

Update on Single Event Effects in GaAs MESFETs

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Background

➤ 1996 on Paper published by a.o. Philippe Calvel (TAS)

“Heavy ions evaluation of GaAs microwave devices”

Barillot, C.; Bensoussan, A.; Brasseur, F.; Calvel, P.

Radiation Effects Data Workshop, 1996., IEEE

Volume , Issue , 19 Jul 1996 Page(s):88 - 93

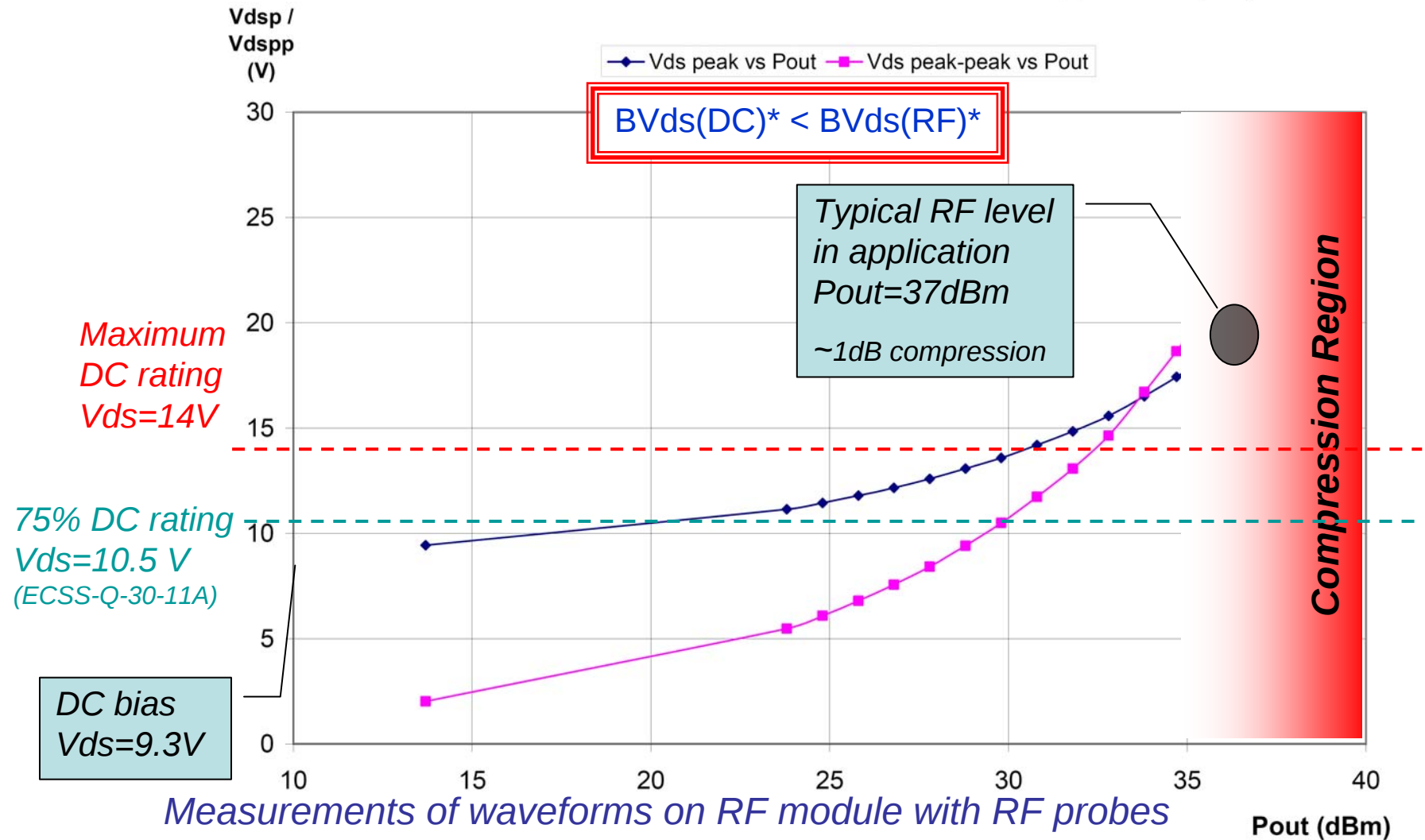
- Several GaAs MESFET and HFET technologies tested
- SEB achieved outside max ratings in conclusion all devices was considered good

➤ ESA In-flight experience of GaAs MESFET:

- One GaAs MESFET device used in power stage of 4 SSPAs, of these SSPAs:
 - 3 failures (non-recoverable)
 - between some few days up to 6 months in operation before failure
 - All anomalies occurred in GCR intense environment.
 - 1 SSPA still operational after 5 years BUT with less severe RF level.

