Selex ES

A Finmeccanica Company

XVIII Giornata di Studio sull'Ingegneria delle Microonde

claudio.lanzieri@selex-es.com

Villa Mondragone, 15th April 2013

Our pedigree

- Mission Critical Systems and Defensive Aids Systems

- Integrated Networking Solutions for Netcentric Capabilities

- Sensors & Systems for Homeland Protection, Homeland Defence, ATC/ATM, VTMS

A global technology leader

To establish a customer-focused international business that can:

- approach complex challenges with an expanded knowledge base
- synergise existing competencies in the air, land, sea, military and civil domain to enhance security & safety
- offer the customer a single point of access to address requirements across defence, safety & security, smart solutions (cities, grid, infrastructures)
- increase the value of our existing products and systems
- develop focused solutions for a broad range of civil and military requirements by leveraging the breadth of our dual application technologies
- achieve a deeper level of customer intimacy
- develop through-life customer support strategies tailored to customer needs
- harness innovation and R&D to ensure timely delivery of critical technologies to our customers

The Company

Key facts

- 17,900 people
- Revenues in excess of 3.5 billion Euros
- Italy and UK as domestic markets
- Strong footprint in
  - US
  - Germany
  - Romania
  - Brazil
  - Saudia Arabia
  - India
  - Turkey

The Divisions

- Airborne & Space Systems
- Land & Naval Systems
- Security & Smart Systems

Entrusted to deliver technology-enabled systems and solutions for a safer, smarter and more secure society

Our divisions

Airborne and Space Systems Division

- Airborne radar
- Sensors
- Electronic warfare systems
- Avionics
- Integrated mission systems
- Airborne surveillance systems
- Tactical UAS
- Target drones
- Simulation systems
- Space sensors and equipment

Land and Naval Systems Division

- Integrated command land and naval command and control systems
- Land and naval radar
- Electro-optical sensors
- Tactical communication systems and equipment
- Battlefield protection systems and equipment

Security and Smart Systems Division

- Homeland and critical infrastructures' protection and security architectures
- Secure communications systems
- Information technology
- Information management and automation systems
- Airport systems
- Air traffic and vessel management and control systems

The **Chief Operating Officer** function brings together the Engineering and Production activities to serve the three divisions by creating and exploiting technology, product and systems' synergies.

Research & Technology mission

- The Research & Technology Unit constitutes a key company asset for the development of innovative enabling technologies for Integrated Systems applications.
- The Unit's mission is to ensure a dynamic technological environment capable of responding to the company's operational needs and to develop new technologies and demonstrators to expand the products and systems portfolio.

Mission Drivers:

- Identifying emerging technologies and collaborating, when necessary, in defining an implementation strategy;
- Promoting technology insertion to ensure company leadership in competitive edge products.
- Capitalising on human resources to maintain and generate "know-how" in compliance with company objectives and technology plan;
- Establishing scientific partnerships with best-in-class national and international institutes;

Selex ES
A Finmeccanica Company

Competences

- Development of Technologies, Electronics and Photonics Solid State Devices for monolithic integrated components;
- GaAs/GaN Foundry for the fabrication of Microwave Monolithic Integrated Circuits (MMIC) for applications up to millimetre waves;
- LiNbO3 Photonic Foundry for microwave-photonics and digital links;
- Design and Test of advanced RF Components and Sub-Systems;
- R&D of emerging enabling technologies: compound semiconductors (GaN, SiGe), advanced interconnections (flip-chip) and packaging, nanotechnologies;
- Reliability evaluation and Components Qualification.

- **Microwave GaAs/GaN Components Manufacturing**
- **Pilot Integration and Assembly Manufacturing Line for RF sub-systems**

R&T LABS & RESOURCES

GaAs /GaN Manufacturing Line

RF - Testing

R&D GaAs /GaN

Clean Rooms: ~ 1500m^2
Tools: ~ 25M€
Human Resources ~ 70
(35% Graduated)

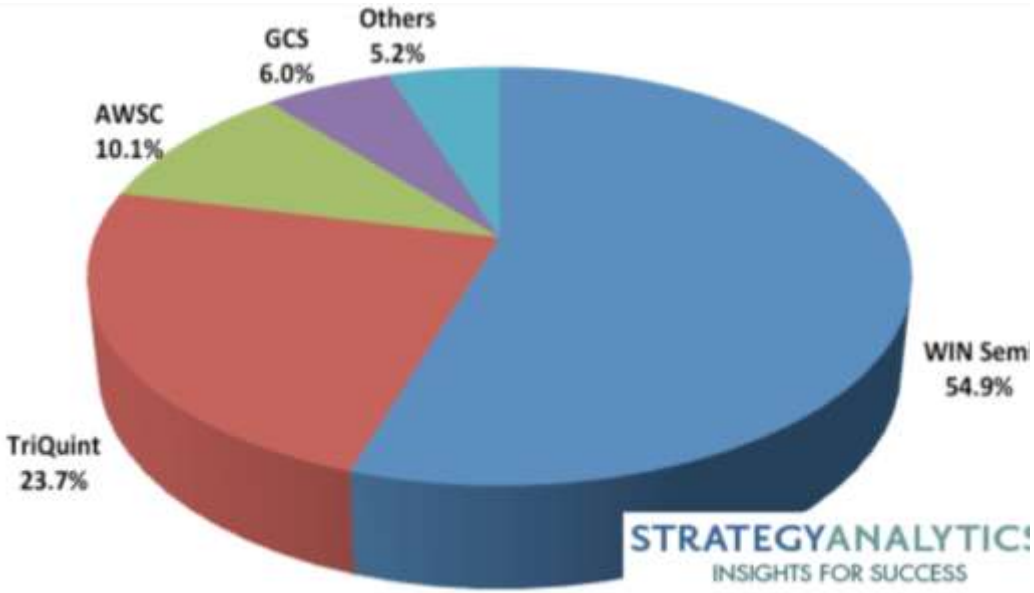
MMIC and Components Design

Pilot Integration and Assembly Manufacturing Line

R&D Microelectronics

Scenario - Electronic Components Suppliers World Market

- Strong concentration with respect to electronics strategic components suppliers
- Possibility of "monopoly" regime for high-volume production
- Potential risk to the market of Defense, Space and Security, often subject to ITAR restrictions, involving production volumes typically mid / bass to ensure a life cycle of products lasting 10-20 years
- In particular, for the GaN technology is expected risks of limitations from U.S. (ITAR) and Japanese (Ethic Code) suppliers



- In Europe the market volume is very low if compared to World Market
- Lack of capacity in terms of market presence

