcome and introduction	Rémy Leblanc	OMMIC	5 min
GaN-on-Si process and design tools for mm-wave front ends	Rémy Leblanc	OMMIC	15 min
GaN-on-Si substrates for RF and mm-wave applications	Marianne Germain	SOITEC	15 min
60 nm GaN-on-Si based mm-wave amplifiers for RF sensing and wireless communication	Robert Malmqvist	FOI	15 min
Q&A and wrap-up			10 min

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SERENA

GaN-on-Si process for mm-wave front-ends

Rémy Leblanc

OMMIC

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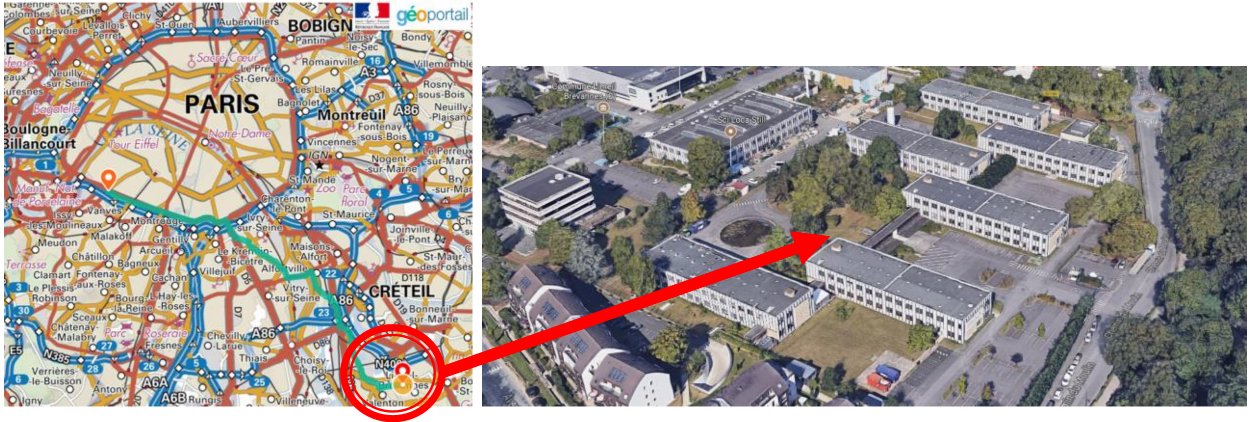
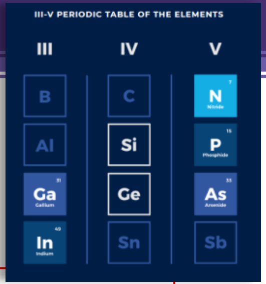
OMMIC
innovating with III-V'S

ESCC
European Space Components Coordination
ISO 9001:2000 SGS
ISO 14001 SGS

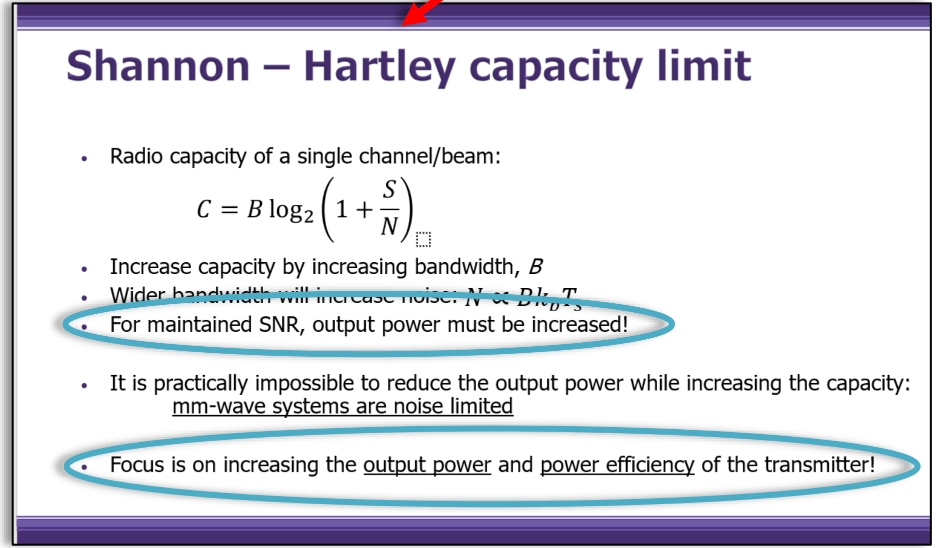


- Created in 2000, III-V activities started in 1970
- Former Philips Semiconductor division
- Over 50 years of experience in III-V semiconductors, including GaAs and InP
- Unique GaN Process best suited for upcoming 5G
- Only foundry in Europe offering complete service including Epitaxial Growth, Process Development, MMIC Design & Fabrication, Test & Product Qualification

Why GaN ?