Background

GaAs MESFET in RF power amplifiers



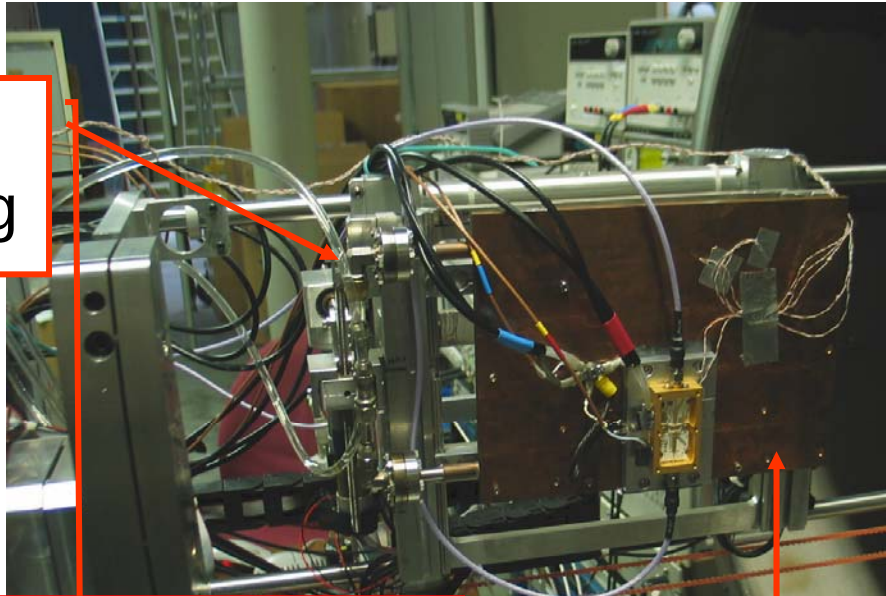
RF Module test setup

- GaAs MESFET tested in RF matched module (flight designs)
- No added protection of gate and drain supply
- Transients and failure can be recorded
- Continuously monitors performance of DUT
- RF signals tested:
 - CW at different RF level
 - Modulated RF signal (e.g. QPSK) at different RF level
- Heat dissipation handled by using copper baseplate with water cooling
 - UCL facility has been upgraded for this purpose

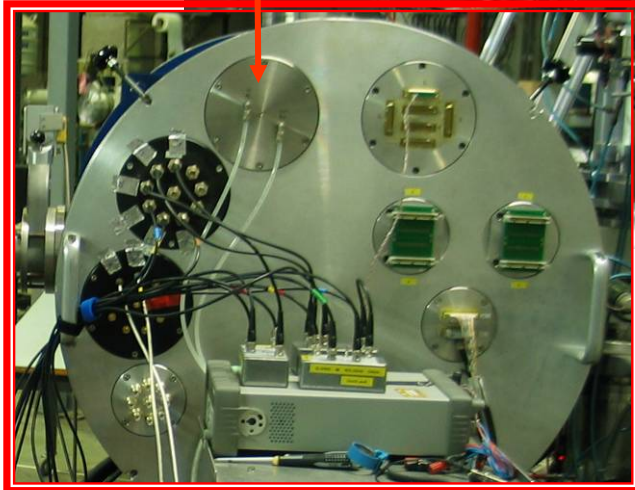
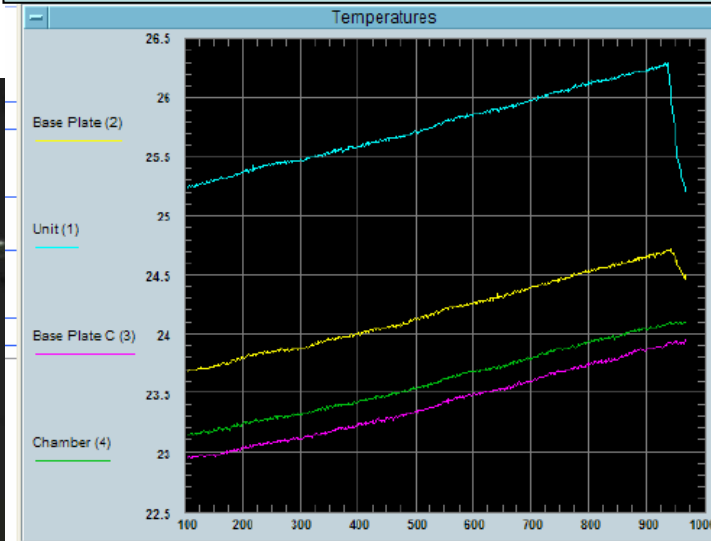
Details on test results and test setup

