






UMS Foundry Service

March 2022

United Monolithic Semiconductors

UMS Foundry Service Presentation Plan

- UMS at a Glance
- UMS Foundry Service Highlights
- UMS Process Design Rule Manuals and Design Kits
- UMS Foundry Service Know-How
- UMS Foundry Service Offering
- UMS Foundry Service Goal

UMS at a Glance

- Since 1996, European III-V foundry with robust shareholders
- Leading RF/mm-wave solutions supplier
- Proprietary GaAs and GaN technologies qualified for space

- Manufacturing in Europe
- Sales offices in Europe, the USA & Singapore
- World-class engineering expertise in:
  - Modelling
  - GaN/GaAs processing
  - Packaging
  - MMIC design
  - Back-end operations
  - Foundry service

UMS foundry service highlights

Value Proposition

UMS Foundry Service Facts and Figures

Addressed Markets

UMS Process Commitment

Value Proposition

End-to-end GaN & GaAs foundry expertise as a service

UMS, the RF & mm-wave specialist with foundry service, committed to customer success

- Open Access to:
  - Leading-edge GaN & GaAs technologies qualified for space
    → **Reliability and high performance**
  - Widely scalable and highly accurate models
    → **Design safety and fast time-to-market**
  - Extensive back-end capabilities
    → **A la carte services on wafers or products**
  - Industrial low-cost packaging services
    → **Competitive scalability**
- One-stop offering:
  - Dedicated support from design to tested and packaged products
  - European manufacturing for small to large volumes

UMS, Your long-term Partner

UMS Differentiators

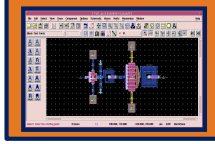
- Sole non pure-play fully open foundry
- Extensive back-end capabilities, with DC/RF On-Wafer Test & Space qualification
- Flexibility
- Expertise in all disciplines involved in foundry service projects
- Complete PDK functionalities
- Electrical models accuracy
- MMIC design know-how
- Broad range of GaN/GaAs industrial processes
- Unique offer of specific processes (MESFET, Schottky, GaAs passive)
- Processes qualified for Space
- Eagerness to adapt UMS foundry service offer to customer needs

UMS Foundry Service Facts and Figures

Manufacturing based in Europe

Industrial Processes Qualified for Space

Experienced Models/CAD/Support Engineers



> 80 Recurrent Customers

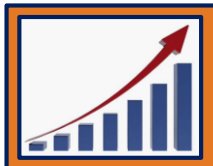
GaAs since 1996

GaN-on-SiC since 2014

> 90% Export Sales

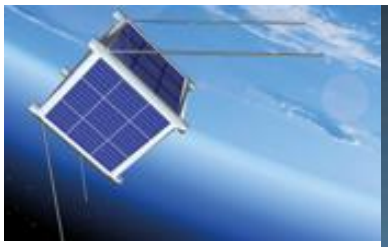
>70 new projects launched in 2021

>1,800 Wafers Shipped in 2021



30% of 2021 UMS business

Addressed Markets



Space

Telecom
Earth observation
Navigation
Scientific
Constellations

Defense

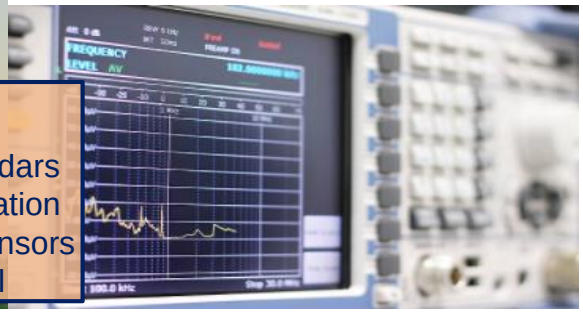
Communications
Radars
Electronic Warfare

SatCom / VSAT

5G

Telecom

5G BTS & FWA
Point-to-Point Radiolinks



ISM

Weather radars
Instrumentation
Industrial sensors
Medical

UMS Process Commitment

In foundry service mode,

UMS core commitment is that the processed wafers comply with UMS nominal Wafer Acceptance Rules

➔ *UMS guarantees a robust and reproducible process*

Wafer Acceptance Rules

- Details are in the Design Manual
- Measurement of UMS proprietary DC/RF circuits, called Process Control Monitors (PCM)
- One PCM cell placed on each wafer tile
- Wafers are deemed operational when related PCM results are compliant
- PCM results are shipped along with deliverables

UMS Process Design Rule Manuals and Design Kits

Process Design Manual

Process Design Kits (PDK)

Electrical Models Accuracy

Complete PDK Functionalities

Thermal Models Validation

Customer testimonials

UMS Process Design Manuals

Design Manual

1. MMIC Foundry
2. Process Description
3. Wafer Acceptance
4. Maximum Ratings
5. Electrical Models
6. Layout Rules
7. Tile building

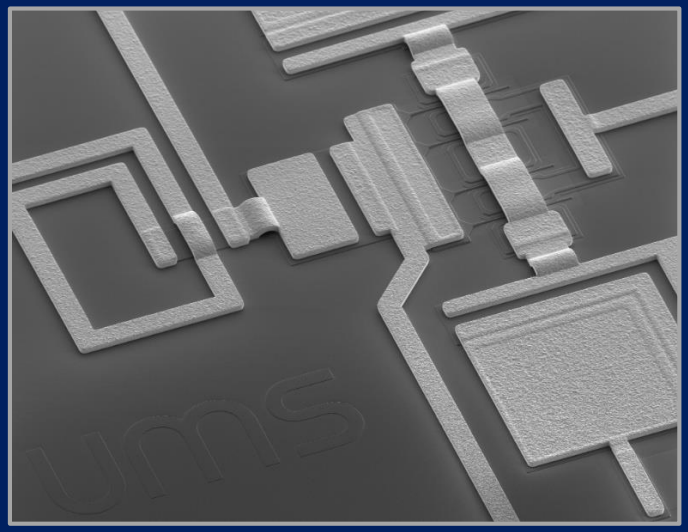
Author : _____
Approver : _____
Releaser : _____

Process Design Kits

Widely **scalable** and highly **accurate** electrical models

➔ *The right mix for a **first pass success***

- UMS-developed electrical models
- Extensive active device options
  - Linear, non-linear & noise FETs
  - Parallel & series switches
  - Schottky diodes & varactors
- All passive devices
- Spread analysis
- Supported CAD software

