United Monolithic Semiconductors




UMS III-V Compound Semiconductors

- ECI Presentation Days 2016 -

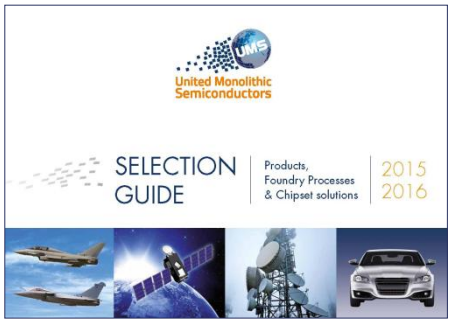
UMS at a glance

- European source of RF MMIC solutions, GaAs and GaN foundry services
- Industrial facilities in:
  - **Ulm (Germany)**: GaAs & GaN technology development and production
  - **Villebon (France)**: product development, back-end production and support
- >80 M€ turnover (2015)
- 390 people
- Long heritage of supplying to most demanding applications

Product offer

From DC up to 110GHz

Catalogue



~ 200 Products

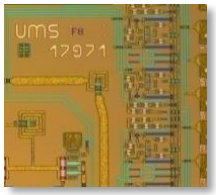
- Power Amplifiers up to 200W
- Very Low Noise Amplifiers
- Mixed signal functions
- Multichip modules

Asic

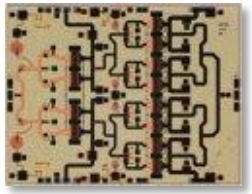
20 RF designers

Technology Platform

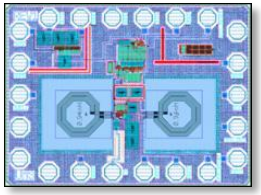
GaAs



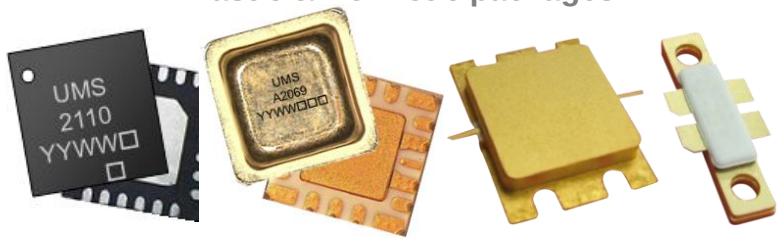
GaN



SiGe



Plastic & Hermetic packages



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Our Markets

Defence & Security

- Phased Array Radar
- Electronic Warfare
- Communications

Space

- Communications
- Earth Observation
- Scientific Missions

Automotive ISM

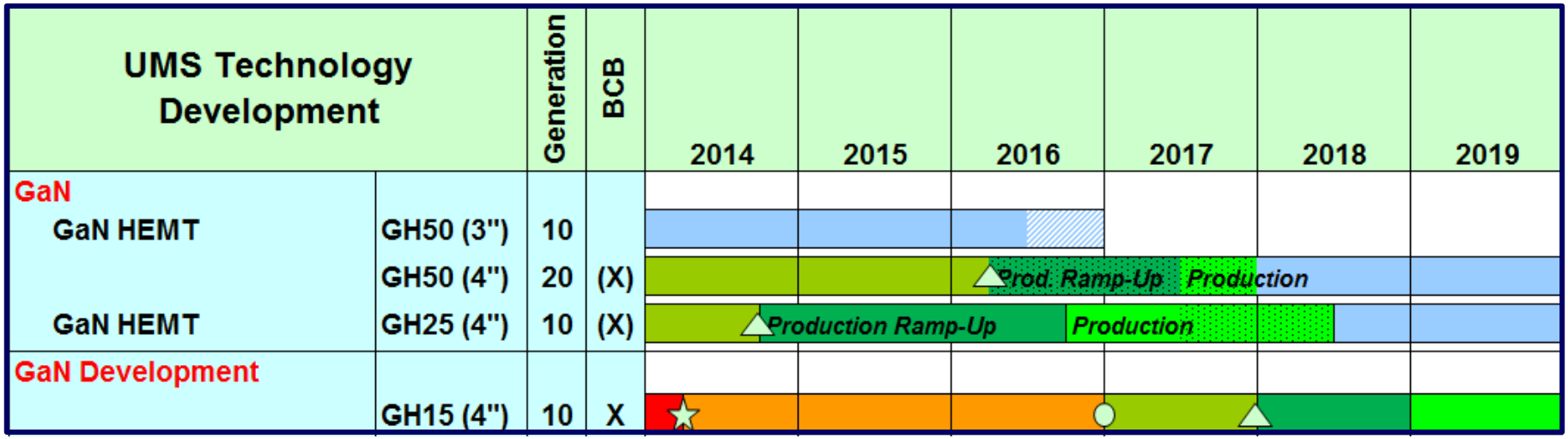
- Long Range Radar
- Short Range Radar
- Industrial Sensors

Telecom

- Point to Point
- VSAT Terminal
- Base Stations

UMS strategic markets

UMS GaN Technologies Roadmap



- Research
- Research & Development
- Qualification
- Production Ramp-Up
- Production
- Space Evaluation
- Space Evaluated / EPPL

- ☆ Decision / Spec Definition; M1
  Performance Achievement; M2
- ○ Process Freeze; M3
- △ Qualification; M4

	GH50	GH25	GH15
Gate length	**0.50µm**	**0.25µm**	**0.15µm**
Power	**5 W/mm**	**4 W/mm**	**3.5 W/mm**
Operating Vds	**50 V**	**30 V**	**20V**
Breakdown voltage (Vbds)	**>200 V**	**>120 V**	**>80 V**
Domain of frequencies	**Up to 7GHz**	**Up to 20GHz**	**Up to 40GHz**