Foundries Strategy in the world

- The main arrangements of the largest Foundries can be summarized as follows
- Pure-Play Foundry (WIN): only offer foundry services on a limited carnet of qualified technological processes. They are characterized by high volumes and low costs (Tens of Thousands of wafers / month GaAs on 6 ")
- "Mixed" Foundry (TriQuint, RFMD): offer both foundry services that MMIC products (also in package). High-volume production / GaAs on 6"
- Strategic Foundry (Raytheon, Northrop-Grunmann, Lokheed-Martin, Cassidian-EADS, M/A-COM Tech.): foundry services limited and focused on the development of strategic components for the products of specific market. Implement a strategy of "Make / Buy"
- The latter solution is applied by companies "leader" in the field of Defense and Security electronics that, to obtain an advantage and consolidate their markets, organize themselves into integrated structures (Foundry, design and microelectronics) for the development and production of RF and microwave components
- In some cases this approach involves the creation of so-called "Microwave Factory" (Raytheon, Northrop-Grunmann, Lokheed-Martin, Cassidian-EADS)
- The Selex ES Foundry is organized in a similar structure which includes: development and production of devices and MMICs (GaAs / GaN), design components and sub-assemblies, RF, microelectronics and microwave photonics

- **Selex ES Foundry could represent a useful "Solution" for Defense and Space European market**

SES Foundry Capability

- The Foundry production capability has evolved with time in response to the growing demand of MMIC components. To-day the facility, occupying more than 700m^2 of clean-room and equipped with state-of-the-art tools has a 4-inch production capability for approx. 300 wafers per year (1 shift).

- **Processes in Line:**
  - Half-micron MESFET technology for L-Band
  - Half-micron PHEMT technology for S and C Band
  - Quarter-micron PHEMT technology for X-Band
  - GaAs VPIN Diode technology for X-Band

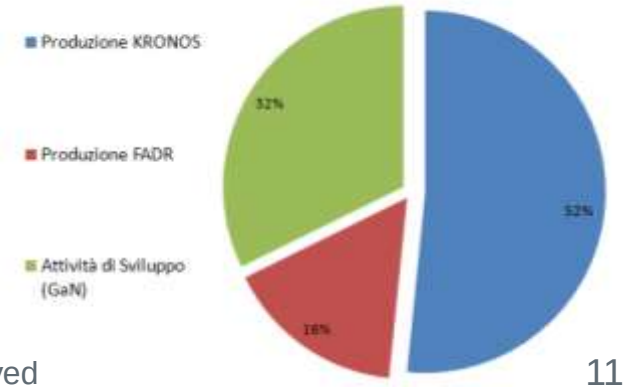
0.5 µm MESFET: In production since 1997 for D band T/R Module

Produced > 4000 KIT (173 mm^2 /KIT)

0.5 µm Lg PHEMT: In Production since 2008 for C Band T/R Module

Maximum rate > 10.000 KIT/year : Produced in 3 years 40.000 KIT (25 mm^2 /KIT)

0.5 & 0.25 PHEMT 4”	**GaAs Wafer/year Min/Max 200/1000**
	GaAs mmq Capability Min/Max 1-6 Mmmq

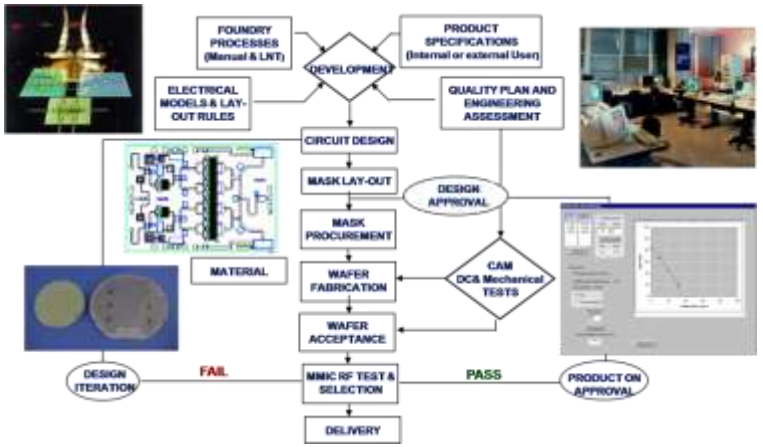


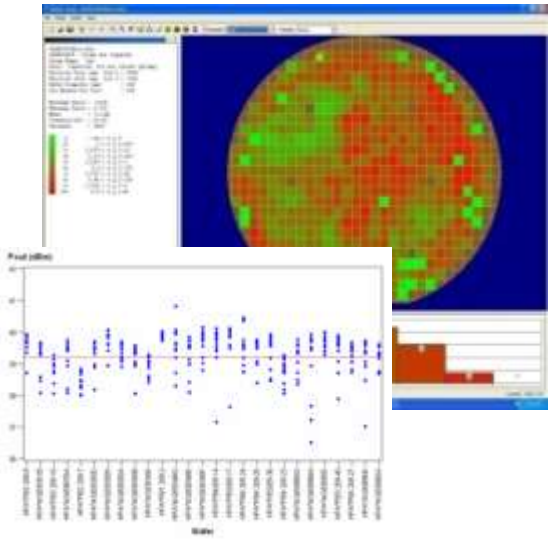
Foundry Service

- Complete range of engineering support services for customers at all capability levels

- Tool Kit for circuit Design and Layout
- AWR Process Design Kits
- Design Rules and Technology Documentation

- In addition to the basic Foundry service:
- Circuit design of MMIC's to customer specifications
- On-wafer RF testing
- Assembly and packaging

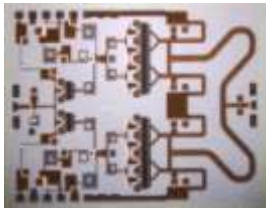




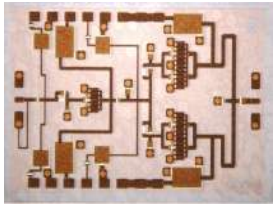
- Product quality is assured by a Management Plan on "Productivity and Quality" within the company's quality strategy framework.
- The Foundry process is fully controlled and documented via a computer aided manufacturing (CAM) network.
- Each process step is rigorously controlled and process data is managed to guarantee: lot tracking, production control and reporting, statistical process control, engineering data analysis and product yield and quality monitoring.