Base Plate with Water cooling

Water
Cooling



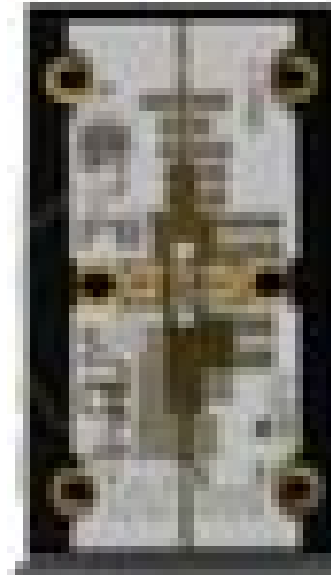
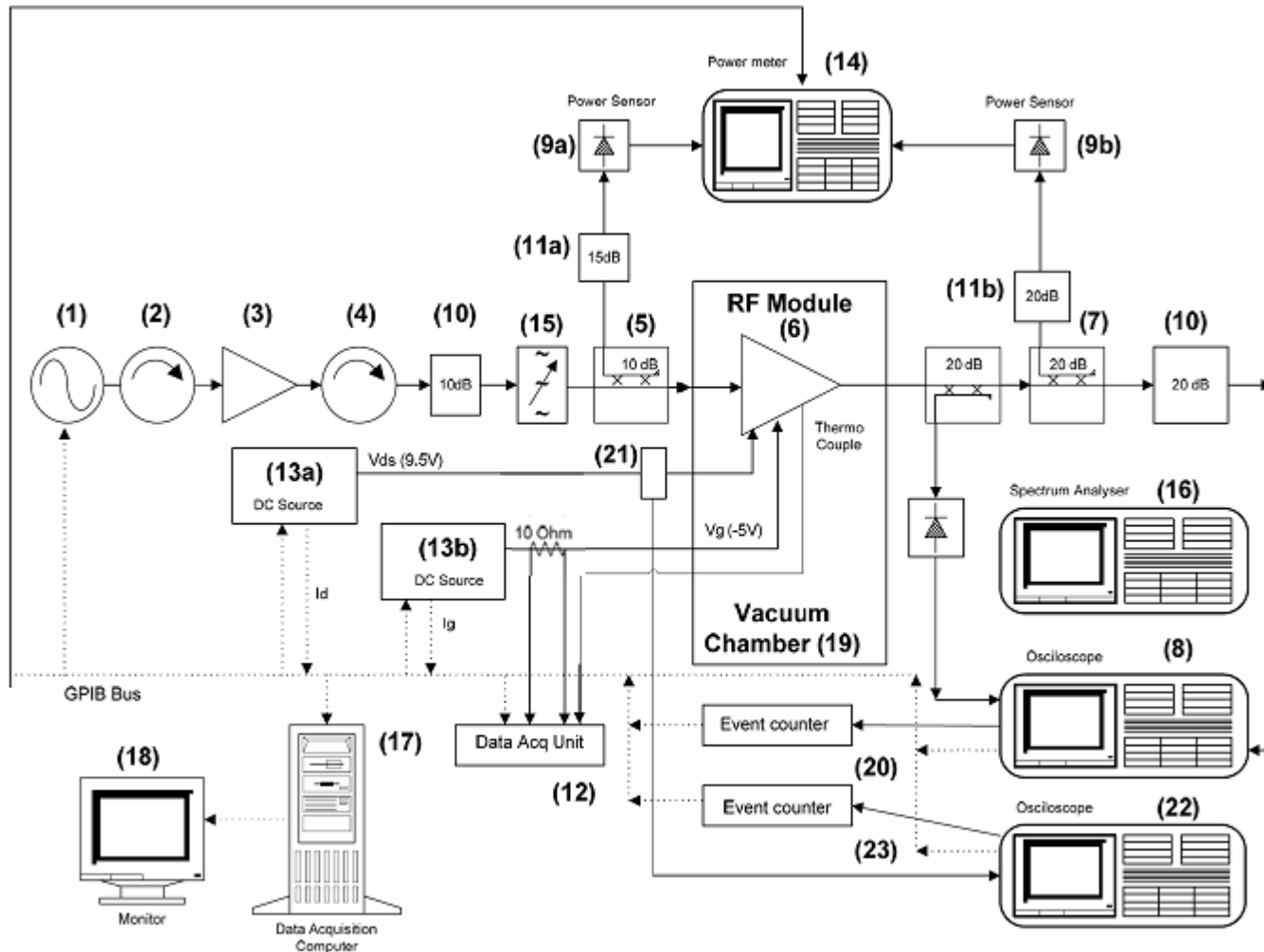
Temperature at Pout=37dBm
Power dissipation ~10Watt