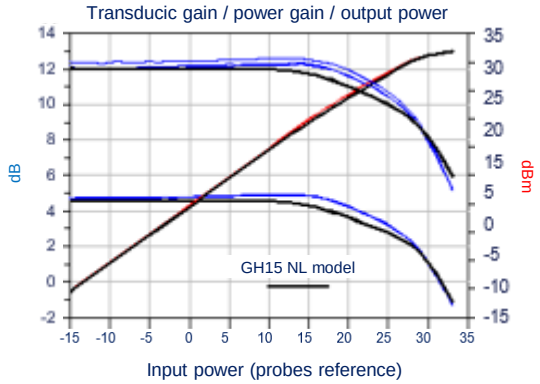


PATHWAVE Advanced Design System From Keysight & AWR From Cadence

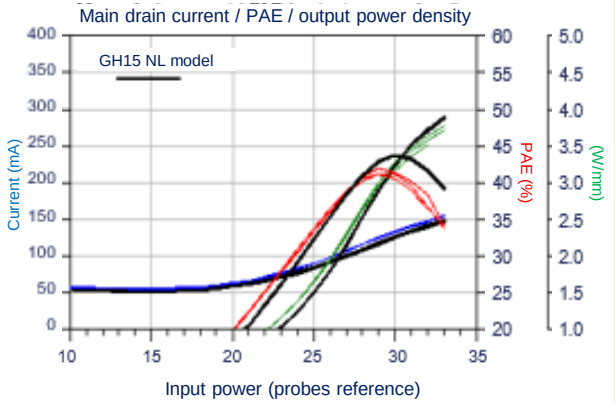
Electrical Models Accuracy

Best in class electrical **model accuracy**

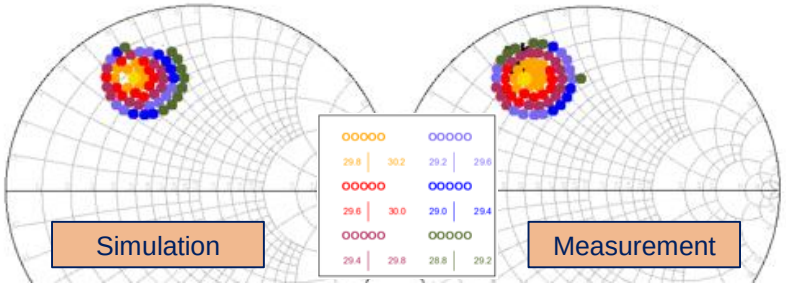
➔ *Excellent match between **simulation** and **MMIC performance***



30GHz, 8x50µm, 20V, 150mA/mm



GH15 HFET
model validation

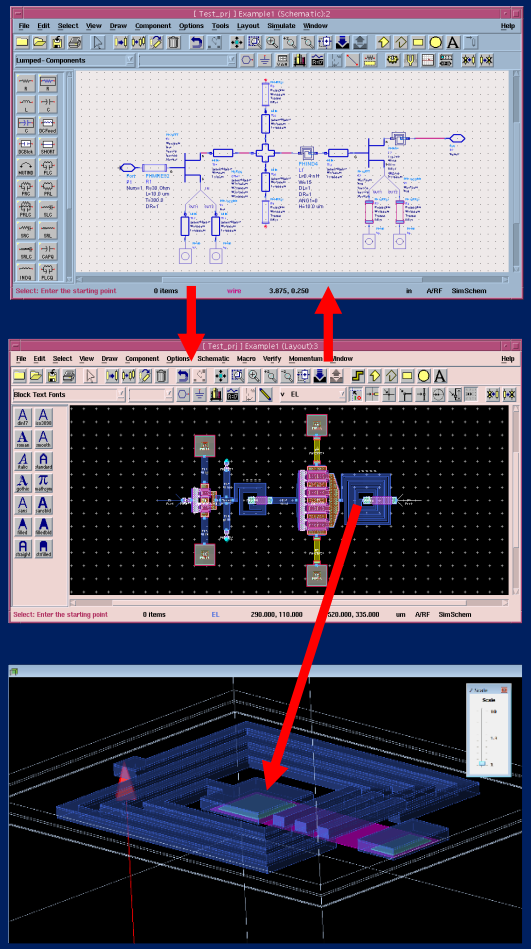


30GHz, 8x50µm, 20V, 150mA/mm

Complete PDK Functionalities

Complete libraries & functionalities

➔ *Full MMIC **design enablement***



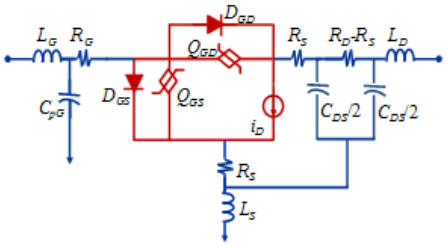
- Schematic and layout library
- Stack definition for E/M simulations
- Design Rule Check capability
- Scalable models

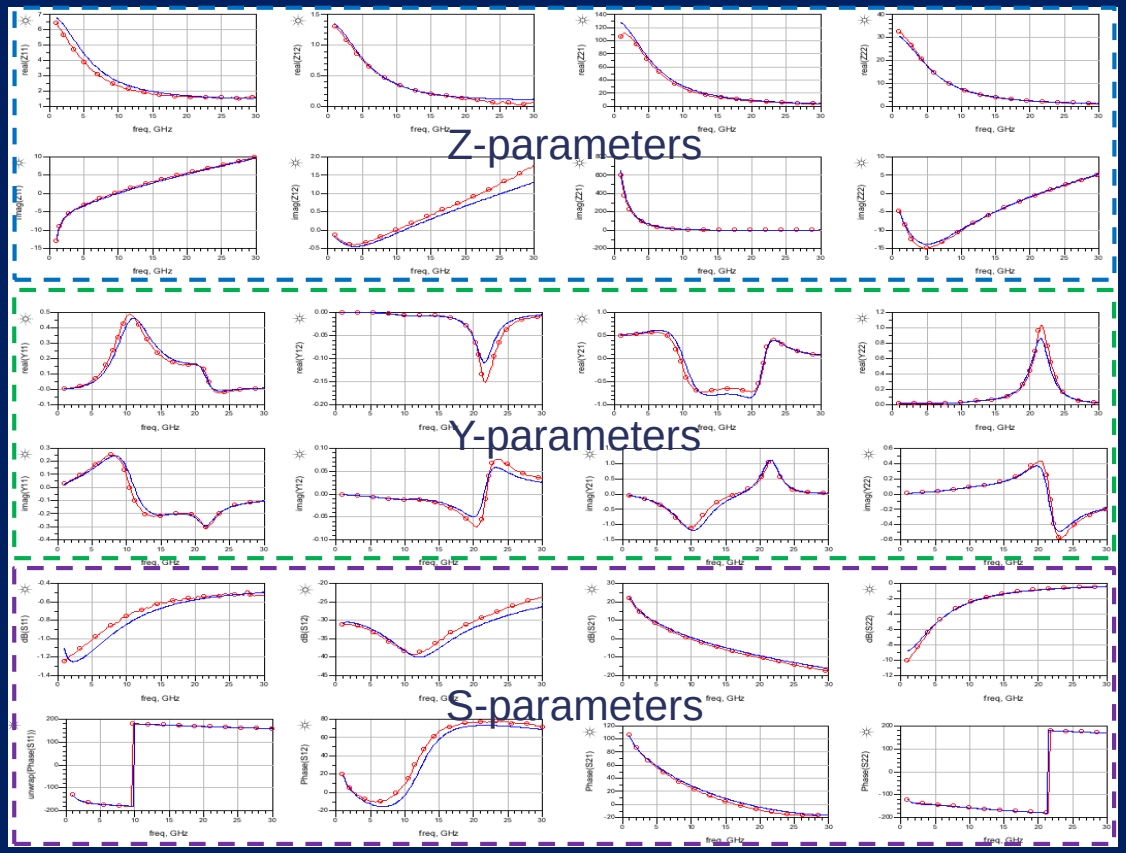
- Latest upgrades
  - ERC implementation (max. rating verification)
  - ADS Thermal tool support (ETH on GH25)