Technologies and Related products SELEX ES

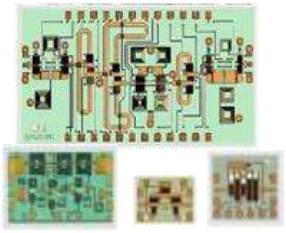
Technology	TRL Level	Component Typology	Fab	Fabless
GaAs MESFET	TRL 6	Discreet Power Bars and Medium Performance MMICs	√	
GaAs PHEMT	TRL 6	High performance MMICs for Power, Gain, Low-noise and Switching applications	√	√
GaN HEMT	TRL 5	Very High Performance MMICs for Power, Robust Low-noise and Switching applications	√	
GaAs VPIN Diode	TRL 4	MMICs for Power Limiter and Switching applications	√	
RF Si / SiGe	TRL 4	Low-cost Mixed Signal ASICs for signal phase/amplitude control and/or processing		√
GaAs E/D FET	TRL 3	Specific Mixed Signal (Analog/Digital) MMICs for signal phase/amplitude control	√	√
GaAs/GaN MEMSICs	TRL 3	Integrated MEMS-MMIC for reconfigurable low-loss components	√	



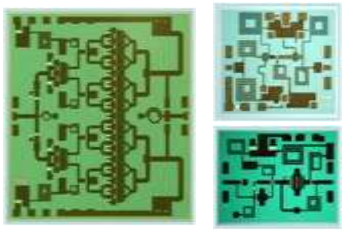
25 W C Band HPA GaN HEMT



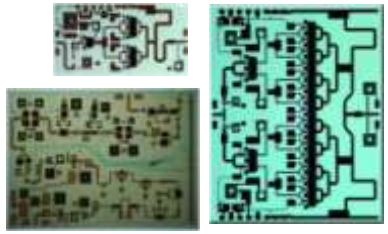
15 W X Band HPA GaN HEMT



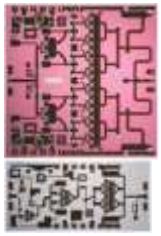
L Band Chip - set (MESFET)



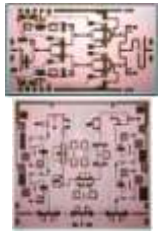
C Band Chip - set (0.5 PHEMT)



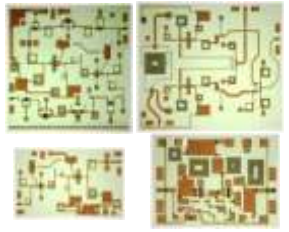
S Band Chip – set (0.5 PHEMT)



X Band Chip - set (0.25 PHEMT)



WB Chip - set (0.25 PHEMT)



Compact Receiver Chip - set (0.5 PHEMT)

GAN RESEARCH & DEVELOPMENT PROJECTS

- Main Projects on GaN Technologies (2010-2015)

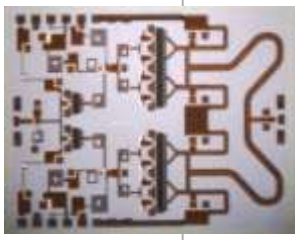
  - **MANGA (Manufacturable GaN): SiC Substrates and Epi-wafer Supply Chain (EDA Funded Project, started 2010 - 3.5 years program)**
  - **ASI Tile 2nd Generation: SVILUPPO DI TECNOLOGIE PER TILE DI SECONDA GENERAZIONE (ASI Funded Project, started 2010 - 2 .5 years program)**
  - **TACSI: Sviluppo ed Implementazione di Tecnologie Abilitanti Chiave per Sensori Integrati Compatti (It MSE Funded Project, started 2011 - 4 years program)**
  - **PNRM GARANTE: Dispositivi GaN ad Alte Prestazioni ed Affidabilità (It MoD Funded Project, started 2011 - 3 years program)**
  - **PNRM TX-SS: Trasmettitori a Stato Solido di elevata potenza in tecnologia GaN (It MoD Funded Project started 2011 - 3 years program); Objective: Develop HPAs MMIC for S Band (80 WATT) and X Band (40 watt) Application**
  - **PNRM AMIGAN: Active Mini-Array GaN for Missile Applications (It MoD Funded Project start 2012 - 3 years program); Objective: Improve high frequency GaN HEMT performance developing 35 GHz prototype**

SELEX-ES GAN-HEMT TECHNOLOGY ROADMAP

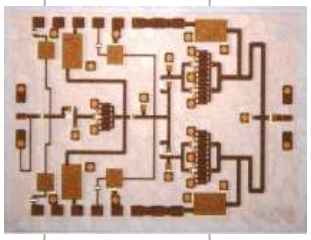
SGN-50 0.5 µm GaN HEMT: C&X Band HPA - S&C Band Power Bar

SGN-25 0.25 µm GaN HEMT: X &W Band HPA – LNA Ku Band Power Bar

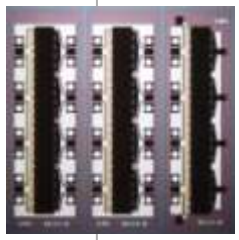
@5.5GHz	25V	30V	35V
Power density @3dBc (W/mm)	6.8	8.2	9.3
Drain Efficiency (%)	62	59	58
Gp @3dBc (dB)	12.7	12.8	12.9



25 W C Band HPA

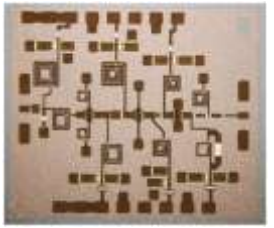


15 W C Band HPA



S & Ku Band PB

0.25 µm GaN HEMT: Robust LNA & WB HPA



Technology Development

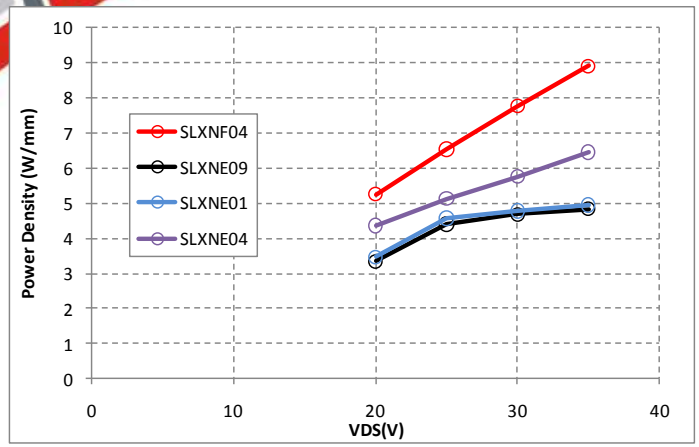
Engineering Phase MMIC Dev.