GaN technologies @ UMS

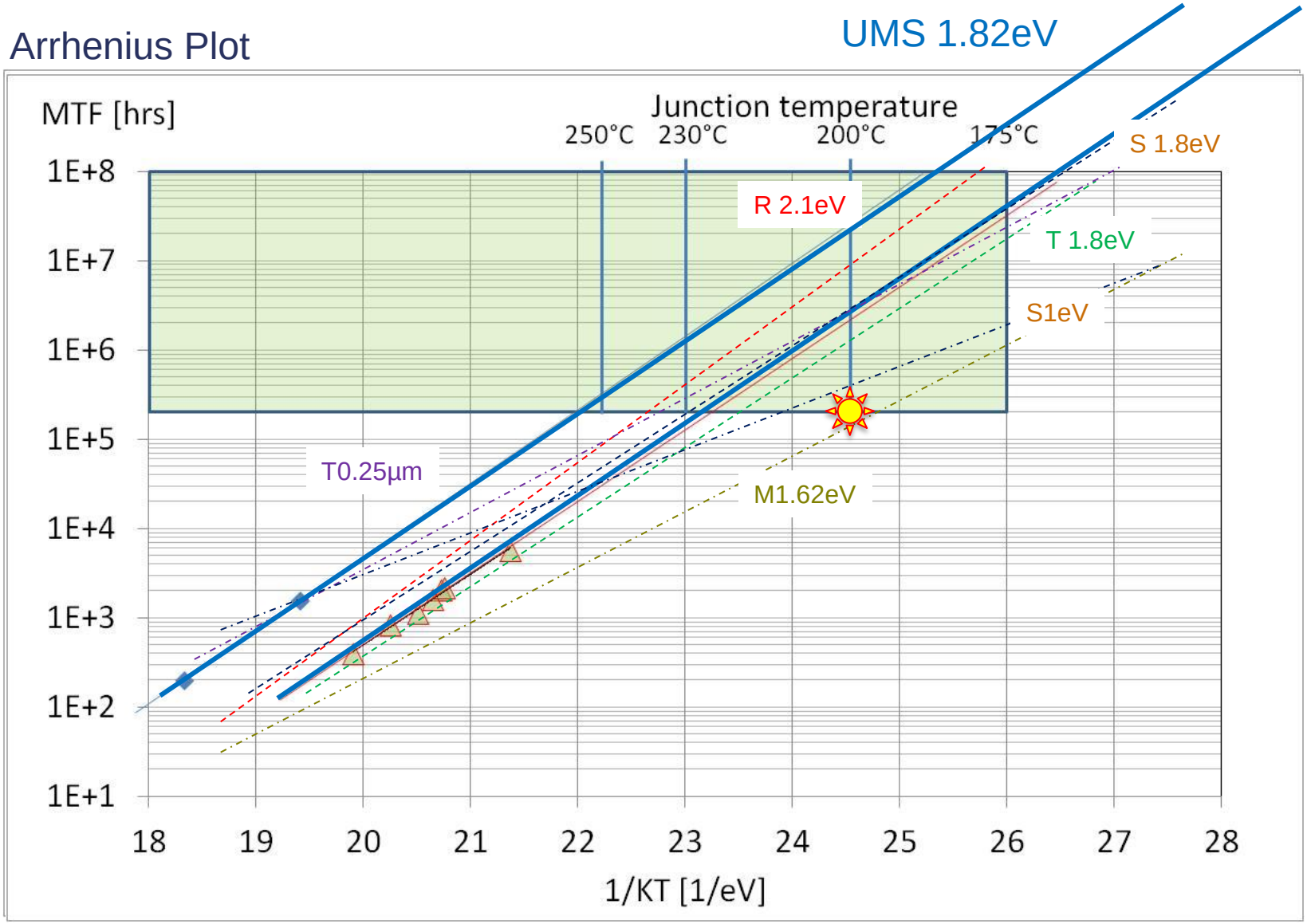
- 2005: Beginning of the GaN development
- 2011: 1st European GaN technology qualified GH50-10
- 2012: 1st GaN technology space evaluated (ESA/EPPL), GH50-10
- 2014: 1st GaN MMIC technology qualified in Europe: GH25
- 2016: GH50-20 qualification

today

- 2017: GH15 qualification
- 2018: GH25 & GH50-20 space evaluated

Wear out mechanism (T_{50}) on 3GH50-10

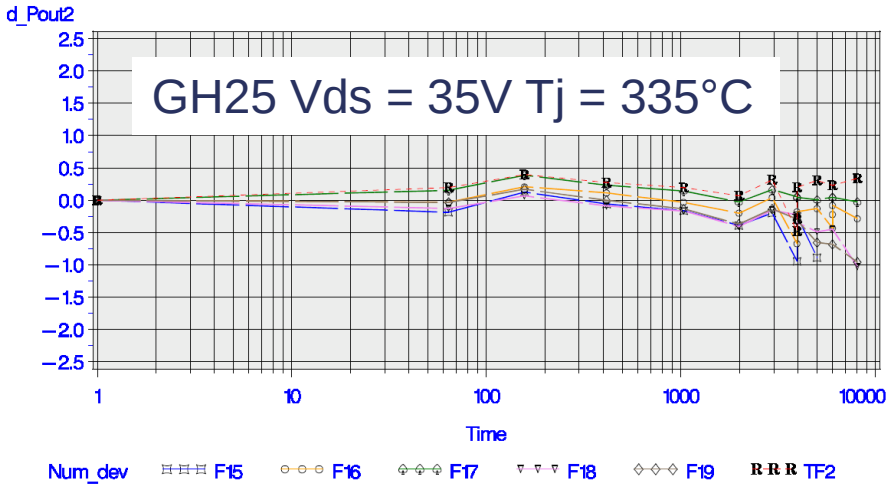
- Arrhenius Plot

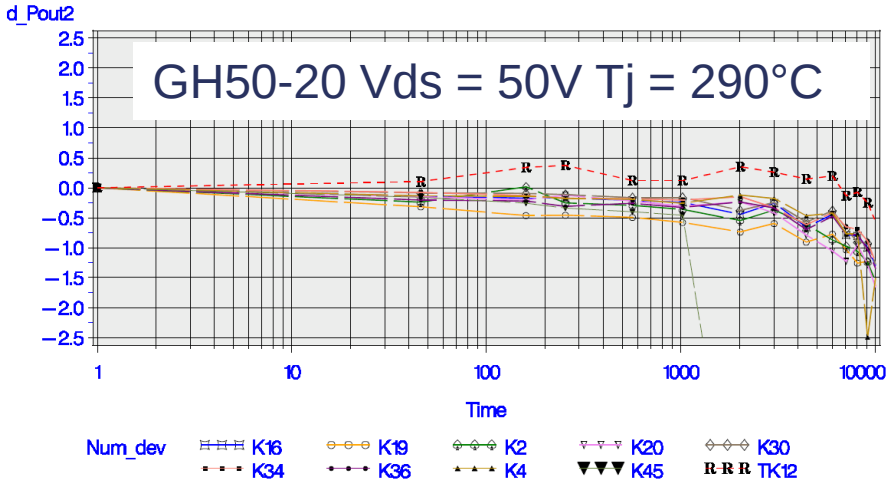


GaN technologies exhibit end of life Ea around 2eV

End of life: latest results on GH25 / 4GH50-20

- GH25 and GH50-20 benefit from GH50-10:
  - Gate leakage current have been reduced => Run-away reduced
  - Pout drift becomes the 1st end of life mechanism.





