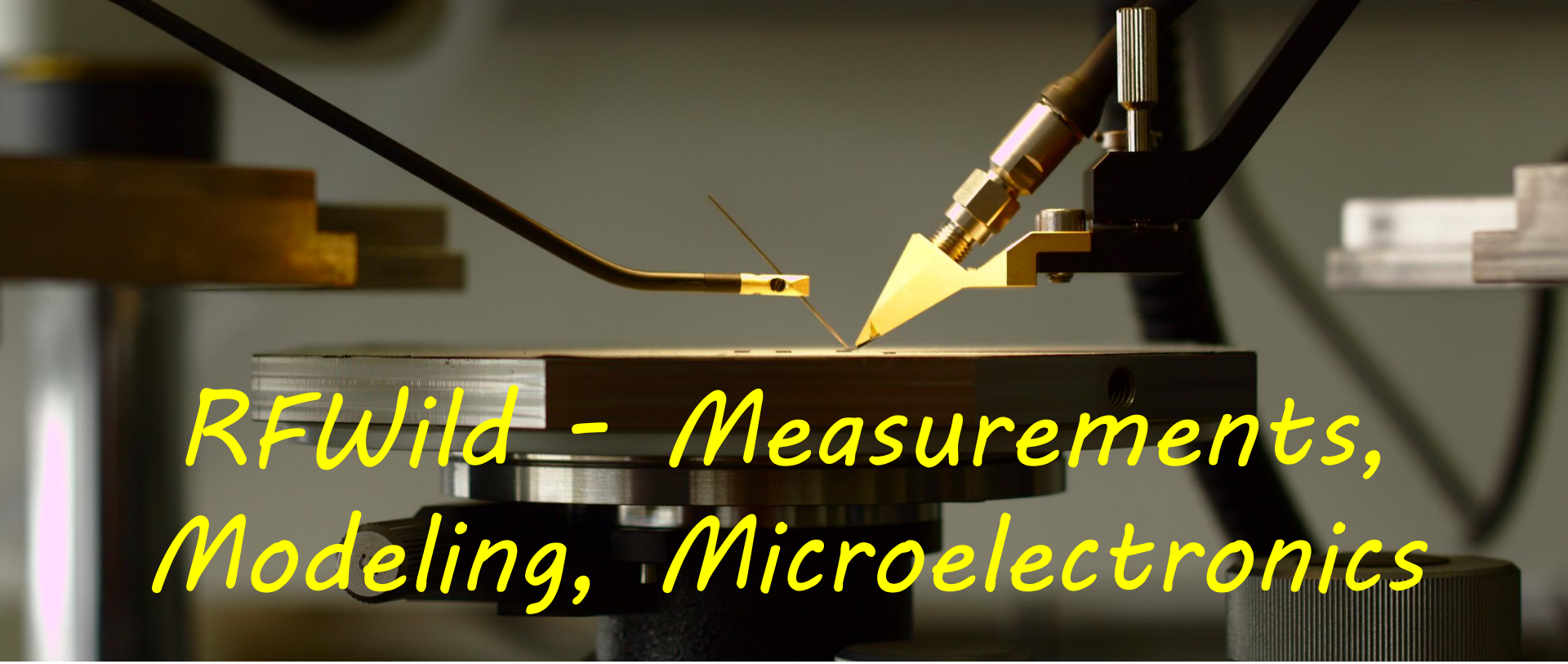


UNIVERSIDADE FEDERAL DA PARAÍBA

INSTITUTO FEDERAL Paraíba

About us

Outline

- A bit about us:
  - RFWild´s (permanent) team
  - Device characterization: a bit of (our) history...
- Activities :
  - Accomplished
  - Under development
- Conclusion and Perspectives

RFWild´s (permanent) team

Research group formally created in 2013
Laboratory formally created in 2016

Antonio Augusto
The eldest ☹
Noise in Devices
Instumentation
Device modeling

Emmanuel Dupouy
Ninja of Oscillators ☺
Low phase-noise VCOs
Low-power front-ends

Joabe Brasil
Technician
Precision Mechanics

Let´s talk a little bit about our background...

Characterization and Modeling
of a ressonator for a
10 GHz Hybrid Oscillator
(Emmanuel Dupouy, during his Ph.D thesis
at the XLIM laboratory)

Passive Devices
Charact. & Modeling

Objectives: design a MEMS based 10 GHz VCO, by modeling all passive components (excluding the MEMS) and an RF transistor (BFP-740F).