Release for production

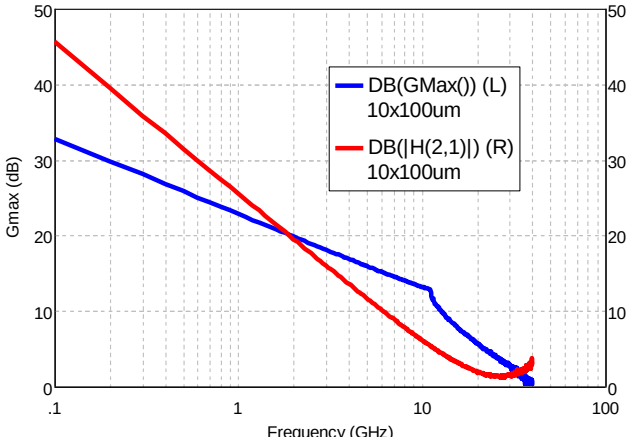
2008 2009 2010 2011 2012 2013 2014 2015

0.5 µm GaN-HEMT Optimization

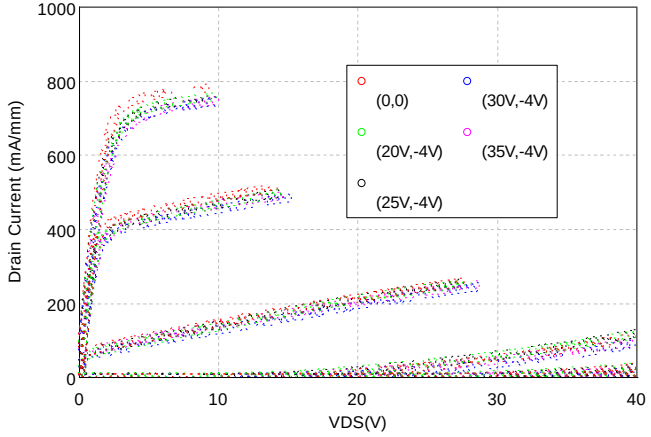
- Optimised:
- Field Plate (Γ gate, T gate)
- Dry-etch

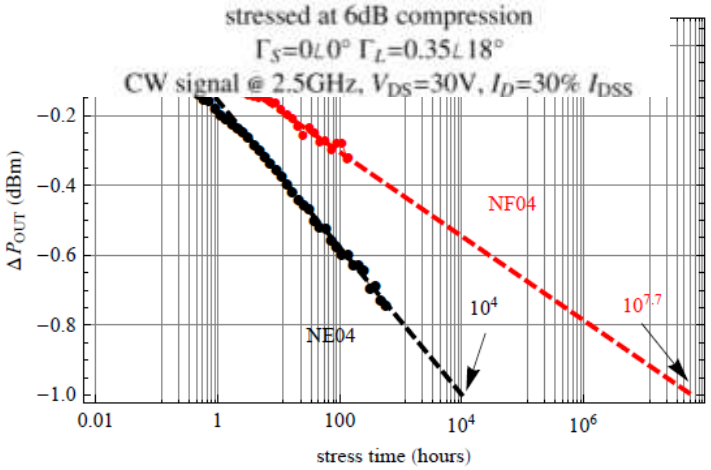


@5.5GHz	25V	30V	35V
Power density @3dBc (W/mm)	6.8	8.2	9.3
Drain Efficiency (%)	62	59	58
Gp @3dBc (dB)	12.7	12.8	12.9

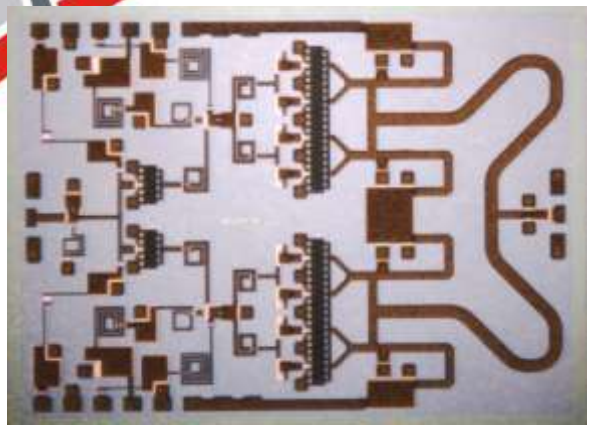


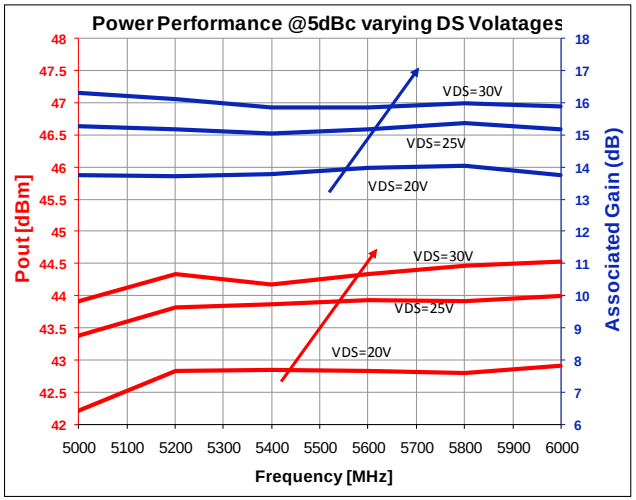
	25V
f_t	19.6 GHz
f_{max}	40 GHz
G_{max} @10GHz	13.1 dB



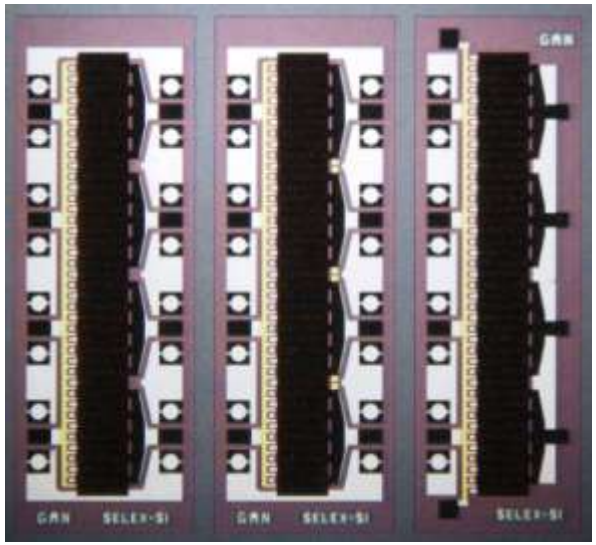


0.5 µm GaN-HEMT: C Band Application & Power Bar





Parameters	Specification	Unit
Frequency Range	5.0÷ 6.0	GHz
Output Power	25	W
Associated Gain	> 14	dB
Chip size	4.7x3.45	mm