Process Design Kits

Best in class electrical & physical **model accuracy**

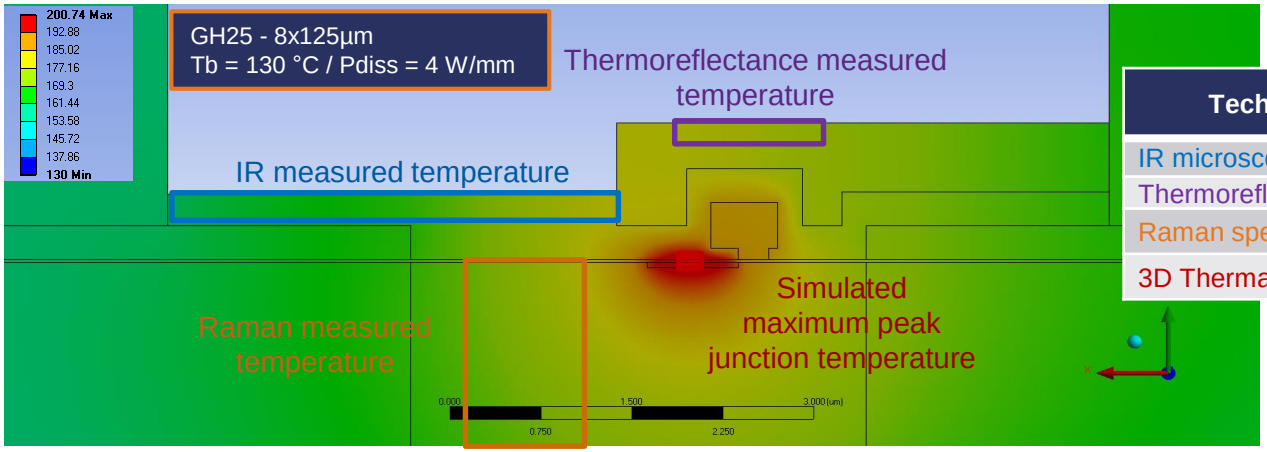
➔ *Excellent match between **simulation** and **MMIC performance***





Thermal model validation

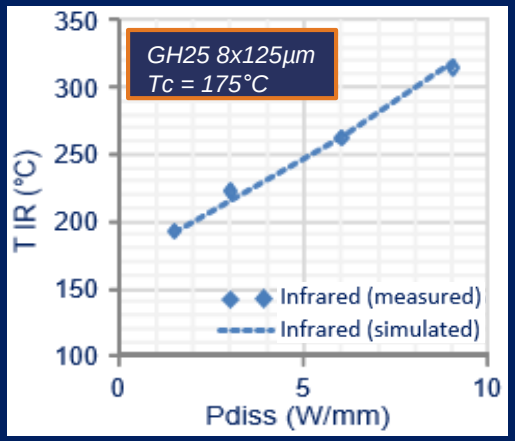
Impact of the temperature measurement technique on the calculated Rth



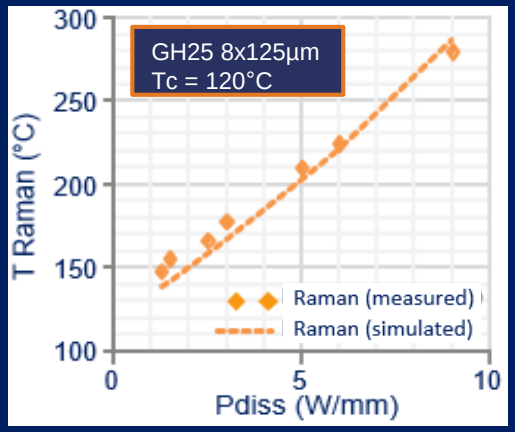
Technique	T (°C)	Rth (°C/W)
IR microscopy	170	10
Thermoreflectance	174	11
Raman spectroscopy	180	12.5
3D Thermal simulation	200	17.5

+70 %

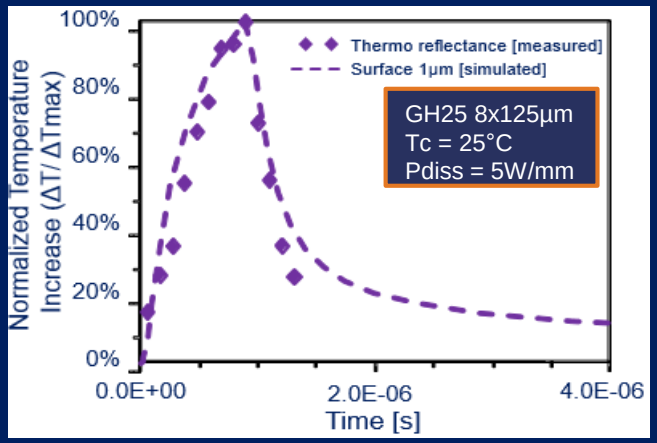
Infrared



Raman spectroscopy



Thermoreflectance



➔ Thermal conductivity of materials validated

➔ Heating dynamic validated

Testimonials

«Reliable models. We were please to find an excellent agreement between simulations and measurement results.

Professional Test Jig design and qualification test services. Very pleased by the quality of service.»

Head of RF & Microwave Hardware Development

Rheinmetall Italia S.p.A.

«We used the UMS GH25 technology to deliver a 40W transmit/receive MMIC for a European Space project.

We observed good agreement between measured results and the foundry models.»

Senior Engineer

Viper RF

«We experienced several designs based on GH25 GaN process with nice measured results.

Good 'simulation/measurement' agreements are obtained thanks to the electrical modeling accuracy and the useful help and guidelines given by UMS»

Head of MMIC Design Team

Thales Alenia Space - France

«The UMS PDK for GH25 facilitated a first pass success of a 10W K-band HPA. Correlations between measured and simulated results were excellent for both small and large signal conditions.»

Senior MMIC designer

Arralis

«GH25 PDK comes with a comprehensive set of reliable active and passive models for the design of state-of-the-art broadband Pas.

UMS foundry service supports the designer throughout post-layouting phase, from DRC analysis to process yield optimization.»

Microwave engineer

Elettronica S.p.A.

«Thanks to the high-performance GH25 process and its very accurate and complete in-house models with a user-friendly interface, all the targeted performances of our X and wideband HPAs have been achieved with only one run.»