Copper
Base
plate

RF Module Test Setup

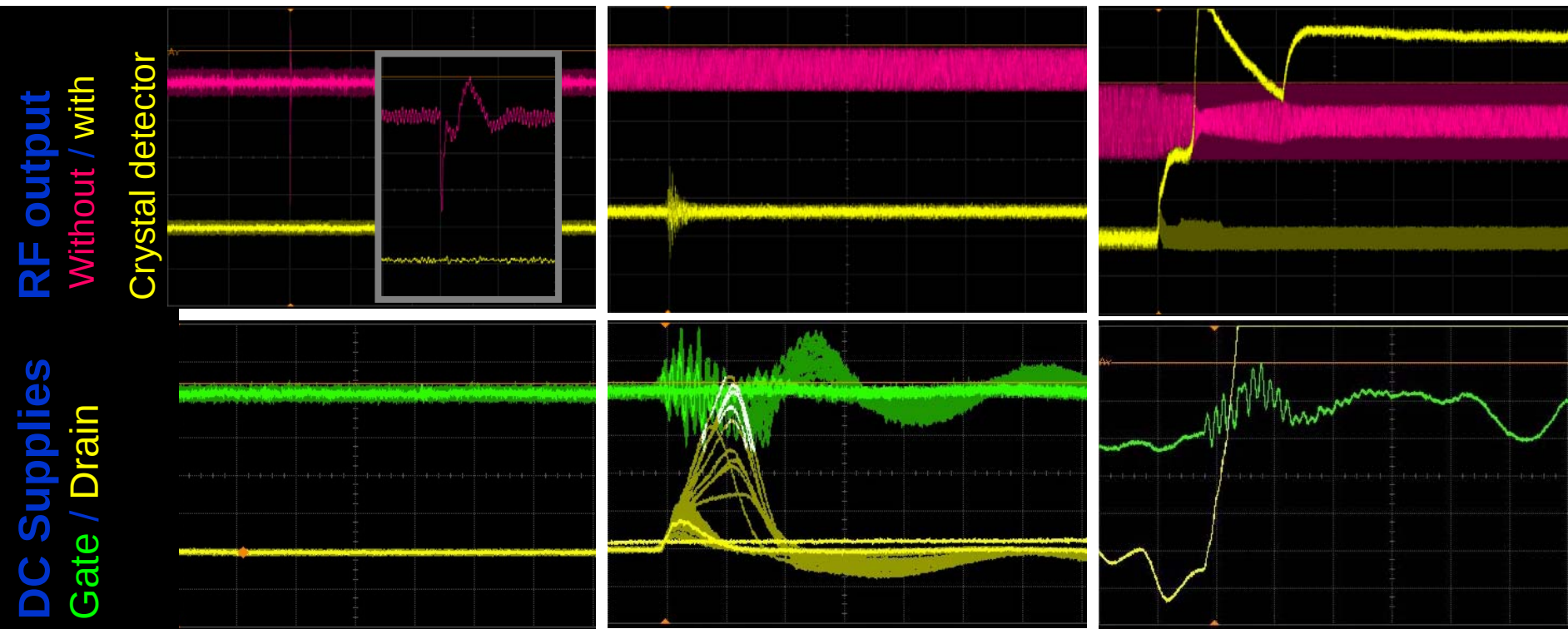
GaAs MESFET tested in RF matched flight module