Workshop #1 slide of last week (K.Andersson, Ericsson)



Shannon – Hartley capacity limit

- Radio capacity of a single channel/beam:

$$C = B\log_2\left(1+\frac{S}{N}\right)$$

- Increase capacity by increasing bandwidth, B
- Wider bandwidth will increase noise: $N \propto Bk_B T_s$
- For maintained SNR, output power must be increased!
- It is practically impossible to reduce the output power while increasing the capacity: mm-wave systems are noise limited
- Focus is on increasing the output power and power efficiency of the transmitter!

Above "some" GHz, III-V processes are required to reach the power.

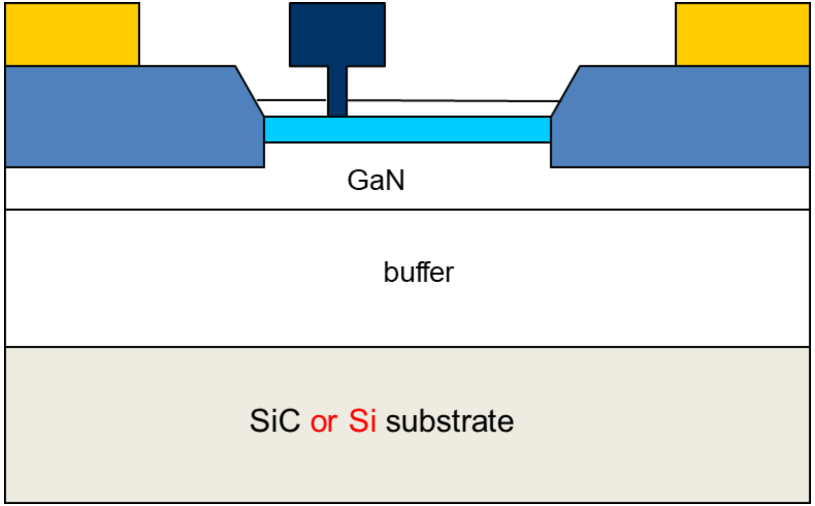
Conventional P-HEMT processes could be used, but GaN allows…

- higher power density
  => smaller MMIC size
- higher Power Added Efficiency
  => better thermal management

Anyhow, the commercial offer for microwave GaN is limited

Why GaN-on-Si ?

Most suppliers provide GaN-on-SiC



"on-Si" Pros…

- Lower cost, larger diameters, compatible with 5G
- Lower risk of import/export restrictions
- Compatible with heterogeneous integration

"on-Si" Cons…

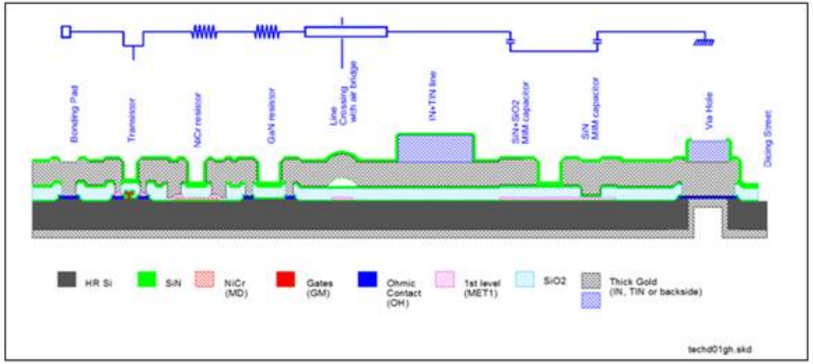
- Higher Rth (≈ x2), but limited impact for medium power at mm-wave
- Higher microwave losses, but limited impact, as epi is good (0.3dB/mm @30GHz)