- 0.5 µm Technology applied up to C Band
- Power Density > 5 W/mm
- 60 W PB developed for S Band application

- 0.25 µm Technology under evaluation for Ku Band

MBDA MISSILE SYSTEMS

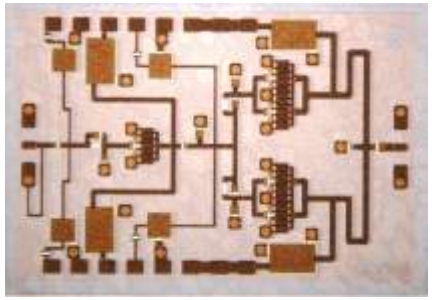
0.5 µm GaN-HEMT: X Band Application

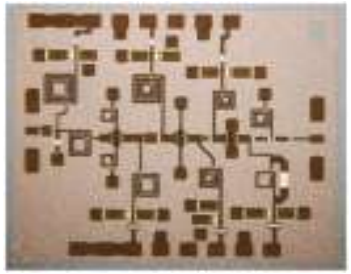
ASI Tile 2ND Generation - Partners:

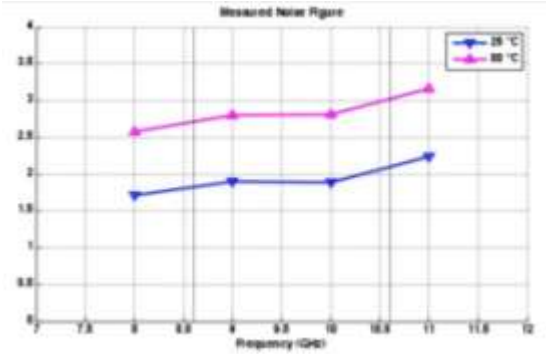
- Thales Alenia Space Italia (TAS-I): (MMICs Design); SELEX ES: (GaN Foundry); MECSA (Università Roma Tor Vergata): (MMICs Design)

Main objectives:

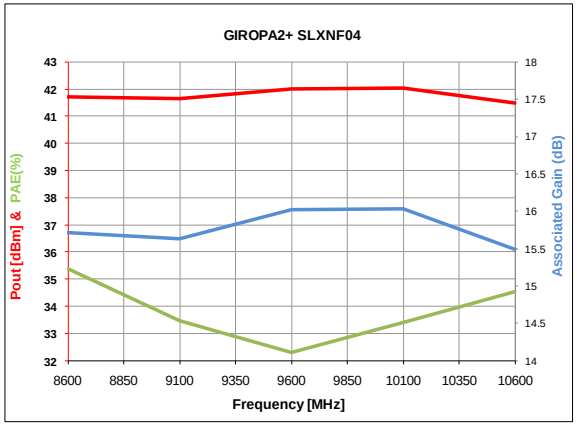
- Develop X band HPA (0.5 µm) and LNA (0.25 µm) prototypes, designed for future X band SAR systems for which High Output Power, Low noise characteristics efficiency, robustness and compactness are the main driving factors

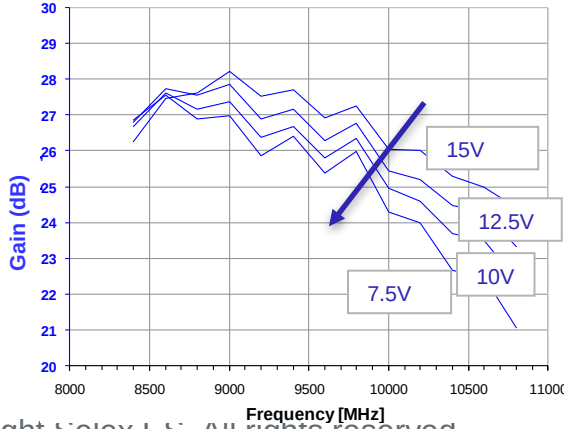






Measured noise figure of the prototype LNA at two backside temperatures

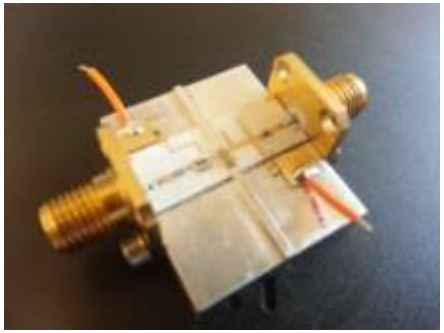


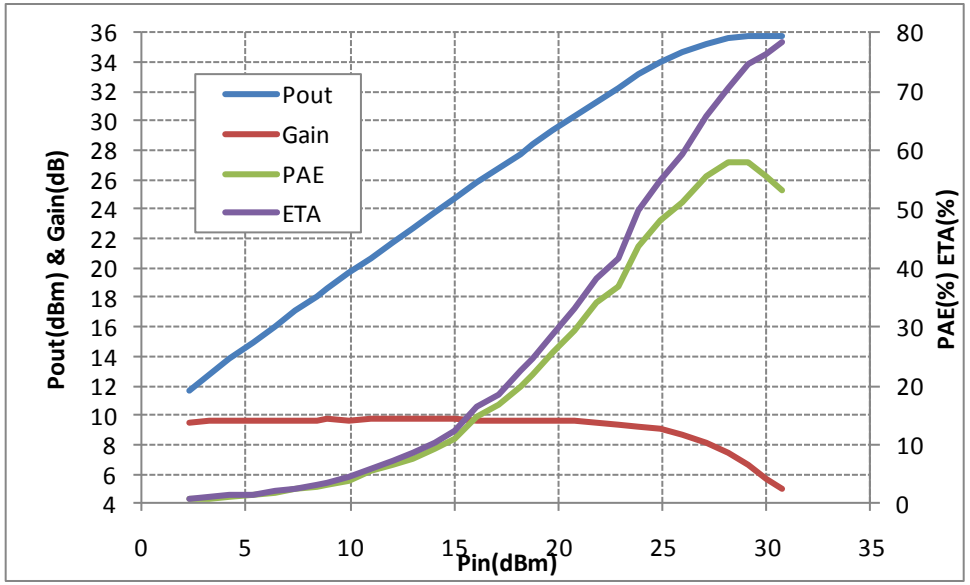


NF<2.1dB and Gain>25dB up to 10GHz with a minimum PDC of 0. 7 W

LNA circuits show no performance degradation with an input RF overdrive up to 41dBm.