Degradation start after ~ 6000hr

…..difficulties to extract time to failure

But Life Time significantly higher than GH50-10

Failure rate: product qualification (GH50)

Product	Environmental tests								Ageing tests							
	Preconditionning MSLx @ 260°C		Temperature cycling		High Temperature Storage		Autoclave test		HTOL		THB		RFLT		ESD	
		Qty	-55°C->+125°C	Qty	+150°C	Qty	+121°C / 15psi 100%RH	Qty	Tj=200°C	Qty	+85°C/ 85% RH	Qty	Tj=200°C	Qty	Class	
CHZ015A-QEG	PC MSL3	64	500cycles	60	1000H	34			4x1000H	60	3x1000H	45	2x1000H	8	HBM : Class 1B MM : Class B	
CHK015A-QIA	PC MSL3	192	500cycles	32	3x1000H	96			3x1000H	45	3x1000H	45	3x1000H	12	HBM : Class 1B MM : Class A	
CHK015A-SMA			3x500cycles	60			3x96H	60			3x1000H	45				
CHK025A-SOA													1x1000H	4		
CHK040A-SOA			3x500cycles	60					3x1000H	60					HBM : Class 1B MM : Class B	
CHZ050A-SEA													1x1000H	4		
CHK080A-SRA													1x1000H	4		
CHKA011-SXA			2x500cycles	20											HBM: Class 1C MM: Class B	
CHZ180A-SEB			3x500cycles	15					3x1000H	45			2x1000H + 1x2000H	12	HBM: Class 2 MM: Class 4(500V)	

Sucessfull product qualification support the manufacturability

- More than 600 devices tested
- More than 38 000 hrs of life test

4GH50-20 - space evaluation project (ECI-4)

- ESA Contract No. 4000116120/16/NL/BJ "GREAT2 phase 3.1 – GaN process performance validation and space evaluation (GH 50-20)" → ECI-4
  - Phase 1: Space evaluation of the GH50-20
    - up to 25.6mm power bar
    - Completion : 2017
  - Phase 2: Capability approval on product families
    - 15/40/100W unmatched package product up to S band
    - Completion : 2018

GREAT2 P3.1 - Detailed Study Flow

Phase 1 Space evaluation

Technology Domain 2
GH50-20, EU design, V3, **70µm pitch, 400µm finger**

Reliability testing
on DEC3 and RIC3
- ST on wafer/PCM
- HTRB on DEC
- HTOL on DEC
- HTOL on DEC
- RFSST on DEC
- DCLT on RIC
- RFLT on RIC

RFLT test: RIC3
*8*8*400_EU_70_V3*

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cicor

Technology Domain 1
GH50-20, EU design, V3, **70µm pitch, 250µm finger**

DCLT test: RIC2
*6*8*250_EU_70_V3*

RFLT test: RIC2
*2*8*250_EU_70_V3*

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TESAT SPACECOM

Phase 2 Capability Approval

Product Domain B
70µm/400µm, KYOCERA package

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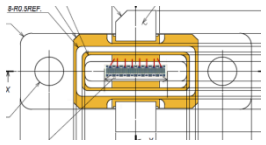
RIC3: 100W
*8*8*400_EU_70_V3*
- testing according to
Chart I



Product Domain A
70µm/250µm, Schott package

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TESAT SPACECOM

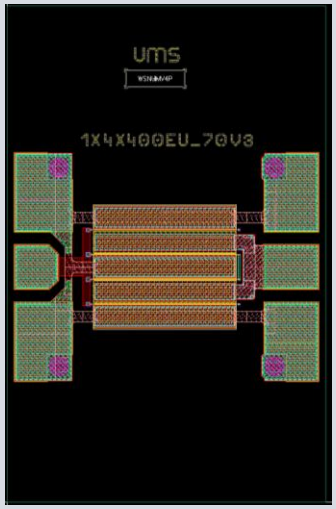
RIC2 40 W
*6*8*250_EU_70_V3*
- testing according to
Chart I reduced

RIC1 15W
*2*8*250_EU_70_V3*
-testing according to
Chart II

GREAT2 P3.1 - Test vehicles (all EU layouts)

DECs

- DEC3
  - Gate periphery: 1*4*400µm
  - Gate to gate pitch: 70µm
  - Egide package

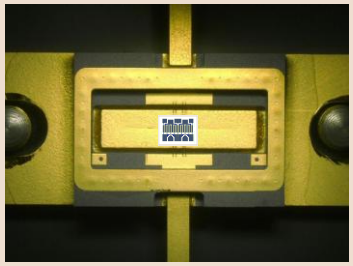


Space evaluation

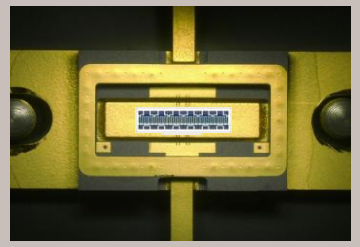
RICs

Capability approval

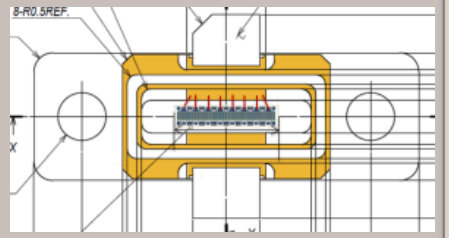
- RIC1 (15W)
  - One 4mm power bar
  - BIO15 Schott package



- RIC2 (40W)
  - One 12 mm power bar
  - Schott package



- RIC3 (100W)
  - One 25.6mm power bar
  - New Kyocera package



GREAT2 P3.1 - Space Evaluation Test Plan

Domain 2

Environmental Tests (2269010 chart IA Group 2B, 2265010 chart IB Group 2B)							
Set Name	**Test Type**	**Device**	**Ta**	**Tj**	**time**	**Samples**	**Remarks**
ST1	storage	Wafer / PCM	275		2000 h	21	
ST2	storage	Wafer / PCM	300		2000 h	21	
Accelerated life test for wear out mechanism (2269010 chart IA Group 2A, 2265010 chart IB Group 2A)							
HTRB1b	high temp. reverse bias	DEC3	175		2000 h	10	100 V, -7 V
HTOL3a	high temp. operation life time	DEC3		320	50% Fails	10	50 V, 100 mA/mm
HTOL4	high temp. operation life time	DEC3		300/ 340	50% Fails	10	50 V, 100 mA/mm
DCLT5	dc life time	RIC3a		235	4000 h	15	50 V, 50 mA/mm
RFLT1	rf life time	DEC3		250	4000 h	4	50 V, 50 mA/mm, max PAE
RFLT4	rf life time	RIC3a		230	4000 h [1]	4	50 V, 50 mA/mm, max PAE
Maximum rating (2269010 chart IB2 subgroup 2E)							
RFSST2	rf step stress	DEC3	80		up to 1st fail	4	40 V +5 V/cycle
Radiation (2269010 chart IA Group 3A, 2265010 chart IB Group 3A)							
SEE1	Rad Hi DC	RIC3a				10	
SEE2	Rad Hi RF	RIC3a				10	
TID1	Rad Co60	RIC3a				10	
DD1	Rad -Proton	RIC3a				5	

Domain 1

Endurance test for failure rate estimation							
DCLT4	dc life time	RIC2		250	2000 h	20	50 V, 50 mA/mm
RFLT2	rf life time	RIC2		210 [2]	4000 h	4	50 V, 50 mA/mm, max PAE