OMMIC D01GH/D006GH GaN-on-Si

Electrical Characteristic	100 nm	60 nm
Frequency Cut-off (H21)	105 GHz	130 GHz
Maximum Stable Gain @30 GHz	13 dB	13.5 dB
Min Noise Figure @35 GHz	1.5 dB / 8 dB	1.1 dB / 10 dB *
RF Power Density	3.3 W/mm (5.7 W/mm meas. peak)	3.3 W/mm
Extrinsic Transconductance	800 mS/mm	950 mS/mm
Source Resistance	0.18 Ohms.mm	0.18 Ohms.mm
Extrinsic Drain Source resistance Vds=0V (Ron)	0.6 Ohms.mm	0.6 Ohms.mm
Gate Drain voltage for 300µA/mm	>40 V	>40V
Quiescent Voltage	12 V	12V

…has all the performances and features of a conventional MMIC PHEMT process (Gain, Noise, Ft)

… plus power !



*W. Ciccognani, EuMw 2019

OMMIC D01GH/D006GH GaN-on-Si

Short gate length

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Min Noise Figure @35 GHz	1.5 dB / 8 dB	1.1 dB / 10 dB *
RF Power Density	3.3 W/mm (5.7 W/mm meas. peak)	3.3 W/mm
Extrinsic Transconductance		[illegible]50 mS/mm
Source Resistance	0.18 Ohms.mm	0.18 Ohms.mm
Extrinsic Drain Source resistance Vds=0V (Ron)	0.6 Ohms.mm	0.6 Ohms.mm
Gate Drain voltage for 300µA/mm	>40 V	>40V
Quiescent Voltage	12 V	12V

Regrown Ohmic contacts

…has all the performances and features of a conventional MMIC PHEMT process (Gain, Noise, Ft)

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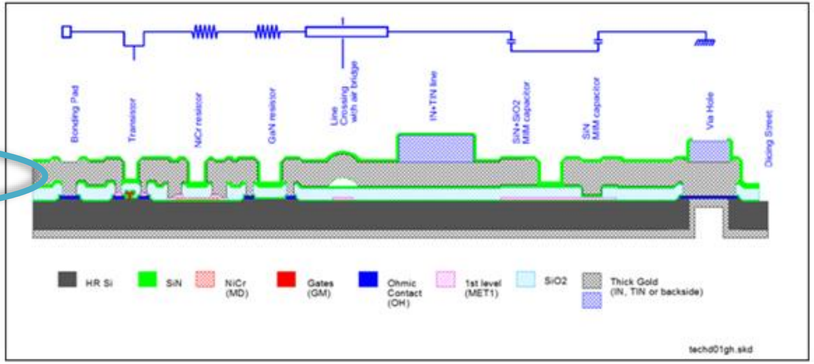
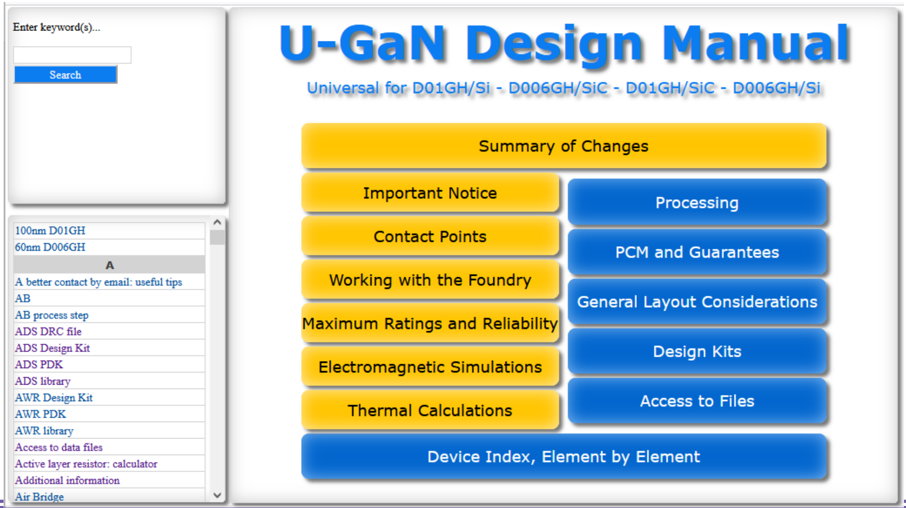