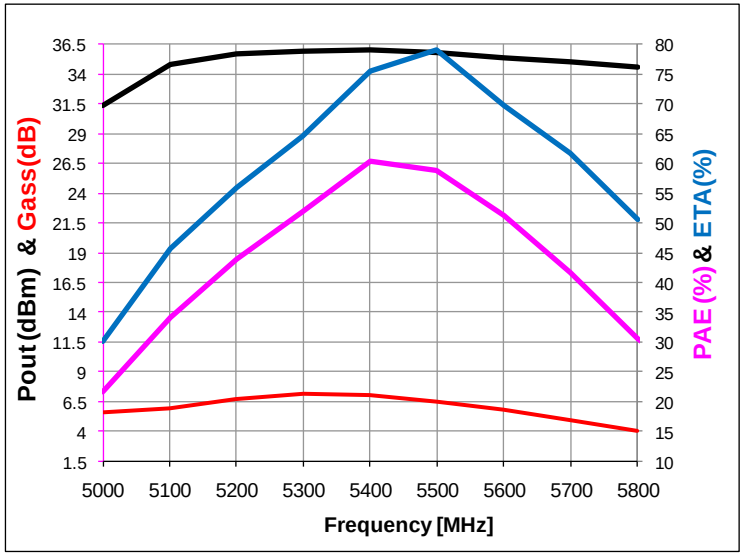
0.5 µm GaN-HEMT: High Efficiency Hybrid Prototype



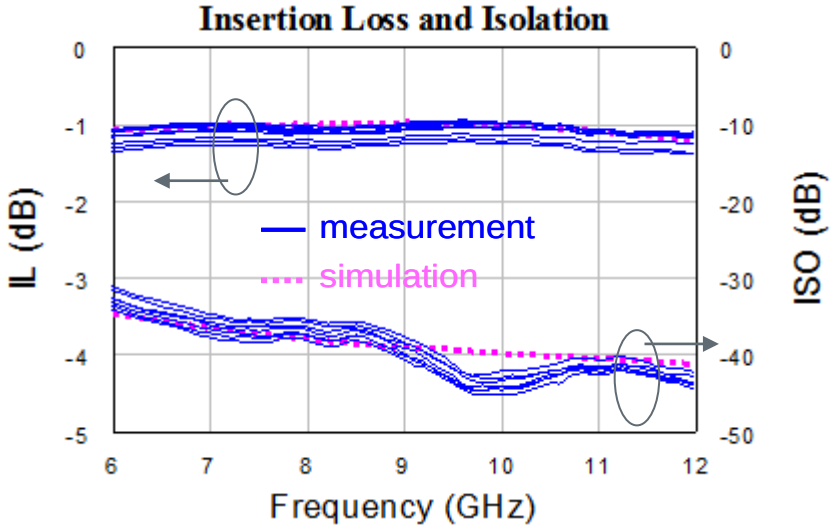


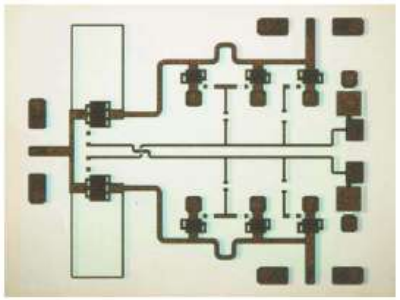
- Frequency: C Band
- Gate Periphery: 1mm
- Test Condition:VDS=25V VGS=-1.4V; CW

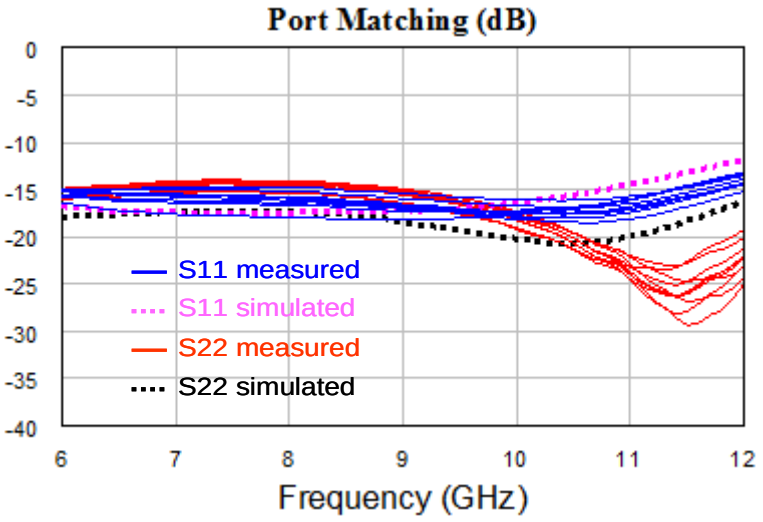
- Pout=36.0dBm, PAE=60% ETA=78%, GL=9.7dB