GREAT2 P3.1 - Capability approval test plans

RIC3

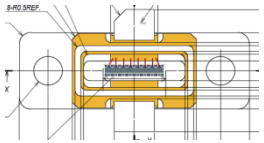
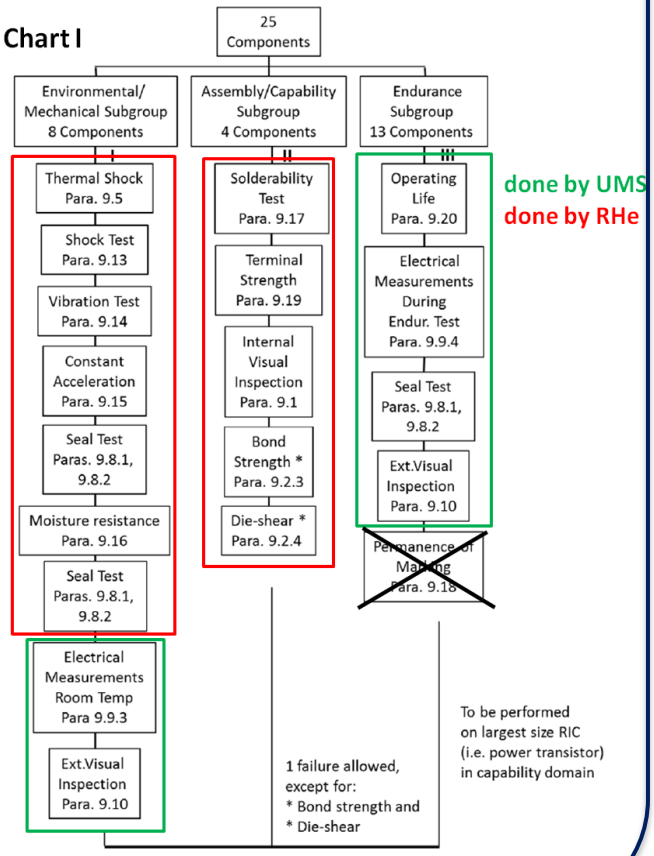


Chart I



RIC2

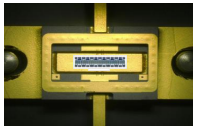
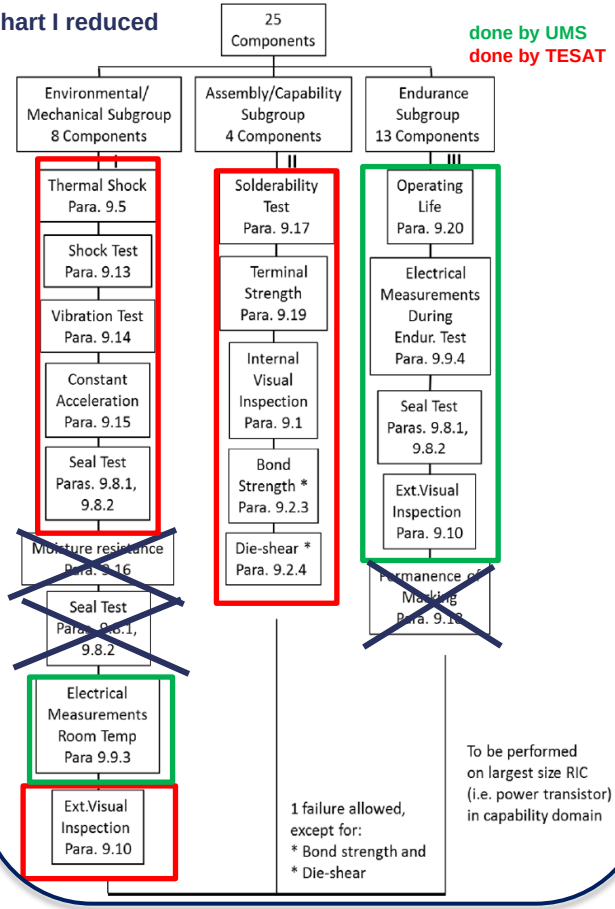


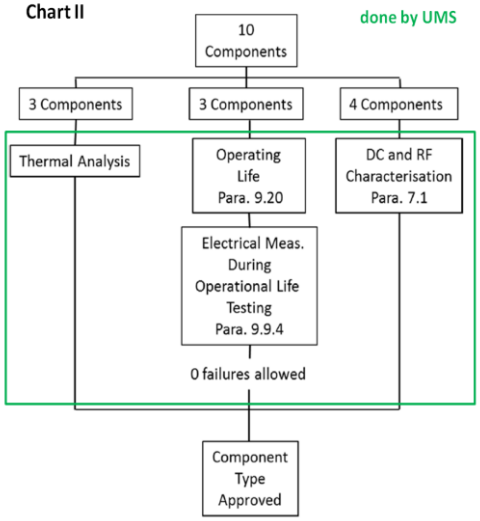
Chart I reduced



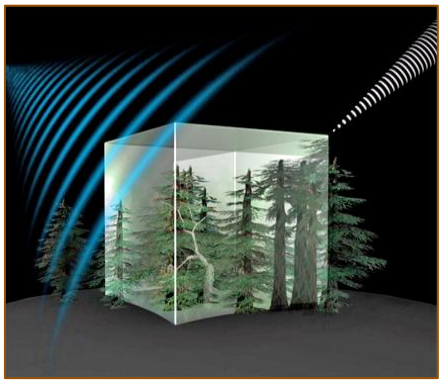
RIC1

Chart II

done by UMS

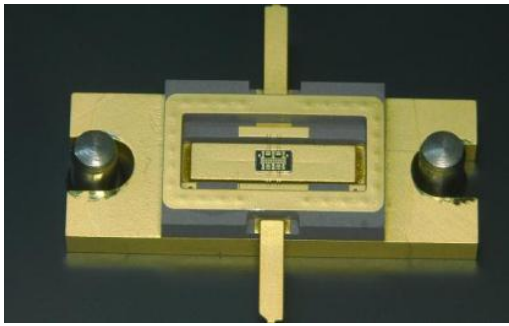


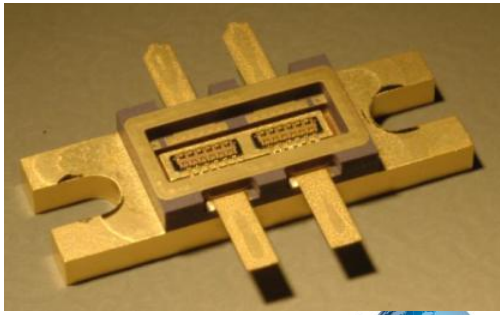
GaN in space: BIOMASS



ESA earth observation mission (launch date: 2021)