Components team

Thales DMS

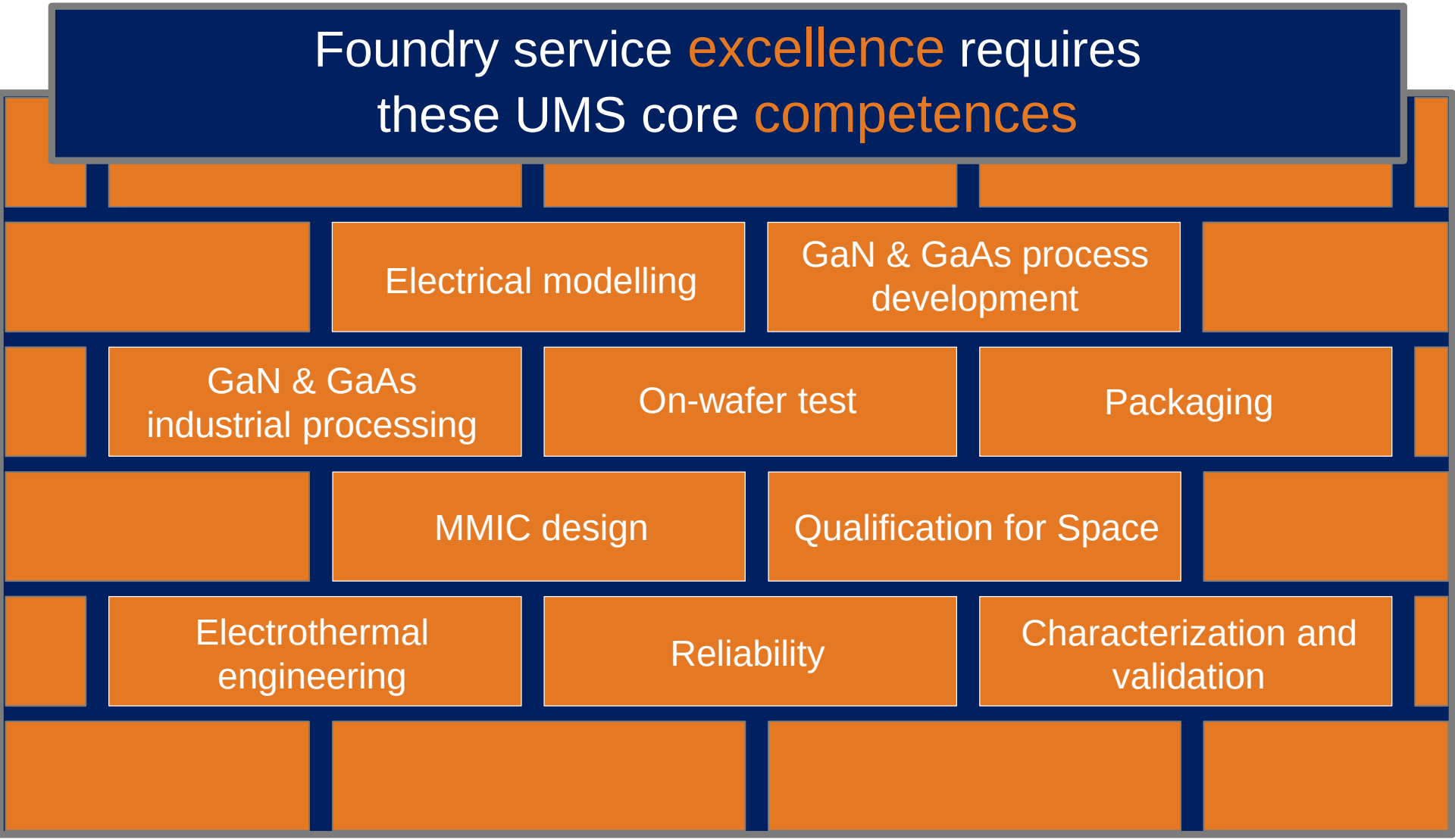
UMS Foundry Service Know-How

UMS Foundry Service Domains of Expertise

Front-End Capabilities and Services

Back-End Services and Capabilities

UMS Foundry Service Domains of Expertise



UMS Front-End Capabilities and Services

Lithography, Wet Chemistry, Metallization and Implantation

Plasma, Electrical Test and Inspection, In line Metrology

Process Integration Expertise

Lithography, Wet Chemistry, Metallization and Implantation

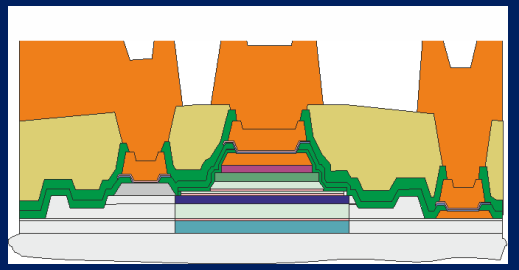
- Lithography
  - i-line using steppers and mask aligners
  - eBeam using 25/50/100keV acceleration voltage
- Wet Chemistry
  - Gold Electroplating Processes
  - Cu/Zn electroplating in preparation
  - Patterning by lift-off and etching processes
  - Grinding and polishing of GaAs and SiC
- Metallization and Implantation
  - Evaporation and sputtering processes for metals
  - High Energy/Medium Current ion implanters (30keV-400kev)
  - TRIM Simulations
  - Rapid-Thermal-Annealing processes

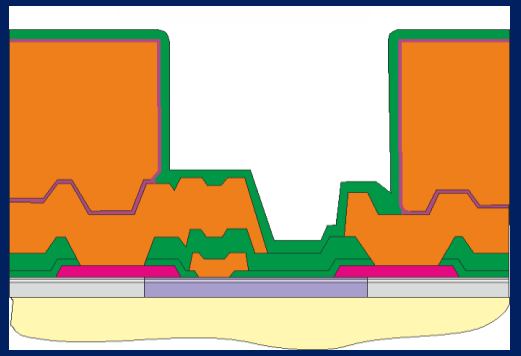
Plasma, Electrical Test and Inspection, In line Metrology

- Plasma
  - ICP-etching processes dielectrics and semiconductor materials
  - PECVD and ALD deposition processes for dielectrics
- Electrical Test and Inspection
  - DC- and RF measurements up to 40GHz
  - Load-Pull and Power measurements 8-12 GHz
  - Wafer Level Reliability
  - Sub-micron and macro automatic optical inspection
  - Defect Review
  - Manual Defect Classification
- In line Metrology
  - SPC-controlled process using several electrical and optical in line metrology techniques

Process Integration Expertise

- Close exchange with customer to understand application
- Support in III-V process and device understanding
  - Support in decision making to use III/V compound semiconductors in application
  - Analysis of competition
- Process integration to meet product and application requirements
  - Process flow design
  - Process module development
  - Design of experiment
  - Reverse engineering and physical analysis
  - Joint layout design with customers
  - Risk assessment and definition of control plan
- Technical project management
  - Project planning
  - Project execution
  - Project cost assessment and monitoring





UMS Back-End Services and Capabilities

On-Wafer MMIC DC & RF measurement

Wafer/MMIC Optical Compliance

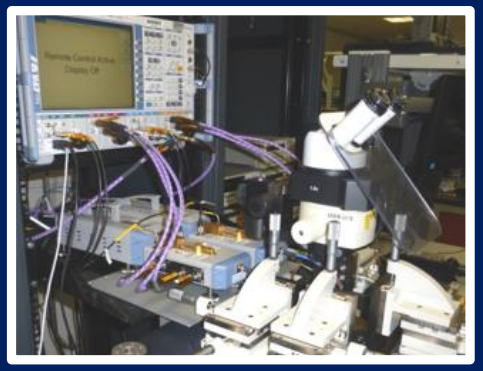
Dicing, MMIC Selection, Wafer/MMIC Conditioning

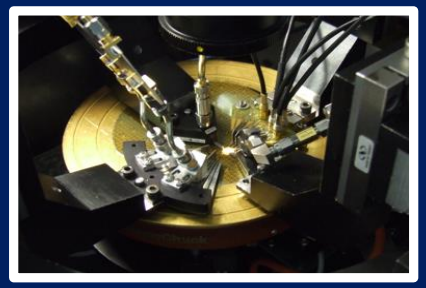
MMIC Packaging and Testing

Space Application

On-Wafer MMIC DC & RF measurement

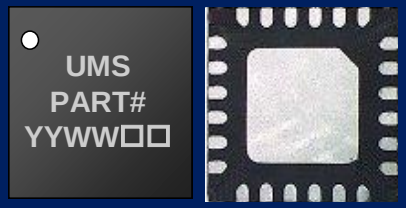
- Vector analyzers up to 110GHz
- 3-port equipments up to 20GHz
- Noise test benches from 2 to 44GHz
- Mixer and VCO benches from L band to 77GHz
- DC stations
- Power stations up to 40GHz in CW or pulsed mode
- DC probe card manufacturing





MMIC Packaging and Testing

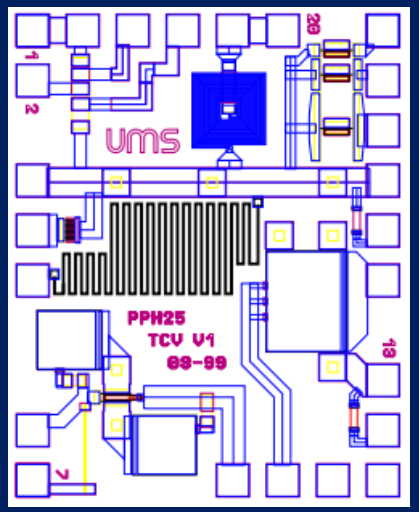
- Low-cost plastic molded SMD package co-developed by UMS
- Assembled in Unisem Malaysia
- Subcontracted Tape & Reel conditioning
- High-speed automatic test in UMS Villebon