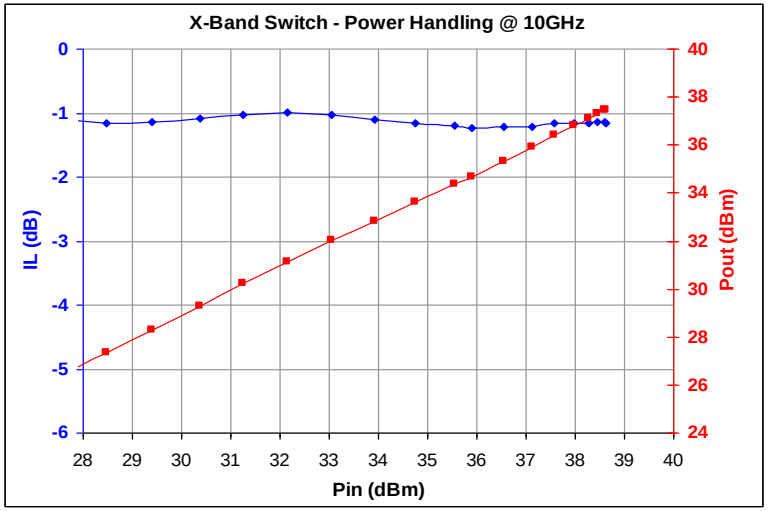


0.25 µm GaN-HEMT: X Band SPDT



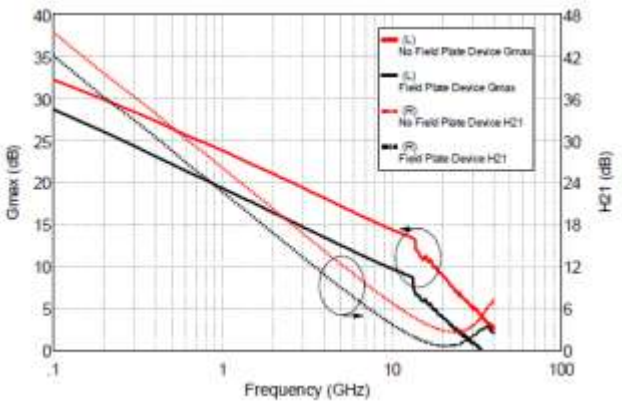




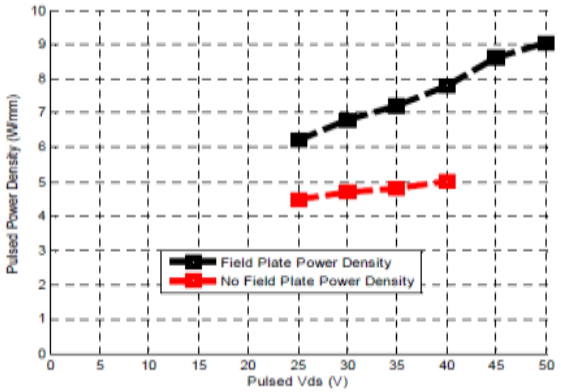


0.5 µm GaN/Si HEMT

Small signal S-Parameters
(V_{DS}=25V, I_{DS}=30%I_{DSS})

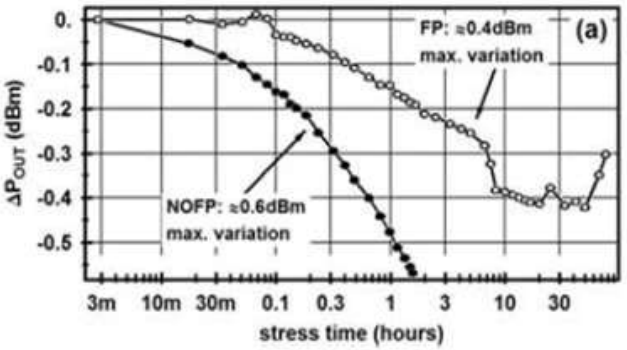


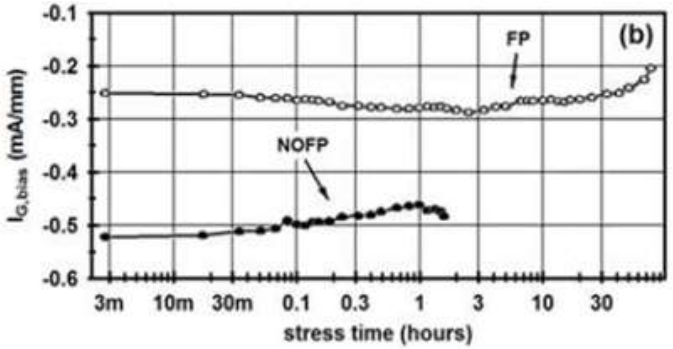
Large signal Load Pull
f=3GHz, I_{DS}=30%I_{DSS}, P_D@-5dBc)



- High power density (up to 9W/mm @ 50VDS). Obtained for FP Device

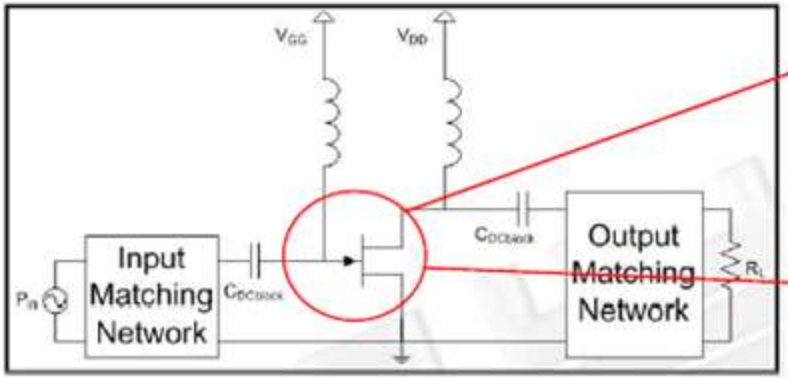
- CW RF stress @ 2.5GHz, 3W/mm and 90°C base plate temperature (TCH≈ 160 °C).

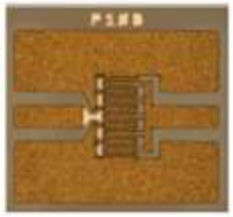




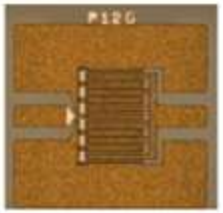
75 hours CW RF stress at 2.5GHz carried out on a typical FP and NOFP device. Base-plate temperature is 90°C, and devices are biased at V_{DS}=30V and 5% of I_{DSS}.

0.5 µm GaN/Si HEMT: Hybrid Ultra WB PA





1-7 GHz
(P10D L_G=1mm)



1-6 GHz
(P12G L_G=2.4mm)

Power Amplifier designed with P10D (1mm periphery – 1 to 7GHz) and P12G (2.4mm – 1 to 6GHz).

MIKON-2012
Warsaw May 21-24, 2012

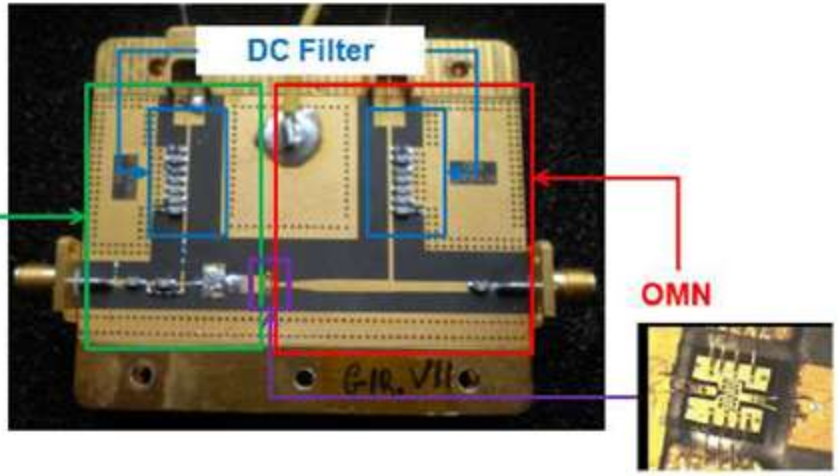


Photo of the realized Power Amplifier using P12G active device.