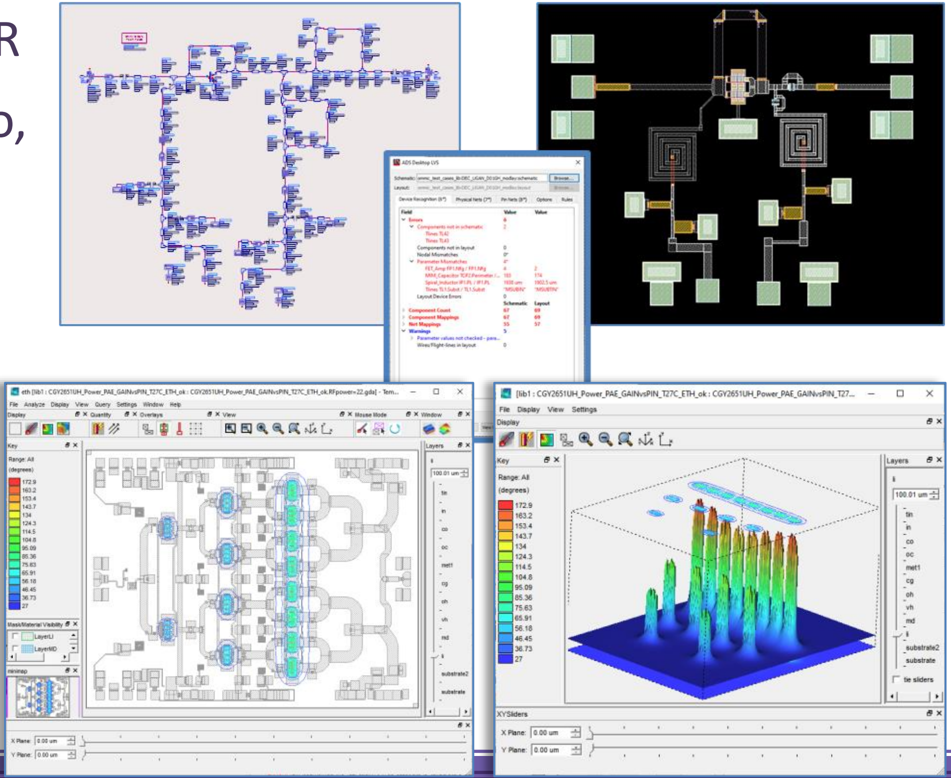
*W. Ciccognani, EuMw 2019

OMMIC D01GH/D006GH GaN-on-Si

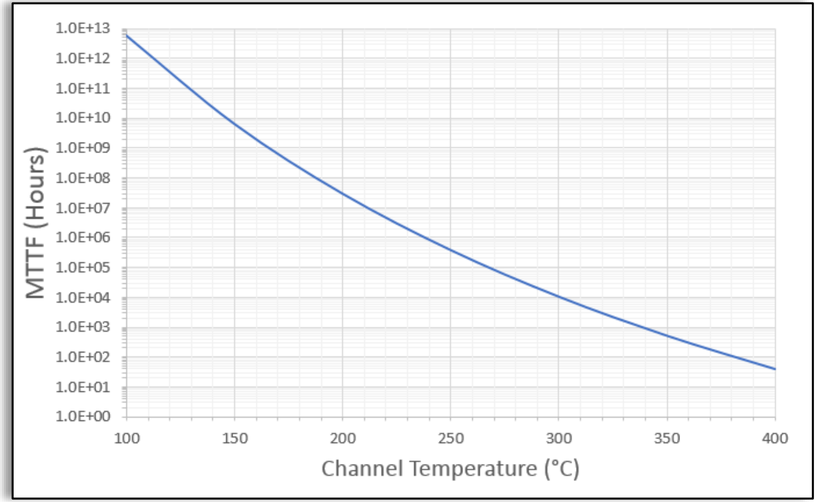
Design Tools for Keysight & Cadence AWR

- Microwaves, Non-Linear, Monte-Carlo, Electro-thermal, LVS, DRC



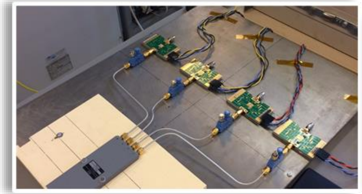


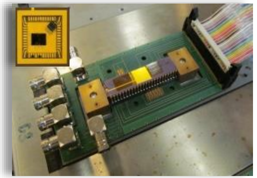
OMMIC D01GH/D006GH GaN-on-Si



- Reliability assessment successfully completed through Thales/DGA contract in 2019