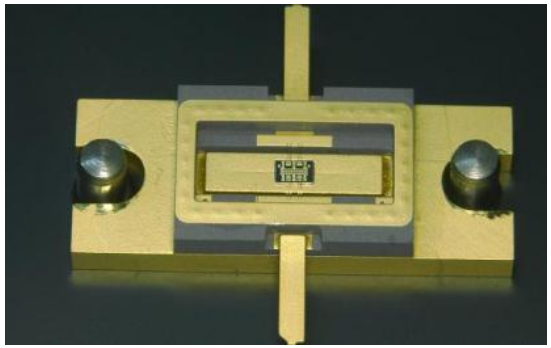
- UMS with partners Tesat and Schott deliver GaN RF power devices for the BIOMASS earth observation satellite
- Driver 15W (BIO15) and PA 80W (BIO80) each in hermetic package based on the 0.5µm AlGaN/GaN on SiC technology => 3GH50-10
- Hermetic packages for 15W and 80W in the frame of BIOMASS already qualified
- Prime selected in March 2016: Airbus UK
  - SSPA designer not yet selected

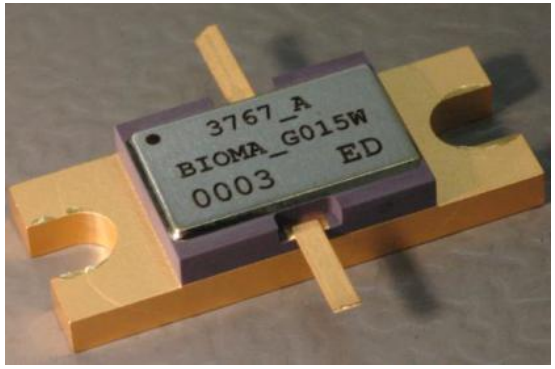




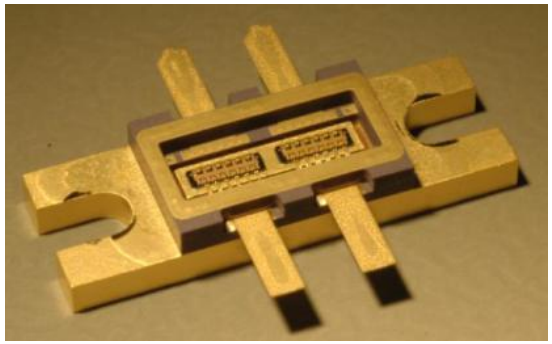
Packaged devices

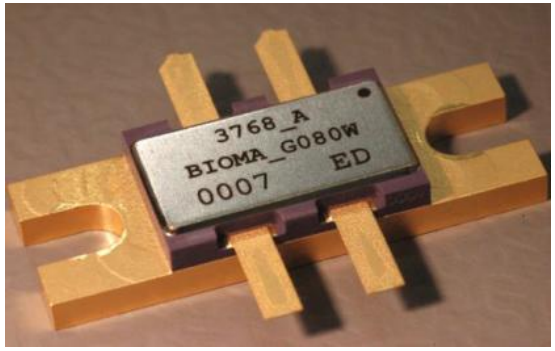
BIO15 (=1x BIO15 chip)





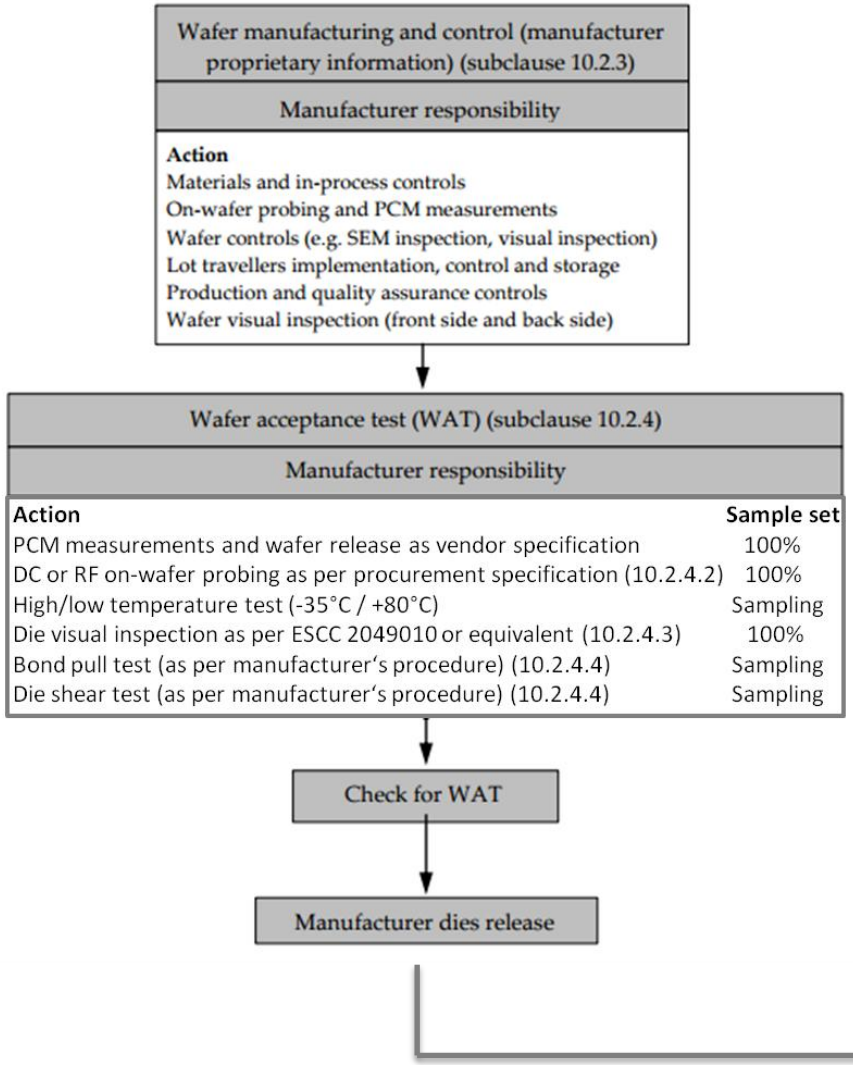
BIO80 (=2x BIO40 chips)