TOR VERGATA

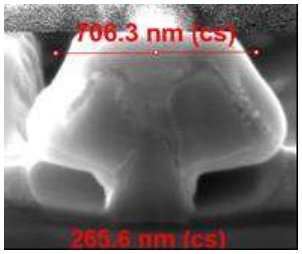
EUROPEAN MICROWAVE WEEK
RAI Amsterdam
28 October – 2 November 2012
EuMW 2012
www.eumweek.com

elt

Current Activities with the Italian Space Agency (ASI)

- SELEX-SI Foundry obtained in 2012 an ASI funding for the Space Qualification of GaAs 0.25 µm PHEMT process. (QUAGAS)
- This activity is aimed to qualify Selex ES as an alternative supplier for the Aerospace Industry.
- The GaAs Technology Qualification, planned to be completed beginning 2014, represents a mandatory heritage for next space qualification of GaN-HEMT technology
- In parallel with this activity, and in synergy with other It MoD Research Programs, currently in progress, the Selex ES commitment is to start GaN technology Space Qualification (2013-2015)
- GaN technology evaluation for space application started in 2010 (ASI TILE 2nd Generation)

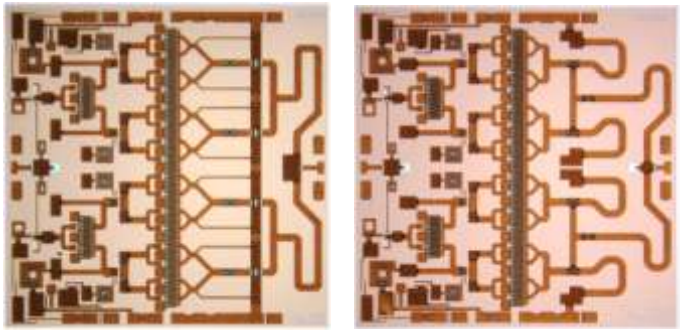
GaAs Technology Development: 0.25 µm PHEMT



Main Characteristics (1 mm gate periphery)

Double recess	**Yes**
Power Density	**> 0.9 W/mm**
MAG	**> 15 dB @ 10GHz**
Breakdown Voltage	**> 18V**
Substrate Thickness	**70 µm**

X Band HPA



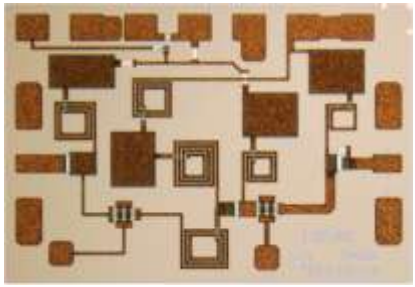
Bias Condition: Vds=8V, Vgs=-0.45V,
3dBc, 50µs, 10%.

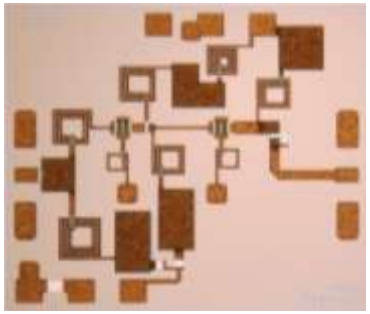
Performance:

	HPA1	HPA2
• Pout (dBm)	39.5	39.5
• Gass (dB)	19.5	15.8
• PAE (%)	35	30

X-Band & C Band Robust LNA (Pin 0.5 W)

Frequency Band: X Band
Bias Condition : Vds=2.5V, Vgs=-0.5.
Noise Figure: 1.5 ±0.1dB.
Gass 19 dB
Power Dissipation < 0.15 W





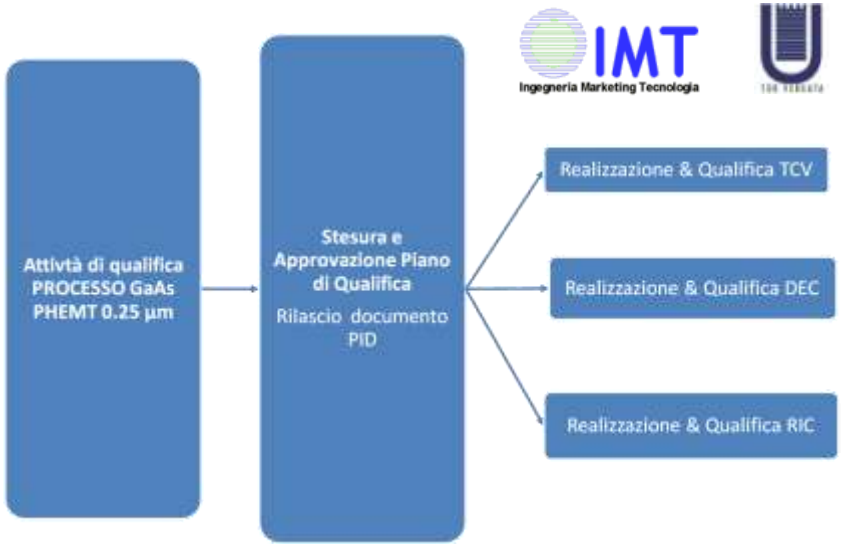
Frequency Band : C Band
Bias Condition : Vds=2.5V, Vgs=-0.5.
Noise Figure: 1.2 ±0.1dB.
Gass 20 dB
Power Dissipation < 0.15 W

QUAGAS: 0.25 µm PHEMT Technology Space Qualify

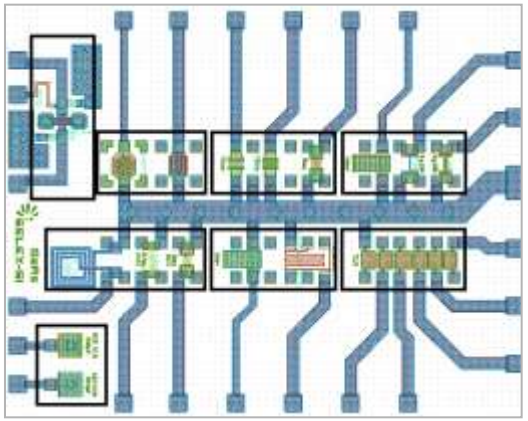
Partners:

- **SELEX ES; Università Roma Tor Vergata, Università di Padova, IMT**

- **Main objectives:**
- Promote the development of enabling technologies used in future space programs consistent with institutional ASI programs
- Obtain Capability Approval from ESSC/ESA
- Increase the competitiveness of the National and European industry



- **Action:**
- Manufacture Evaluation
- Definition of the capability domain and its boundaries
- Definition, review and agreement of the test structure
- Definition & Evaluation of test programme
- Assembly of test structures
- Initial Measurements and design system assessment
- Evaluation testing review



- **The programme spans 19 months and it is scheduled to be completed by the end of April 2014 - work started in September 2012.**

Selex ES
A Finmeccanica Company

Questions