- QFN, DFN packages
- 3x3mm to 5x5mm
- Up to 50W thermally enhanced die attach

Space Application

- UMS processes in the European Preferred Parts List of ESA's ESCIES*
- Space qualification flow
  - Wafer Acceptance Test (Die shear, Bond pull, Visual Inspection, SEM)
  - Lot Acceptance Test (240h Burn-in, 1000h Life Test)
- Test Characterization Vehicles (TCV)
  - Standard circuit used for process reliability tests
  - To be added on FM tiles
- Flight Model heritage
  - All types of space programs
  - >100 satellites from all continents
  - >100K UMS GaAs and GaN FMs in orbit



* European Space Component Information Exchange System

UMS Foundry Service Offering

UMS Process Portfolio

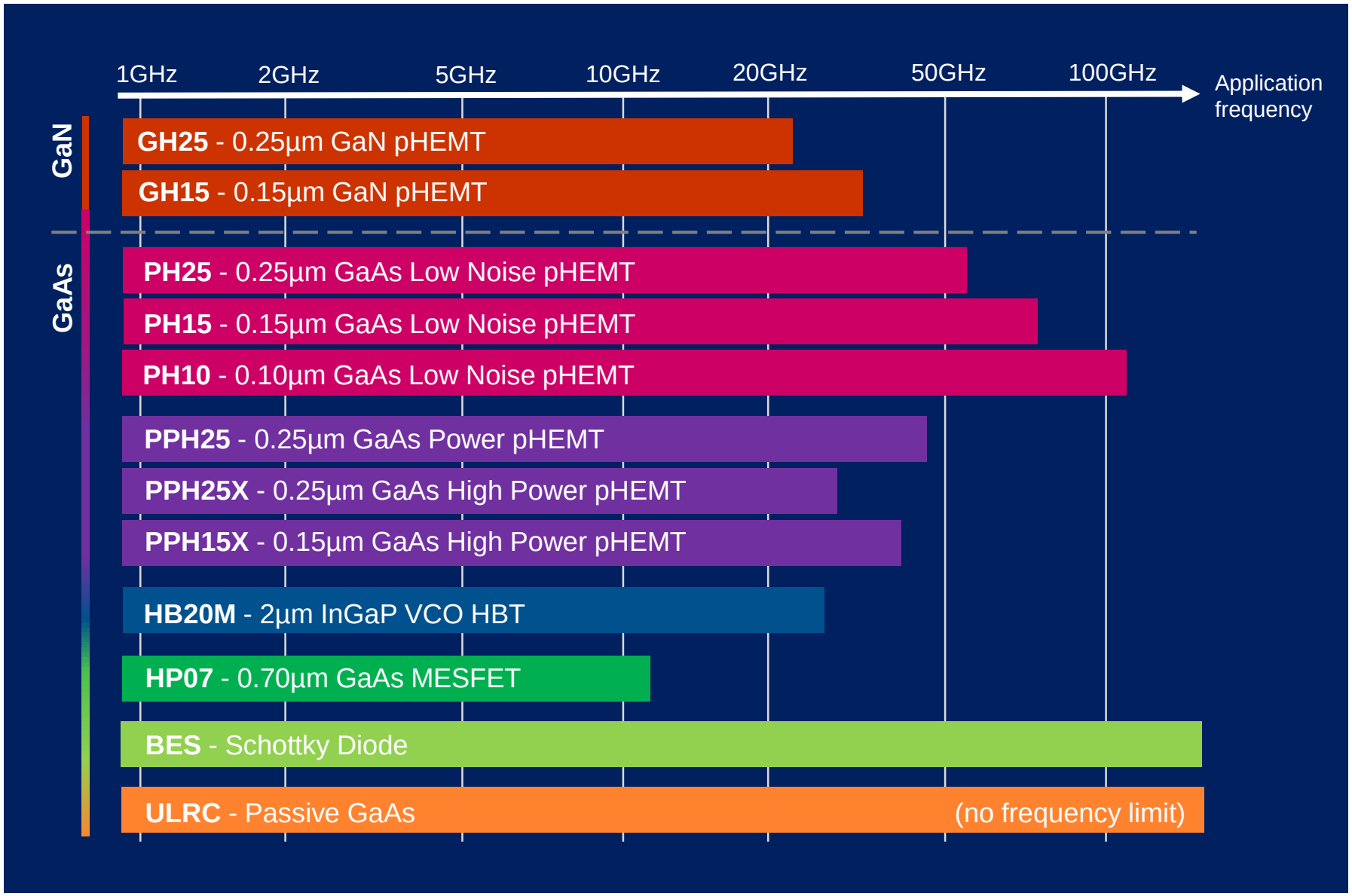
UMS Foundry Service Modes

UMS Foundry Service Flow

MPW schedule

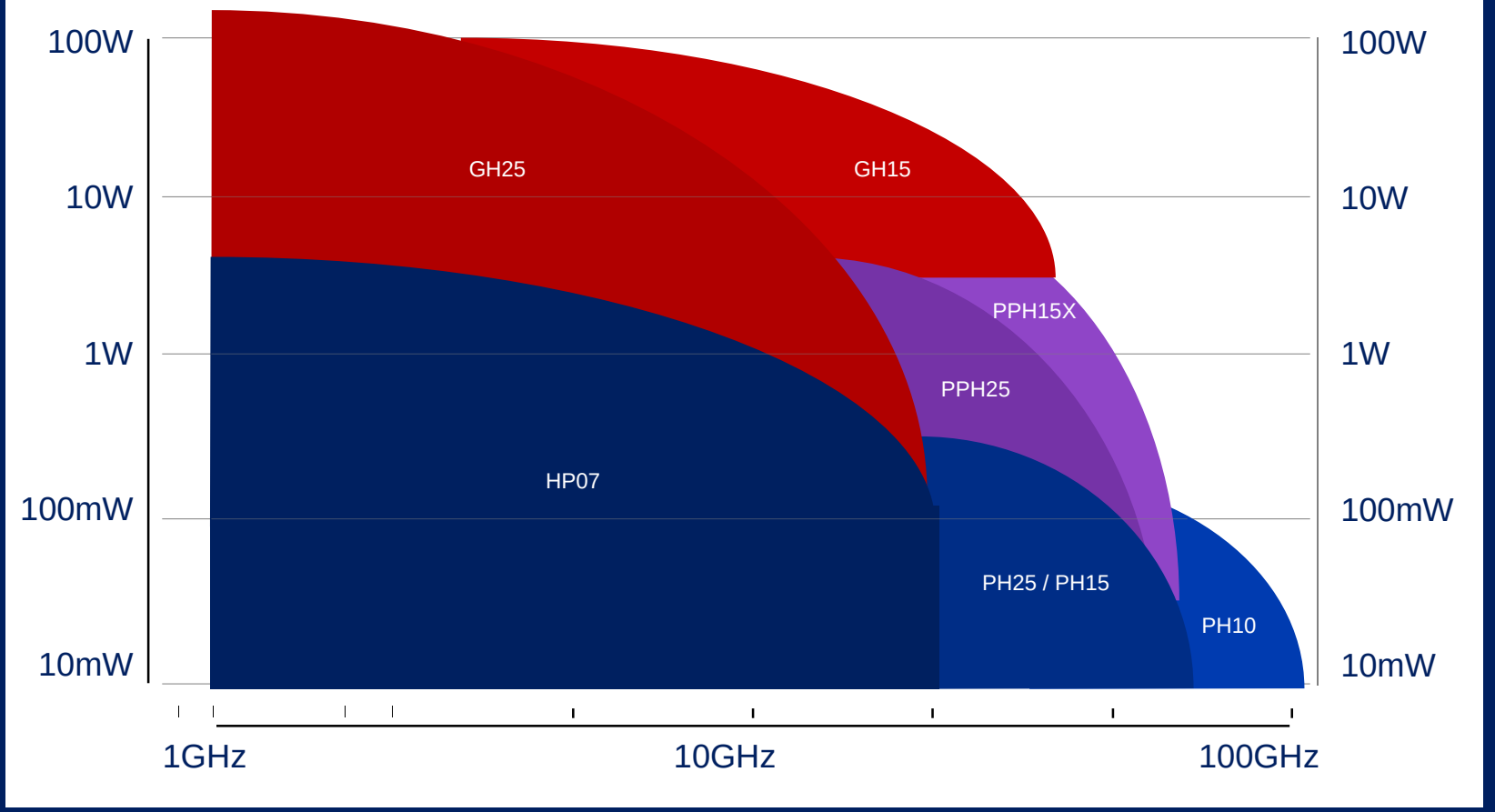
Foundry Course

Portfolio of Processes for Foundry Service



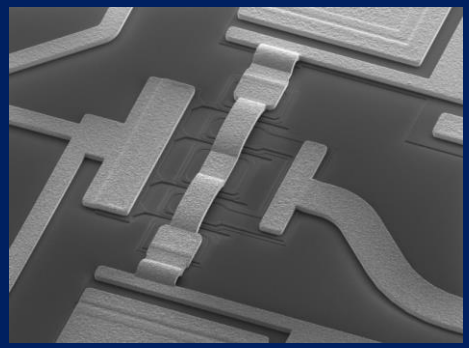
Process Power Performance

Achievable power range at MMIC level



From Reliability to Hi-Rel MMICs

- UMS process qualification
  - Through extensive device reliability assessment
  - DC stress over temperature, voltages and currents
  - RF step stress with increasing compression levels
  - Qualification domain definition



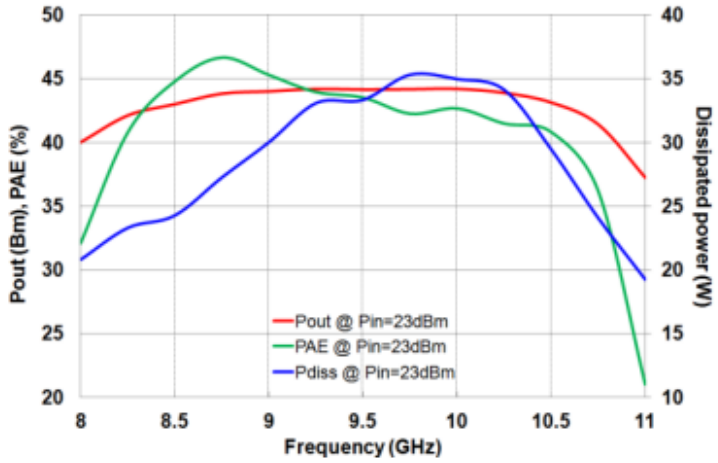
- UMS process qualification for space
  - After internal qualification
  - Cooperation with European Space Agencies
  - Space evaluation based on tests co-specified with ESA

- Flight Models