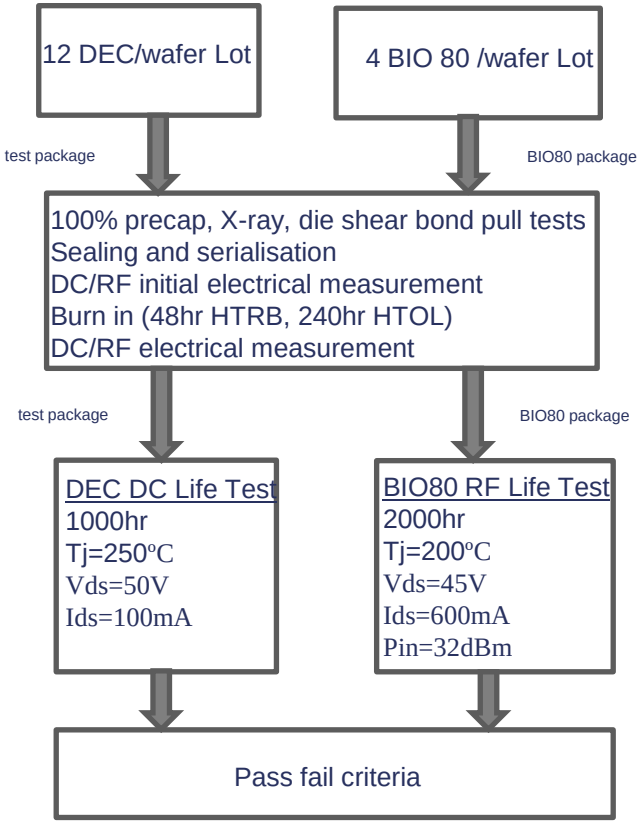


- Hermetic package supplier: Schott
- Packaging: Tesat Spacecom

Wafer Lot Acceptance flow @ BIOMASS

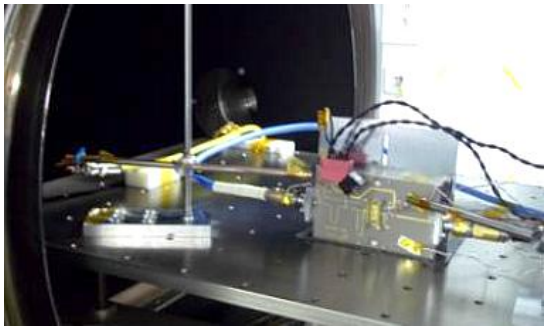


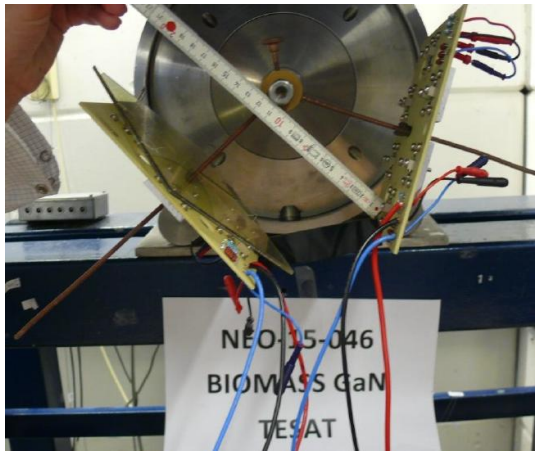
Modified LAT flow for BIOMASS



Radiation and Corona & Multipaction tests

- ✔ No Multipaction (vacuum) and Corona discharge (varying pressure) over Biomass operating range
  - RF power level up to 50.5dBm
  - -35ºC to +65ºC temperature range
- ✔ No Total Ionising Dose (TID) effect on DC or RF parameters up to 1 Mrad HDR observed
  - ^{60}Co irradiation: 21.4 krad / h (HDR) up to 1 Mrad
  - 3 biased + 3 unbiased + control device: BIO15 & 80
- ✔ No Total Non Ionising Dose (TNID) effect up to 1.5E12 (35MeV) p/cm² observed
  - Proton Irradiation: 35 MeV up to 1.5E12 p/cm²
  - 3 biased + 3 unbiased + control device: BIO15 & 80
- ✔ No Heavy ion radiation effects under nominal Biomass RF operating conditions
  - Rated drain voltage VDS =45V
  - P4dB : BIO15->Pout=19W, BIO 80->Pout=100W





Summary

- UMS GaN technologies are now **MATURE** and ready for use in space applications
  - GH50-10 - space evaluated
  - GH50-20 - space evaluation started
    - Technology space evaluated 2017
  - GH50-20 with BCB option - qualification Q1-2017
    → plastic package
  - GH25 - ready for space evaluation!!!
  - GH25 with BCB option - qualification Q2-2017
    → plastic package
  - New challenge: GH15!

UMS GaAs Components

- Development and Space Validation of a European MMIC K-Band Power Amplifier (ECI-2)
- Development and Space Validation of a European MMIC Voltage Controlled Oscillators (ECI-3)

Objective and work plan

- Development and space validation of a MMIC K-band power amplifier for space applications using an ESCC evaluated MMIC process from a European foundry (PPH15X-10)

Main contract inputs

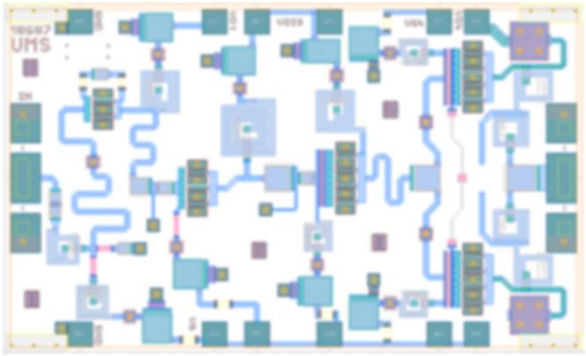
Date of notification : 1st April 2010
Contract duration : 4 months for Phase 1
20 months for Phase 2

UMS : Contractor (Design and process evaluation)
TAS-F : sub-contractor (MMIC space evaluation)

- The work performed during the contract was divided in four main tasks:
  - K-Band PA Commercial evaluation and PA preliminary design
  - PA design activities
  - Manufacturing and full characterisation of the PA
  - Process and MMIC PA space validation

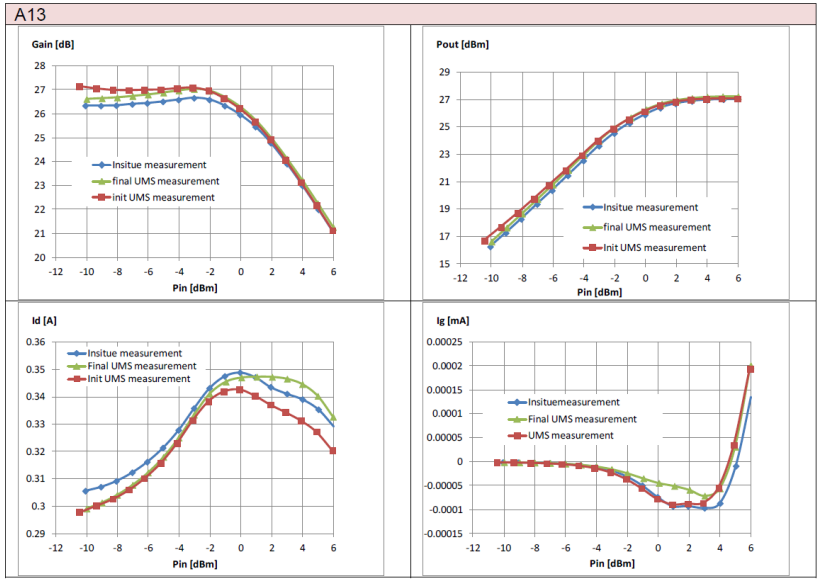
K-Band PA summary results (1st & 2nd run)