- Running Space evaluation through H2020 MiGaNSOS programme (TAS, UTV, VTT, OMMIC)



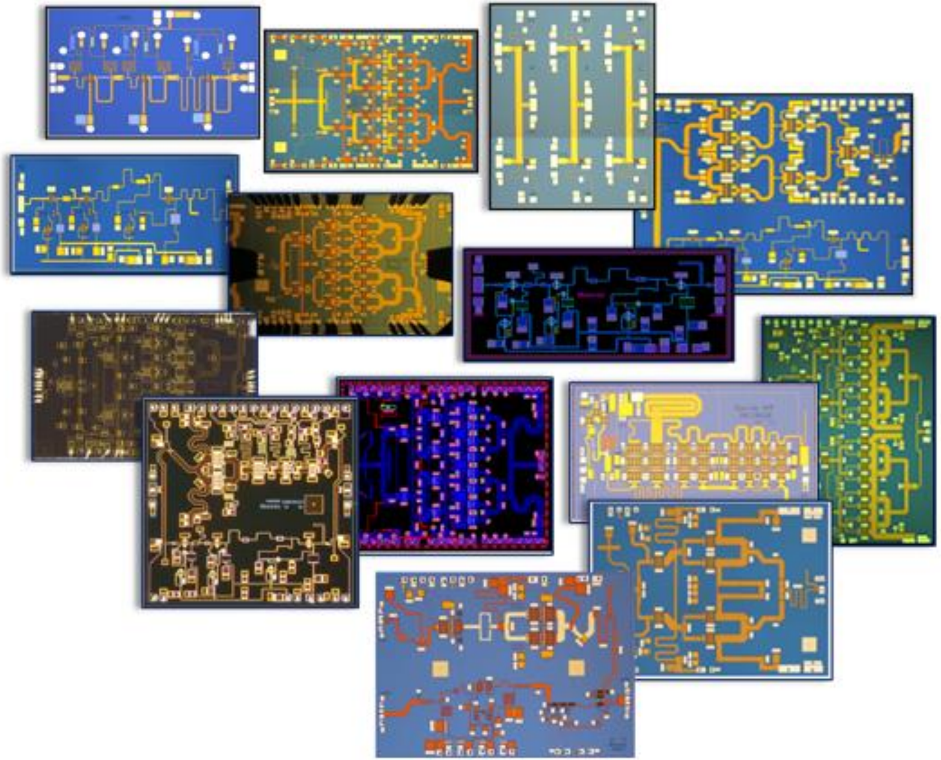


The MIGANSOS project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 779305

OMMIC D01GH/D006GH GaN-on-Si

Examples of MMICs, not only PAs but also LNAs and multi-function chips

X Band GaN LNA : 1.2 dB NF
Ka Band 10W PA, 35% PAE
Ka band switches, 1.5dB loss
Ka band TR chip, 2.8dB NF, 3W (incl switch)
20-34 GHz LNA, 1.5dB NF@30 GHz
40 dBm, 30% PAE, 40GHz PA
37 dBm, 15% PAE, 48 GHz PA
36-41 GHz LNA, 2dB NF@39GHz
15-18 GHz 50W PA
2-18 GHz 10W PA
27-31 GHz 14W 30% PAE PA
39 GHz TR chip (SCFE)
6-18 GHz 10W PA
5-18 GHz TR chip (SCFE)