  - Wafer Acceptance Test and Lot Acceptance Test
  - Construction analysis
  - Life test at high temperature
  - Report

GH25 - 0.25µm GaN HEMT

- AlGaN/GaN on SiC, 100µm thickness
- 4.5W/mm power density
- Power FETs
  - Ids+: 1A/mm; Gm: 290mS/mm
  - Recommended Operating Bias up to 30V
- Cold FETs, diodes, passives
  - 255pf/mm² MIM density
  - 28&1000Ω/sq. metallic resistors
  - Two metallizations, self-inductors, via-holes
- Life Time >20 years at 200°C Tj

GH25 25W X-band HPA



- Frequency range: 8.5-10.5GHz
- Output power: 25W
- PAE: 44%
- Linear Gain: 28.5dB
- DC bias: 25V Vd @750mA Idq

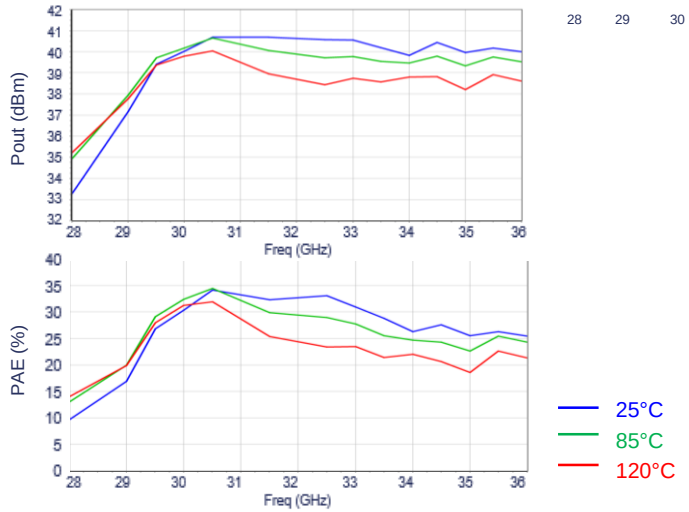
- Released in 2014
- Qualified for Space
- 150 development projects since 2017
- Typical cycle time: 11 weeks*
- QFN packaging early access

* Without back-end activities

GH15 - 0.15µm GaN HEMT

- AlGaN/GaN on SiC, 70µm thickness
- 3.5W/mm power density
- Power FETs
  - Ids+: 1.4A/mm; Gm: 390mS/mm
  - Recommended Operating Bias up to 25V
- Cold FETs, diodes, passives
  - 175pf/mm² MIM density
  - 28&1000Ω/sq. metallic resistors
  - Two metallizations, self-inductors, via-holes
- Life Time >20 years at 200°C Tj

GH15 10W Ka-band HPA (CW @25°C)



- Frequency range: 29.5-36.0GHz
- Peak output power: >10W
- PAE: >25%
- Power Gain @Psat: >20dB
- DC bias: 22.5V Vd @630mA Idq

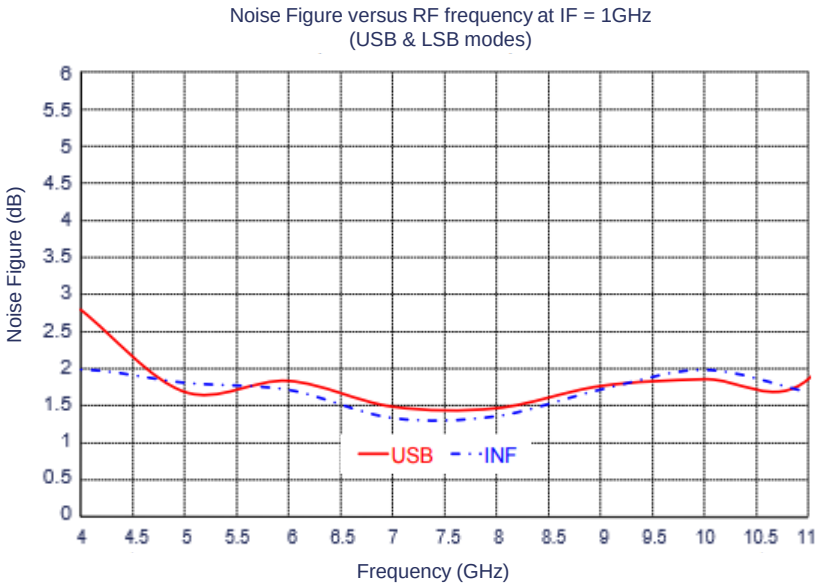
- Released in 2019
- Qualified for Space in Q4 2021
- 30 development projects since 2020
- Typical cycle time: 13 weeks*
- QFN packaging early access from Q1 2022