Parameters		Requirements			Measurements results 1st Run			Measurements results 2nd Run			Units
		Min	Typ	Min	Nom	Typ	Max	Min	Typ	Max	
Operating temperature range T_A		-40	25	+60	-40	25	+60	-40	25	+60	°C
Operating Frequency		17		24	17		24	17		24	GHz
Small-Signal Return Loss	Input		-11			-16			-12		dB
	Output		-18			-12			-12		dB
Linear Gain		20	24			26.5			27.5		dB
Gain Flatness (over operating Frequency range)				+/-1			0.75			0.75	dB
Output Power Operating Point (P1dB)		20	25		25.5	26.5		25.5	27.5		dBm
Psat			26.5			27.5			28.5		dBm
OIP3			34			35			35		dBm
Supply current			250			300			300		mA
Vd			6			6			6		V



Radiation testing (SEE with D+RF)

Run	Pin (dBm)	Compression @ Pin = -10dBm (dB)	Vds (V)	Part	Ion	Energy (MeV)	Range (µm)	LET (MeV.cm²/mg)	Flux (φ) (cm-2.s-1)	Time (s)	Run Fluence (Φ) (cm-2)	Run Dose (krad)	Cumulated Dose (krad)	Pass/Fail	Cross Section
High LET M/Q=5															
1	4.0	3.4	6	A13	124Xe 26+	420	25	46.7	9.80E+03	1020	1.00E+07	7.472	7.472	Pass	<1.00E-07
2	4.4	3.8	6	A13	124Xe 26+	420	25	46.7	1.03E+04	974	1.00E+07	7.472	14.944	Pass	<1.00E-07
3	4.8	4	6	A13	124Xe 26+	420	25	46.7	1.05E+04	953	1.00E+07	7.472	22.416	Pass	<1.00E-07
4	5.0	4	6	A11	124Xe 26+	420	25	46.7	1.53E+04	654	1.00E+07	7.472	7.472	Pass	<1.00E-07
5	4.8	4	6	A15	124Xe 26+	420	25	46.7	1.52E+04	660	1.00E+07	7.472	7.472	Pass	<1.00E-07
6	5.0	4	6	A14	124Xe 26+	420	25	46.7	1.51E+04	663	1.00E+07	7.472	7.472	Pass	<1.00E-07
7	7.0	5	6	A13	124Xe 26+	420	25	46.7	1.51E+04	664	1.00E+07	7.472	7.472	Pass	<1.00E-07
8	7.8	6	6	A13	124Xe 26+	420	25	46.7	1.52E+04	658	1.00E+07	7.472	14.944	Pass	<1.00E-07
9	8.8	7	6	A13	124Xe 26+	420	25	46.7	1.51E+04	664	1.00E+07	7.472	22.416	Pass	<1.00E-07
10	7.0	5	7	A13	124Xe 26+	420	25	46.7	1.51E+04	664	1.00E+07	7.472	29.888	Pass	<1.00E-07
11	7.0	5	7	A12	124Xe 26+	420	25	46.7	1.52E+04	660	1.00E+07	7.472	7.472	Pass	<1.00E-07



No change in DC and RF characteristics after irradiation up to Vds=7V and flux1E7 ion/cm2 (sample A13)

K-Band PA products and EPPL

united monolithic semiconductors

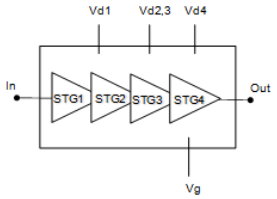
CHA5350-99F

17-24GHz Medium Power Amplifier

GaAs Monolithic Microwave IC

Description

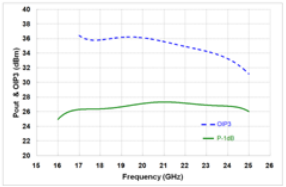
The CHA5350-99F is a four stage monolithic MPA that typically provides an output power of 26.5dBm at 1dB gain compression associated to a high IP3 output of 34dBm.
It is designed for a wide range of applications, from professional to commercial communication systems.
The circuit is manufactured with a pHEMT process, 0.15µm gate length, via holes through the substrate, air bridges and electron beam gate lithography.
It is available in chip form.



Main Features

- Broadband performances: 17-24GHz
- Linear gain = 26dB
- Pout = 26.5dBm @ 1dB comp.
- High OIP3 = 34dBm
- DC bias: Vd=6Volt @ Id=300mA
- Chip size 2.38x1.46x0.07mm

Pout +IP3



Main Electrical Characteristics

Tamb.= +25°C

Symbol	Parameter	Min	Typ	Max	Unit
Freq	Frequency range	17		24	GHz
Gain	Linear Gain		26		dB
P_{-1dB}	Output Power @1dB gain compression		26.5		dBm
OIP3	Output third order interception point		34		dBm

Ref. : DSCHA5350 3018 - 18 Jan 13 1/12 Specifications subject to change without notice
United Monolithic Semiconductors S.A.S.
Bât. Charmille - Parc SILIC - 10, Avenue du Québec - 91140 VILLEBON-SUR-YVETTE - France
Tel.: +33 (0) 1 69 86 32 00 - Fax: +33 (0) 1 69 86 34 34

EPPL Part 2. Microwave Monolithic Integrated Circuits (MMIC):

Type	Description	Manufacturer	Qualification	Remarks
PH25	GaAs process, 0.25µm P-HEMT for low noise, low level applications up to 100GHz	UMS / F	Others	
HB20P	HBT GaInP/GaAs Foundry Process, 0.7 µm GateApplications in Power Amplifiers up to Ku Band	UMS / F	Others	
PPH15X-10	GaAs process, 0.15µ P-HEMT. Absolute Maximum Ratings (AMR) for PPH15X-10: Drain to Source Voltage: Vds = 8V at Ids = 150mA/mm Maximum instantaneous RF Drain to Gate Voltage: Vdgmax = 14V at the maximum DC Operating point specified above (Vds = 8V and Ids = 150mA/mm) RF Compression = 7dB for Power matched 8x75m cell at Ids = 150mA/mm and Vds = 7V - Gate to Source Voltage: Vgs = -2.5V	UMS / F	Others	SEE testing under DC+RF was performed – report available from the manufacturer
CHA5350-99F	K-band Power Amplifier in die form. Available in accordance with ESCC 9012/002	UMS / F	Others	Made on PPH15X-10 process

Detail specifications 9012/002 available under:
https://escies.org/specification/listpubspecs?pubcode=89&family=12

UMS GaAs Components

- Development and Space Validation of a European MMIC K-Band Power Amplifier (ECI-2)
- Development and Space Validation of a European MMIC Voltage Controlled Oscillators (ECI-3)

Objective and work plan

- Development and space validation of European MMIC Voltage Control Oscillators (2 VCOs) for space applications using an ESCC evaluated MMIC technology from a European foundry (HB20M)

  Main contract inputs

  Date of notification : T0 = January 2nd, 2013
  UMS : Contractor (HBT technology and space evaluation)
  TAS-F : Sub-contractor (VCO designs and characterizations)

- The work performed during the contract was divided in four main tasks:
  - Commercial VCO evaluation and VCO preliminary design
  - VCO design activities
  - Manufacturing and full characterization of the VCOs
  - Process and VCO space validation

VCO products and EPPL

United Monolithic Semiconductors

CHV1203-98F

Low Phase Noise S band HBT VCO

GaAs Monolithic Microwave IC

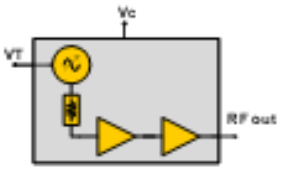
Description

The CHV1203-98F is a low phase noise S band HBT voltage controlled oscillator that integrates negative resistor, varactors and buffer amplifiers. It provides an excellent phase noise of 108dBc/Hz at100khz offset.