Type of Events in RF Module test setup

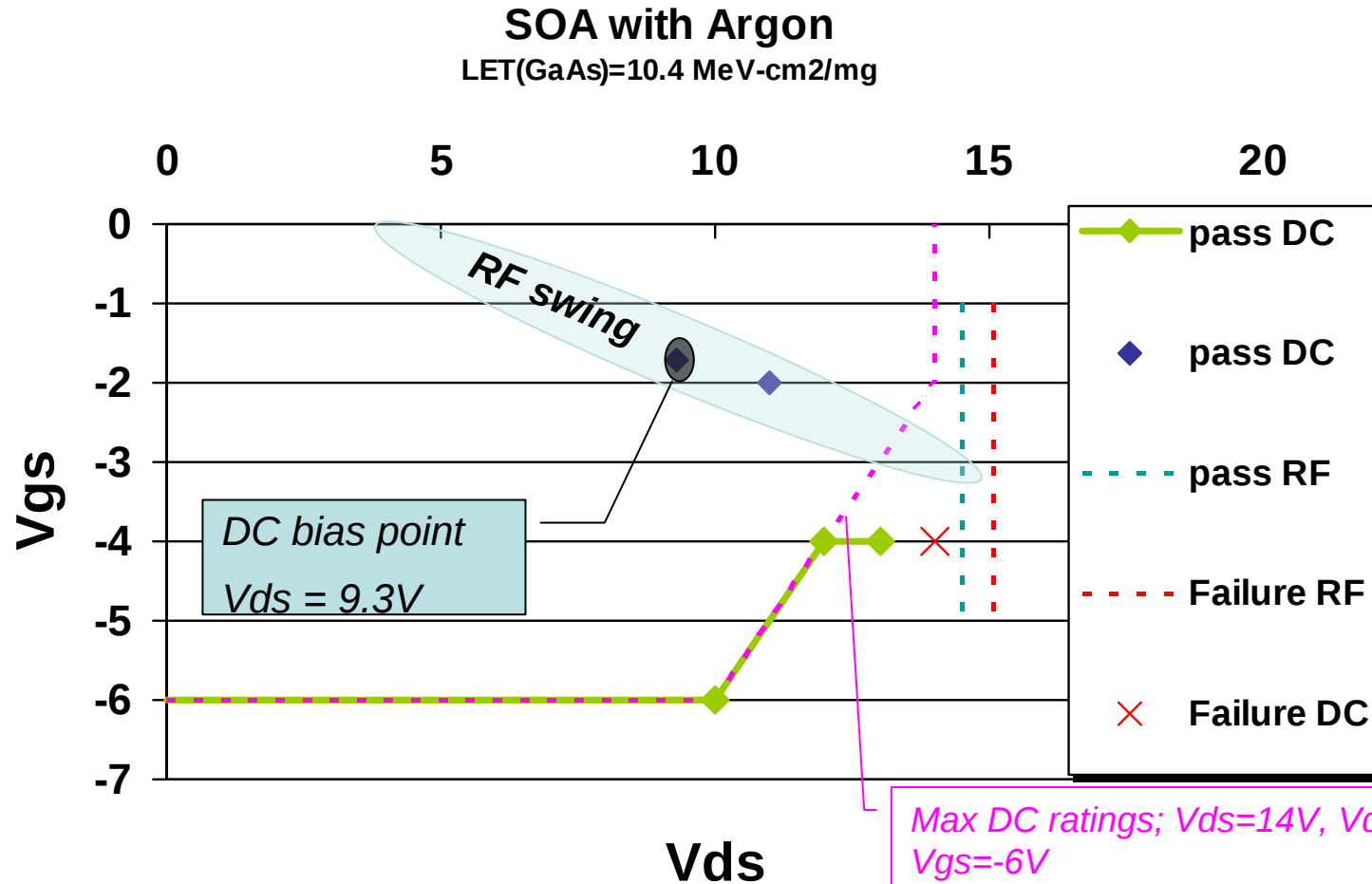
Examples

Single Event Transients (SET) <20 ns pulse width	Enhanced SET 100 – 1,500 ns	Destructive Failure
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