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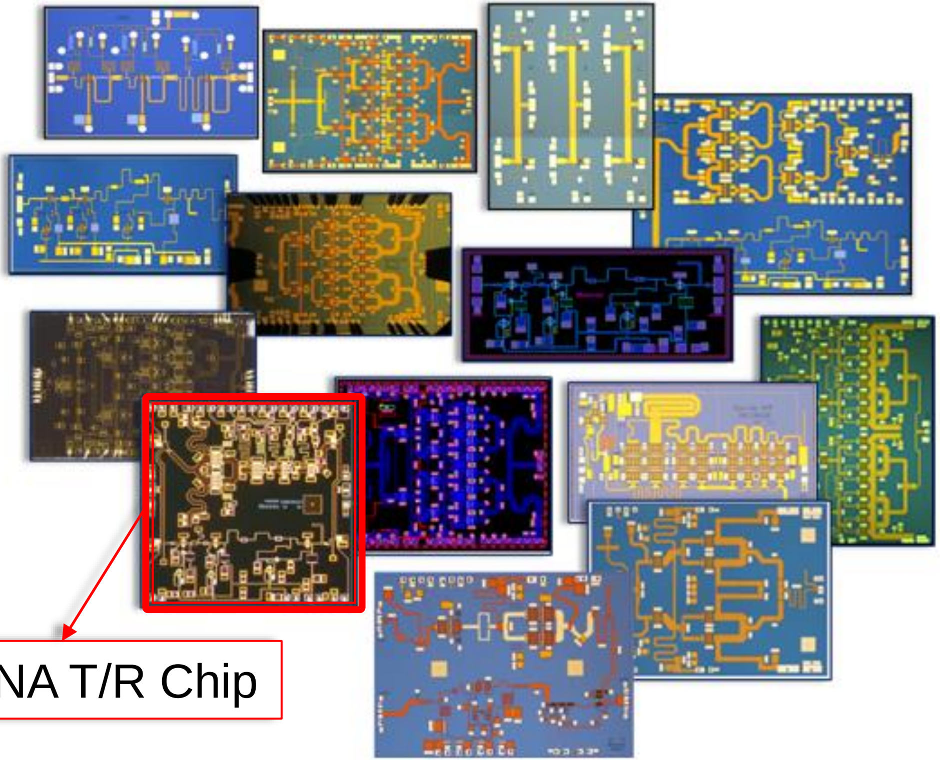
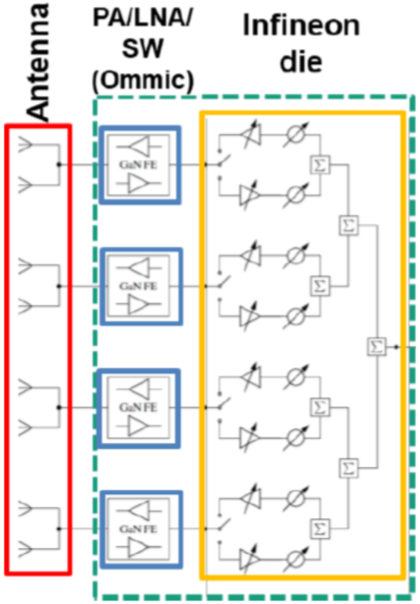
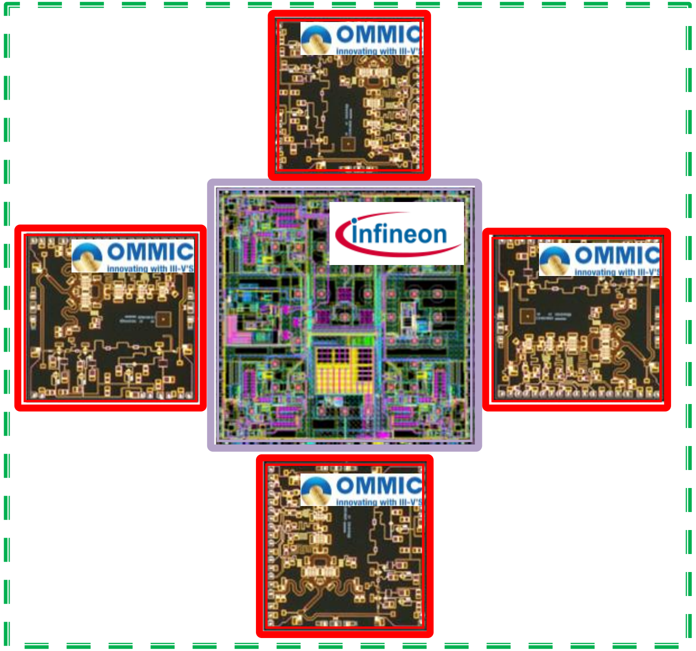
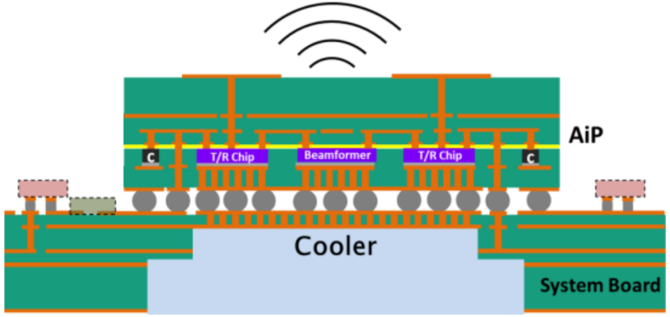
40 dBm, 30% PAE, 40GHz PA
37 dBm, 15% PAE, 48 GHz PA
36-41 GHz LNA, 2dB NF@39GHz
15-18 GHz 50W PA
2-18 GHz 10W PA
27-31 GHz 14W 30% PAE PA
39 GHz TR chip (SCFE)
6-18 GHz 10W PA
5-18 GHz TR chip (SCFE)