It is designed for a wide range of applications, from space to commercial communication systems.

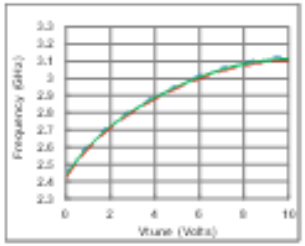
The circuit is fully integrated on InGaP HBT process: 2µm emitter length, via holes through the substrate and high Q passive elements.

It is available in chip form.



Main Features

- S-band VCO + S buffers
- Fully integrated VCO
  (no need for external resonator)
- Low phase noise
- High frequency stability
- On chip self-biased devices
- Available in bare die
- Chip size: 2.77x2.77mm²



United Monolithic Semiconductors

CHV1206-98F

Low Phase Noise C band HBT VCO

GaAs Monolithic Microwave IC

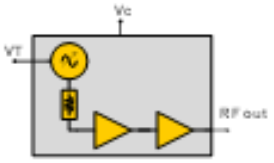
Description

The CHV1206-98F is a low phase noise C band HBT voltage controlled oscillator that integrates negative resistor, varactors and buffer amplifiers. It provides an excellent phase noise of100dBc/Hz at100khz offset.

It is designed for a wide range of applications, from space to commercial communication systems.

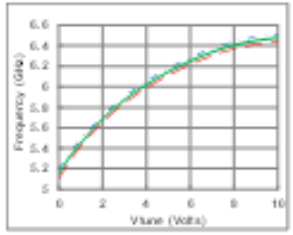
The circuit is fully integrated on InGaP HBT process: 2µm emitter length, via holes through the substrate and high Q passive elements.

It is available in chip form.



Main Features

- C-band VCO + C buffers
- Fully integrated VCO
  (no need for external resonator)
- Low phase noise
- High frequency stability
- On chip self-biased devices
- Available in bare die
- Chip size: 2.77x2.77mm²



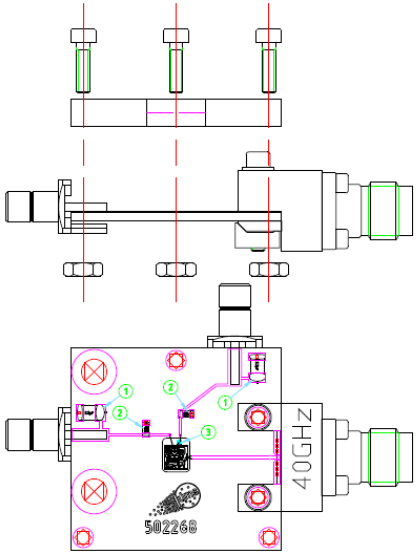
(continued) EPPL Part 2. Microwave Monolithic Integrated Circuits (MMIC):

Type	Description	Manufacturer	Qualification	Remarks
HP07-20	MMIC, GaAs Foundry Process, MESFET 0.7 um for power applications up to Ku Band. Replacement of HP07 Process by HP07-20 process due to a change in the gate lithography process	UMS / F	Others	DO NOT USE BEYOND Vgdmax/2 DUE TO SENSITIVITY TO HEAVY IONS.
HB20M	Mixed digital/analog MMIC HBT process InGaP HBT (Application in mixed digital/analog circuits up to Ku band	UMS / F	Others	SEE to be considered (digital elements)
CHV1203-98S	Voltage controlled oscillator 2.75 – 3 GHz Available in accordance with ESCC 9012/003	UMS / F	Others	Made on HB20M process
CHV1206-98S	Voltage controlled oscillator 5.5 – 6.1 GHz Available in accordance with ESCC 9012/004	UMS/F	Others	

Detail specifications available under:
https://escies.org/specification/listpubspecs?pubcode=89&family=12

VCO2 - Space validation

TEST FILE	DC life Test
FUNCTION	VCO2
	Frequency : VCO2=6.1GHz
DC supply	Vtune according to upper frequency, Vc=3V , Ic=78mA
Quantity	10 VCO2 + 2 reference samples whose 1 is unbiased in the oven (2 different lots Astro)
DC Constraints/ Duration	Vc=3V, VT adjusted for upper frequency/ 0,240,500,1240 & 2240 hours
Ambiant T°	Tamb=130°C
Monitoring during stress test	Supply currents
Initial, Intermediate & Final measurement	F0(VT)
	Current on VT and Vc ports
	Output power
	Phase Noise (only measured at 0h, 1240h & 2240h)
Failure criteria	+/-20% current Ic
	+/-1dB Pout
	Max phase noise
	Max current on VT



HB20M technology being space evaluated and listed in EPPL, it was proposed for the validation of the VCOs to base the test plan on the B sequence of the ESCC standard Q-ST-60-12C.

VCO space validation consisted in HTOL of 2000 hours under nominal biasing (burn-in of 240h prior to HTOL). Due to connectors temperature limit range the ambient temperature was fixed at 130°C.

VCO2 – HTOL test

10 parts VCO2 (5 parts from each wafer lot Astro: S054514 wafer 2R064 and S484214 wafer 1R024) + 2 control devices have been submitted to HTOL Life Test

The duration is 240 h (Burn In) followed by 2000h of life test

Test Conditions are:

- Vc=3V
- Vt= 5V (F=6.1GHz).
- Ta=130°C ➔ Tj~135°C

Measurements have been done at:

- 240h
- 500h
- 1240h
- 2240h

Measurements done:
Ic, It, Pout (vs Vt) and Phase Noise

Conclusion

- UMS has been created to ensure non-dependence of our shareholders (Thales / Airbus DS) and other European space and defence stakeholders
  - GaAs HEMT and HBT microwave components (MMICs)
  - GaN-on-SiC technology and components for microwave applications
  - Packaging for microwave and mm-wave components
- ESA European Component Initiative (ECI) is a perfect complement / support for the mission of UMS
  → high interest in past and future!
- UMS is thankful for having ECI and will further support the initiative