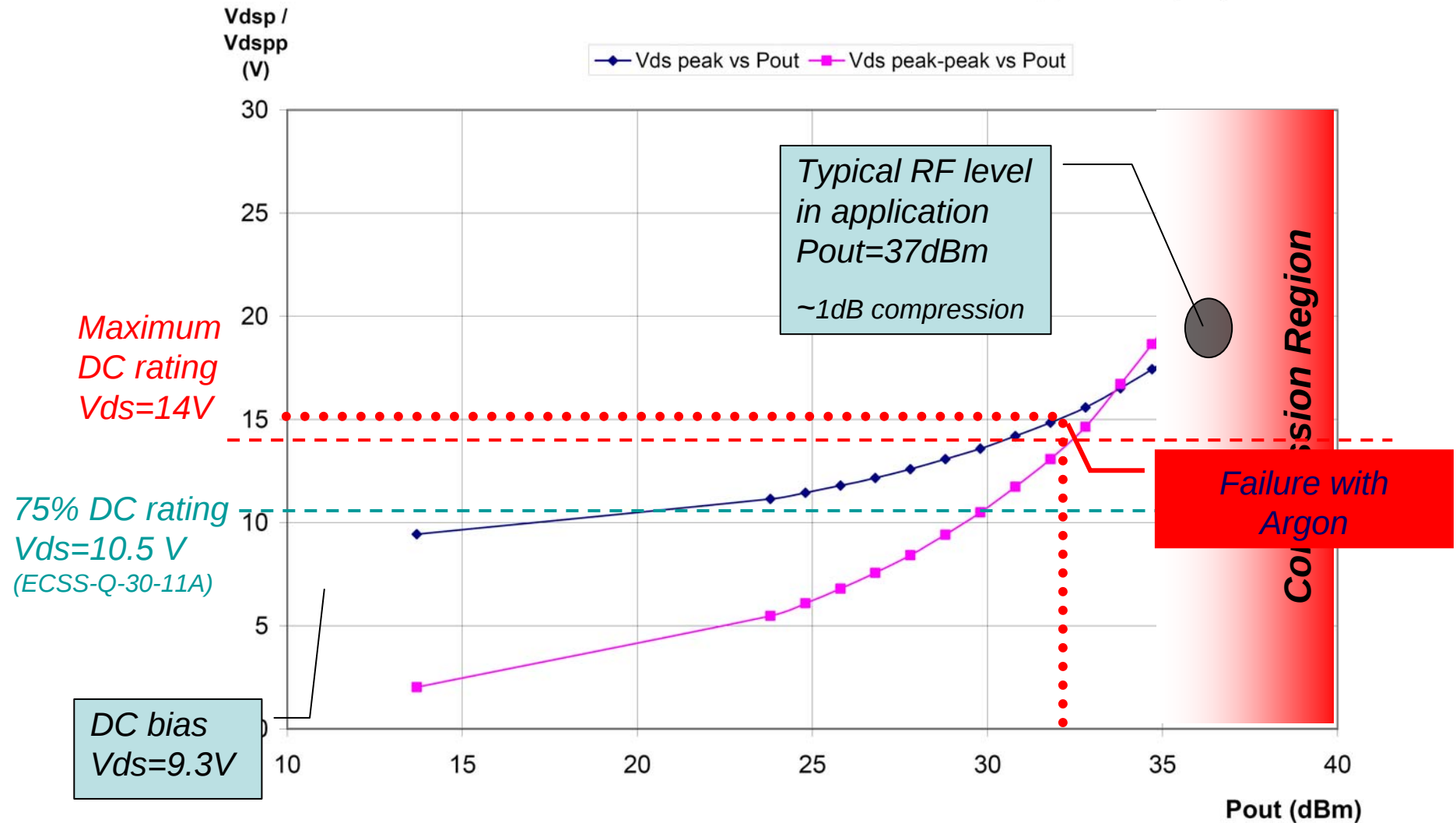
Results on the GaAs MESFET

Is RF swing critical for heavy ion effects?



- ⇒ RF swing shows to be critical but HI SOA in RF > HI SOA in DC
- ❖ This GaAs MESFET can not be used with high RF levels