39GHz T/R chip for SERENA

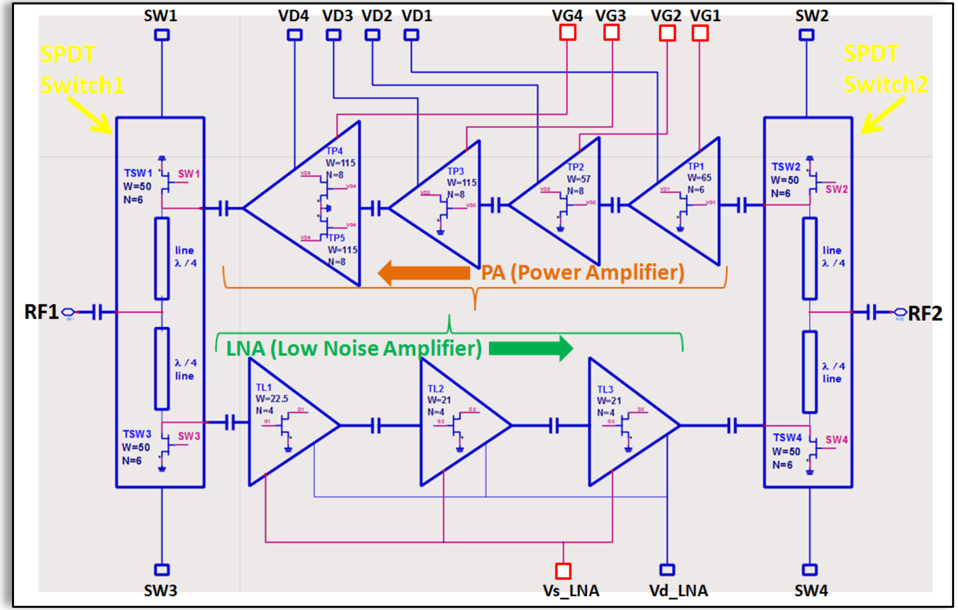


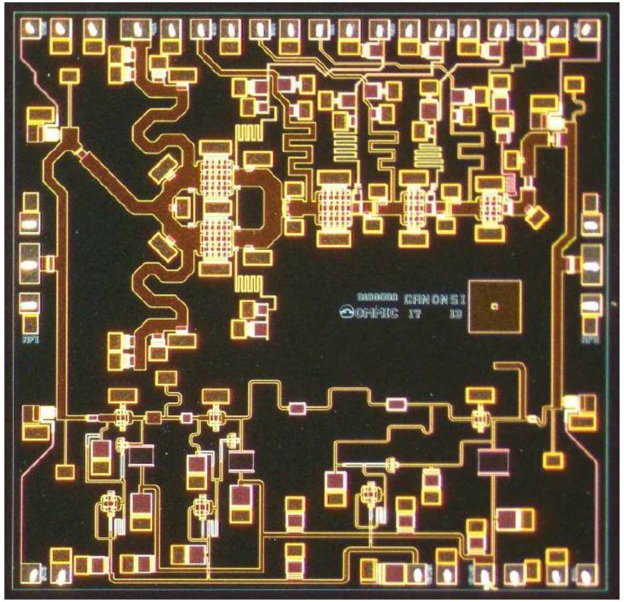




European Patent Nr. EP3346548B1; US20180191062A1

39GHz T/R chip for SERENA

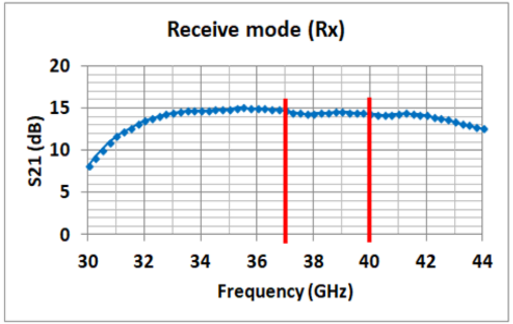


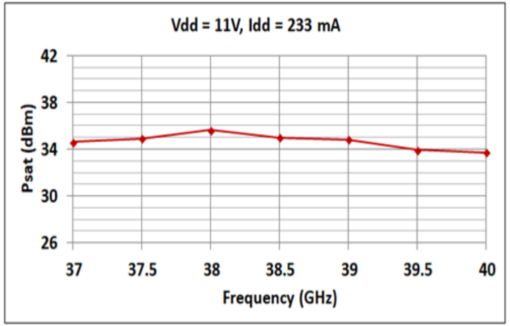


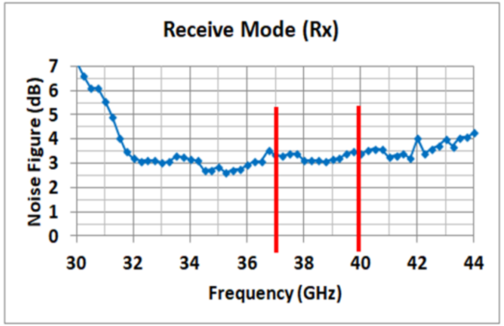
39GHz T/R chip for SERENA

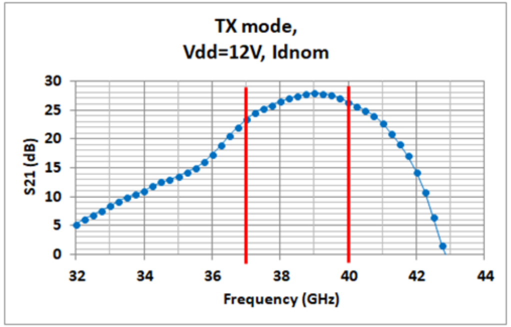
Summary of test results@39GHz
<u>including input and output switches</u> :

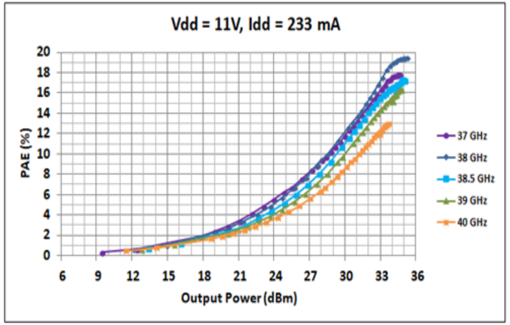
- Rx: 14dB Gain, 3dB NF
- Tx: 28dB Gain, 35dBm Pout, 16% PAE











Summary

- GaN-on-Si is the path for a cost effective solution to increase the transmitter mm-wave output power
- GaN-on-Si is compatible with heterogeneous integration
- GaN-on-Si is compatible with European sourcing
- Short gate length (100nm, 60nm) and regrown ohmic contacts gives the required performance margin for 5G 28 & 39 GHz and E/W band backhaul

SERENA Grant Agreement No. 779305

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If you need further information, please contact the coordinator:

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Webinar Outline, workshop #2

Welcome and introduction	Rémy Leblanc	OMMIC	5 min
GaN-on-Si process and design tools for mm-wave front ends	Rémy Leblanc	OMMIC	15 min
GaN-on-Si substrates for RF and mm-wave applications	Marianne Germain	SOITEC	15 min
60 nm GaN-on-Si based mm-wave amplifiers for RF sensing and wireless communication	Robert Malmqvist	FOI	15 min
Q&A and wrap-up			10 min