* Without back-end activities

PH25 - 0.25µm Low Noise GaAs pHEMT

- GaAs pHEMT, 100µm thickness
- Gm >580mS/mm (Vds=2.0V, Gm_max)
- Idss >220mA/mm (Vds=2.V, Gm_max)
- Vbds >6V, 3V operating voltage
- 2 metal interconnect layers
- TaN/TiWSi/GaAs resistors, MIM capacitors

PH25 5.5-9.0GHz low NF, high IIP3 down-converter



- Frequency range: 5.5-9.0GHz
- 14dB Conversion Gain
- 1.7dB Noise Figure
- DC bias: Vd = 3V @Id = 100mA
- QFN package, MSL1

- More than 500 projects since 2001
- Low noise and multi-purpose process
- Qualified for Space
- Typical cycle time: 8 weeks*
- BCB option for QFN packaging

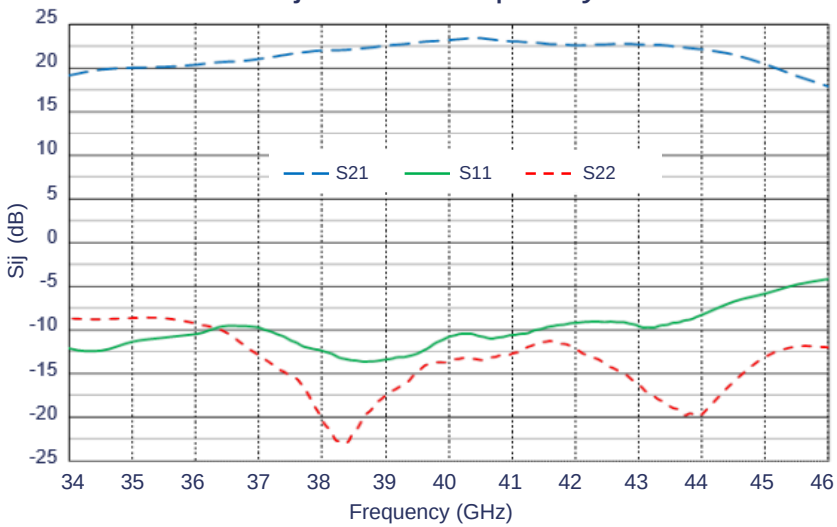
* Without back-end activities

PH15 - 0.15µm Low Noise GaAs pHEMT

- GaAs pHEMT, 100µm thickness
- 10dB Gain, 0.8dB NF @20GHz
- Vbds >4.5V, 3V operating voltage
- 2 metal interconnect layers
- TaN/TiWSi/GaAs resistors, MIM capacitors

PH15 36.0-43.5GHz Medium Power Amplifier

Sij versus Frequency



- Frequency range: 36.0-43.5GHz
- 18dBm P1dB
- 22dB gain
- 29dBm OTOI
- DC bias: Vd = 4V @Id = 200mA
  (resistive bridge at the drain input)
- QFN package, MSL1

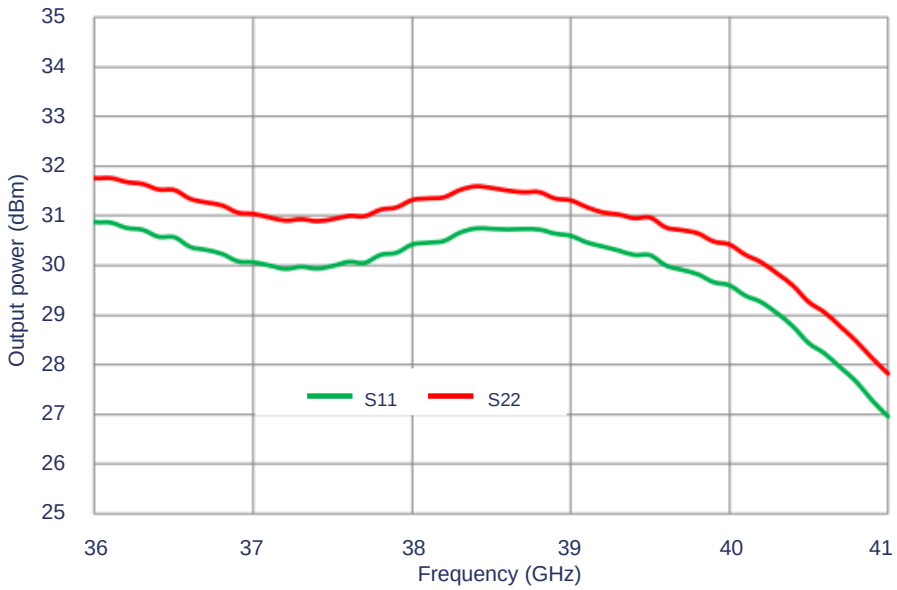
- More than 100 projects since 2007
- Qualified for Space
- More than 100 development projects
- Typical cycle time: 8 weeks*
- BCB option for QFN packaging

* Without back-end activities

PPH15X - 0.15µm High Power GaAs pHEMT

- GaAs pHEMT, 70µm thickness
- 800mW/mm power density
-
- Vbds >12V Vbds, 6V operating voltage
- 2 metal interconnect layers
- TaN/TiWSi/GaAs resistors, MIM capacitors

PPH15X 37-40GHz High Power Amplifier



- Frequency range: 37.0-40.0GHz
- 31dBm Psat
- 38dBm OIP3
- 20dB gain
- DC bias: Vd = 6V @Id = 800mA
- QFN package, MSL3

- Released in 2012
- Qualified for Space
- More than 100 development projects
- Typical cycle time: 10 weeks*
- BCB option for QFN packaging