Results on the GaAs MESFET



Details on test results and test setup

SEM picture from FA

Destruction between drain and gate

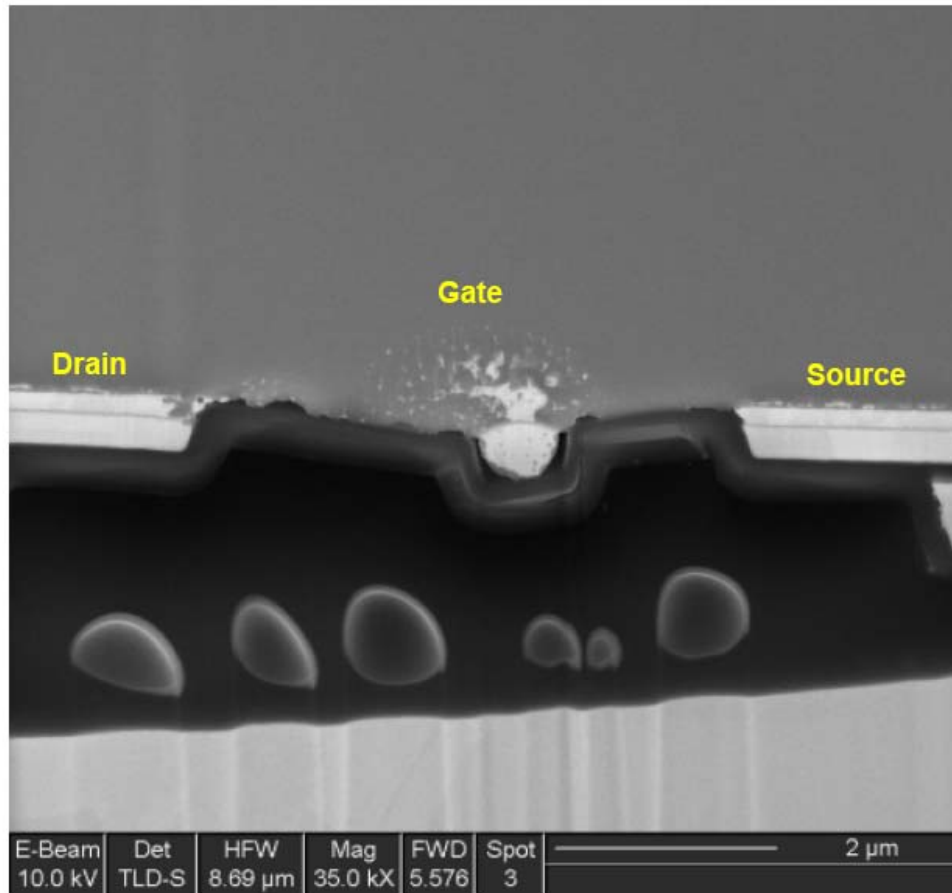


Photo N°25

FIB cutting from backside (next axis) inside the transistor
Fusion and diffusion of metal between Drain and Gate with craterization of GaAs

CONCLUSION

- Heavy ion irradiation test have been performed
 - in Static transistor off condition
 - in RF application condition
- Heavy ion test has revealed (at low LET)
 - SEE in a GaAs MESFET transistor
 - Transients recorded for both cases
 - Destructive events for both cases
 - At same LET with lower RF levels SEE immunity has been demonstrated
 - Monitoring data shows no cumulative effects
 - SEE cross section is around $10e-3 \text{ cm}^2$ ~total gate area
 - Results from all tested samples (in total 7 with heavy ions and 2 with Cf-252) are consistent

ESA Alert

EA-2008-EEE-05A

- Historically heavy ion effects in GaAs MESFET and HFET has not been considered critical (at least at ESA)
 - All reviewed GaAs PADs in ESA programs states SEE insensitivity
 - GaAs MESFET in Power Amplifier application considered most critical
- Recommendations in the Alert
 - the voltage in the RF swing must respect the Heavy Ion SOA
 - ⇒ In Heavy ion test with DC bias it is not always possible to apply DC up to the level of the RF swing
 - ⇒ Only option left is heavy ion test with RF
 - or justification with flight heritage...

ESA ongoing activities

- A internal Task force team has been established that continuously support the programs with respect to the ESA Alert
 - Support heavy ion test on case by case basis
- One person has been dedicated for the purpose to with experiments
 - Map the extent of the problem with radiation tests on GaAs MESFETS and HFET devices from several different manufacturers.
 - Gain deeper understanding of the SEE mechanism in GaAs MESFET
 - Evaluate different test approaches/methods for GaAs MESFET and other RF amplifier device types/technologies.

Latest Updates

Heavy ion testing on GaAs MESFET devices

Tested GaAs FETs	LET(GaAs) MeV-cm ² /mg	Transients <20ns	Destructive events in RF condition
In-Flight failure GaAs MESFET	<5	Low voltage levels	Yes
Mitsubishi MESFET	62	Near BVds	No
Triquint HFET	62	Near BVds	No
Triquint PHEMT	49	Near BVds	No

V_{gs} / I_{ds} vs V_{ds}