* Without back-end activities

Foundry Service Modes

Full wafer mode

■ Standard
○ Optional

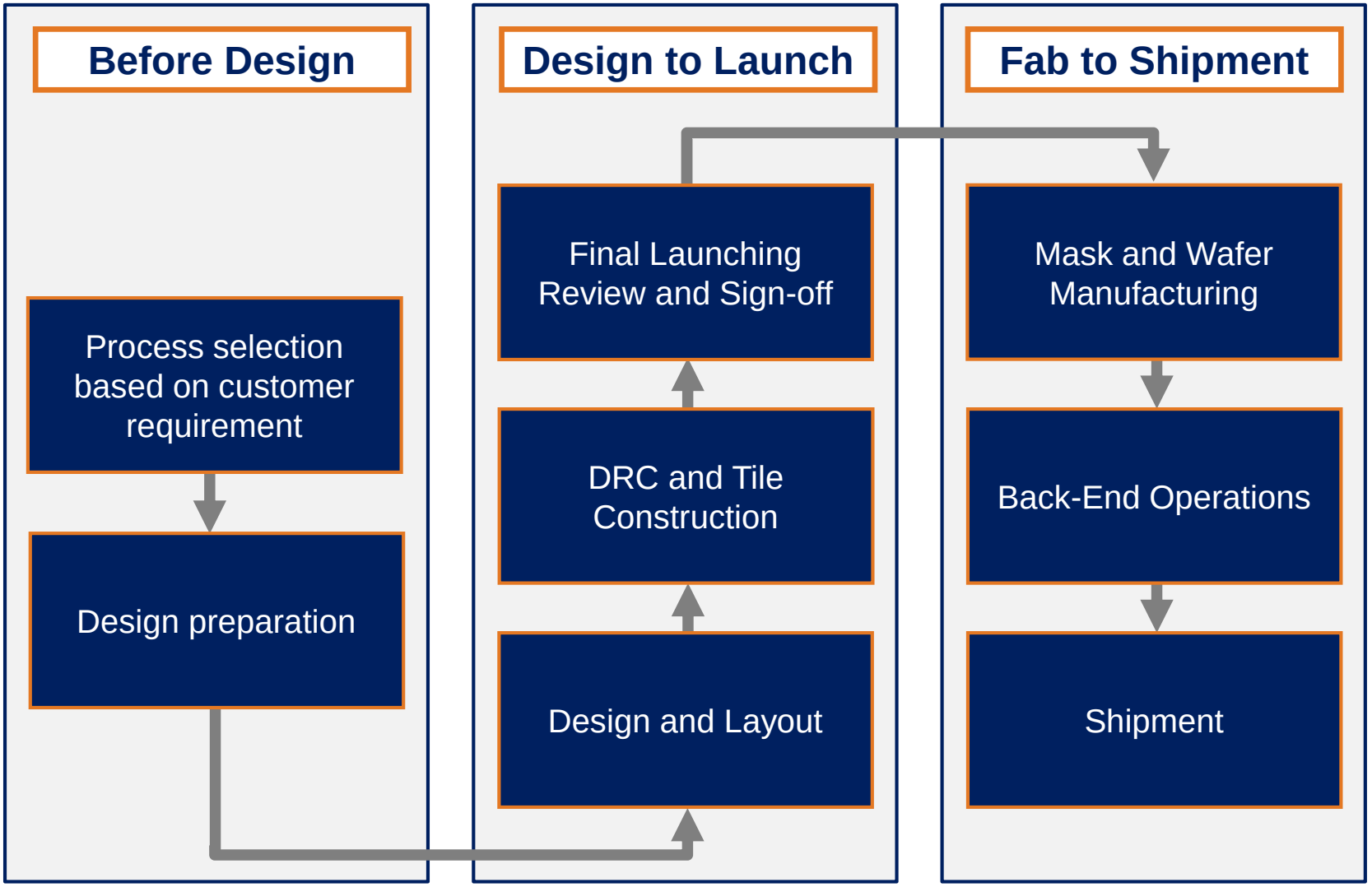
- ■ Full mask
- ■ Technical support
- ■ Full wafer / Known Good Dies
- ■ Standard process time
- ○ Full Back-End offering
- ○ Space screening
- ○ QFN packaging

MPW* mode

- ■ Shared mask
- ■ Restricted UMS support
- ■ Low budget opportunity
- ■ Fixed project launch date
- ■ Fixed MMIC dimensions
- ■ 16-20 chips per MMIC version
- ■ No On-Wafer Test

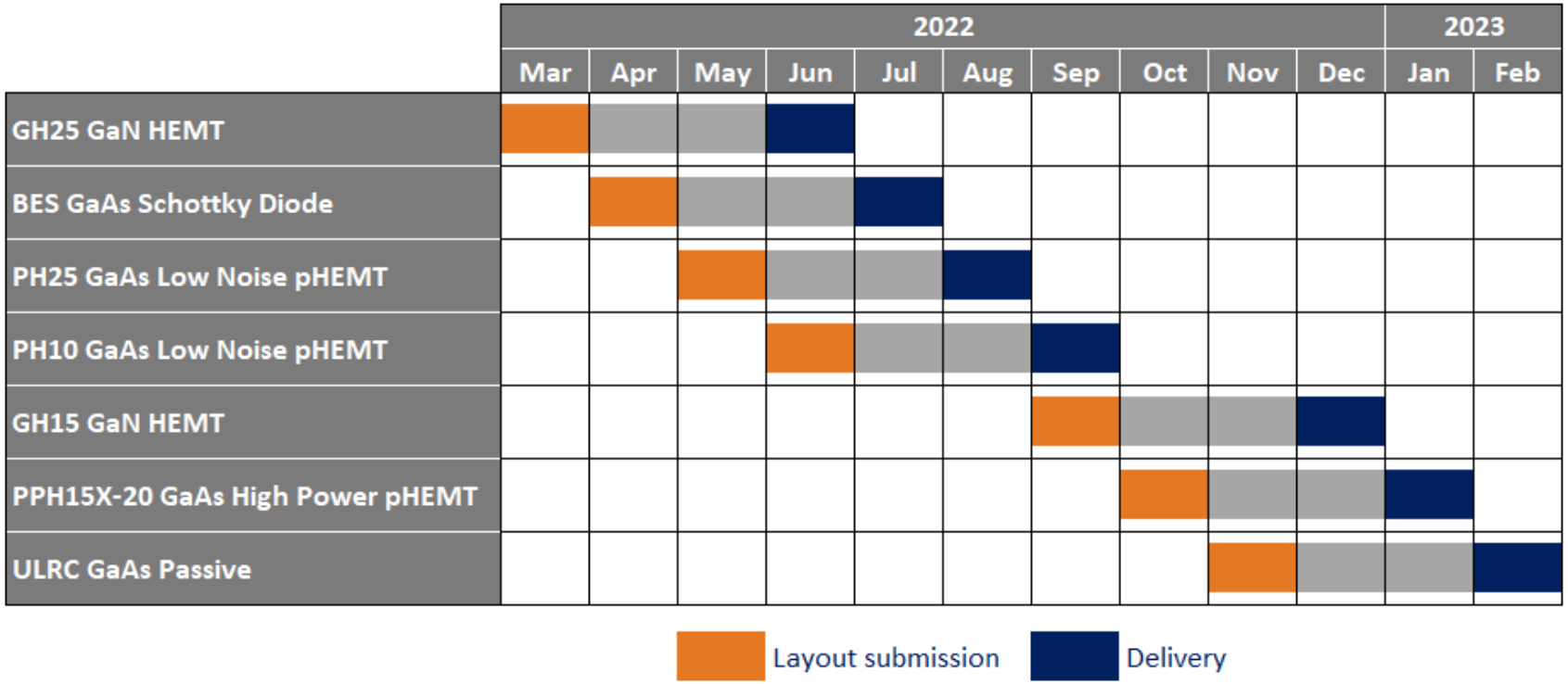
* Multi Project Wafer

High Level Foundry Service Flow



MPW Schedule

2022-2023 Multi-Project Wafer Runs



Foundry Course

- On-demand 2-day foundry course
- Technologies, methods, standards and spirit of UMS foundry service
- Course agenda
  - Technologies and design rules
  - LNA, PA, mixer, VCO design examples and design tricks
  - CAD tools and electrical models
  - Discussions and demo with external CAD support engineers
  - Back-end services
  - Thermal methodology and simulation
  - Reliability
  - Packaging & Measurement capabilities for production
- Possibility to provide additional e-training

All this brings us to…

UMS Goal: Enable Customer Success

Over 25 years, UMS has developed the expertise to master all facets of a foundry service project

Whatever your objective…

Succeed with a foundry service project ?

Overcome electrothermal challenges ?

Improve MMIC design skills ?

Secure an MMIC product development ?

Launch production timely ?

Innovate ?

➔ UMS gets your job done