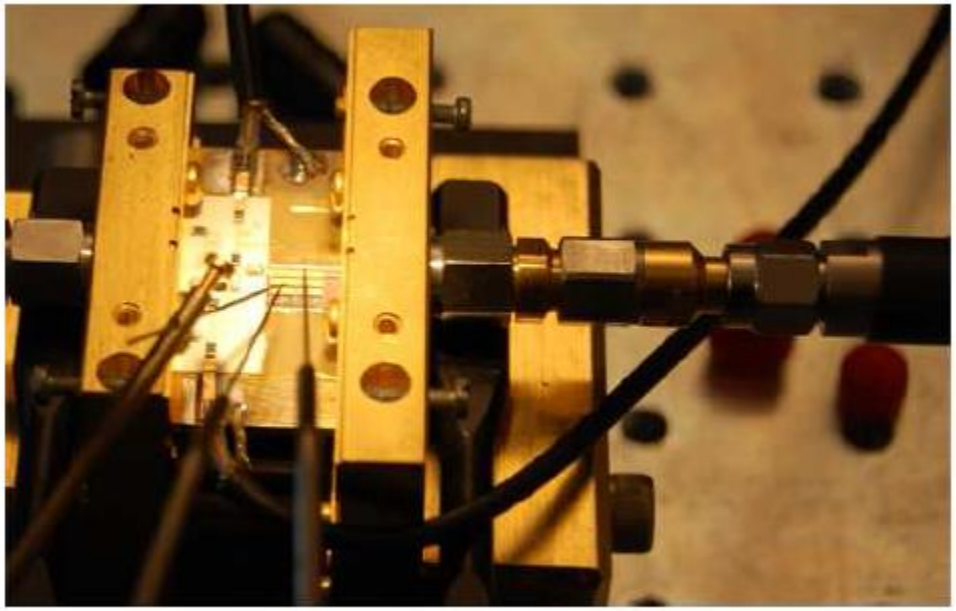
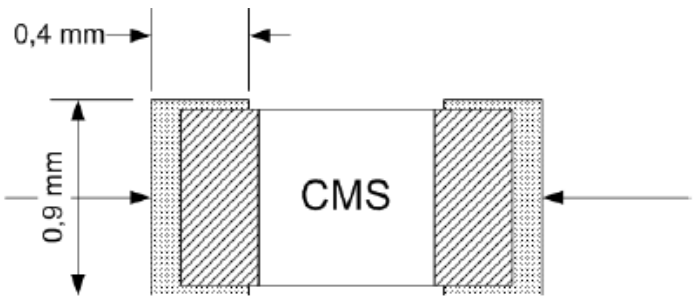


FIG. 3.48 – Photographie du VCO à varactor MEMS

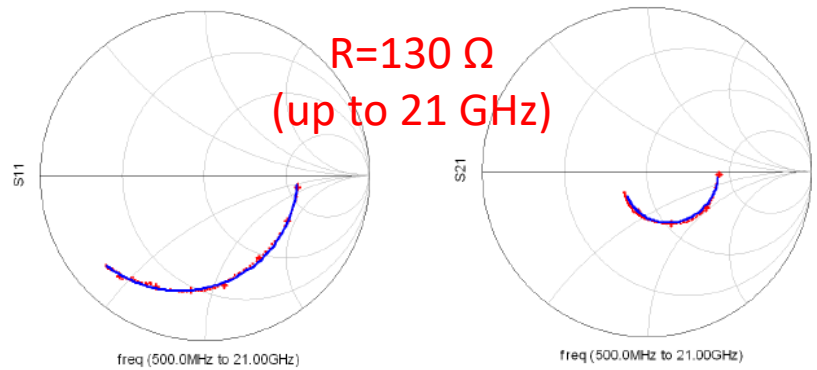
Passive Devices
Charact. & Modeling

RFWild
Measurements & Microelectronics

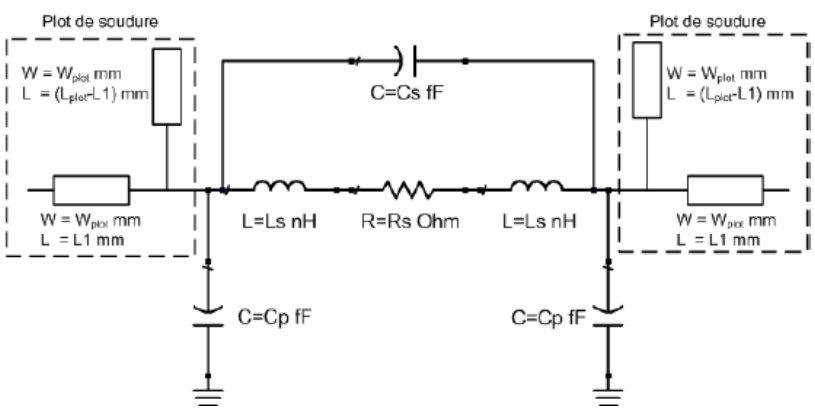
Characterization and modeling of the SMD resistors (including solder pads)

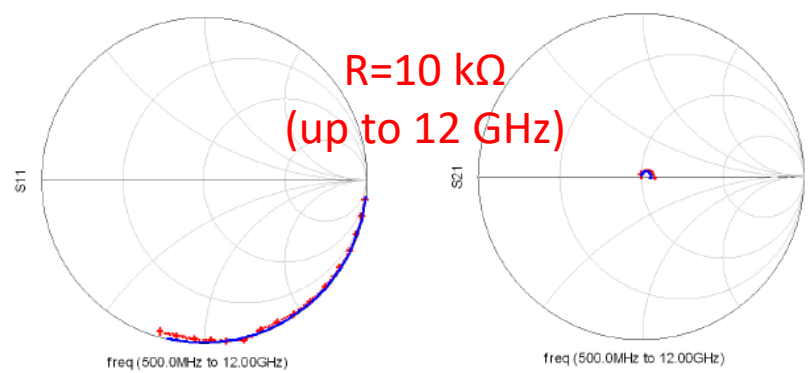


S11 and S21: Comparison between measurements and simulation results:



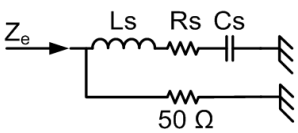
Model topology:



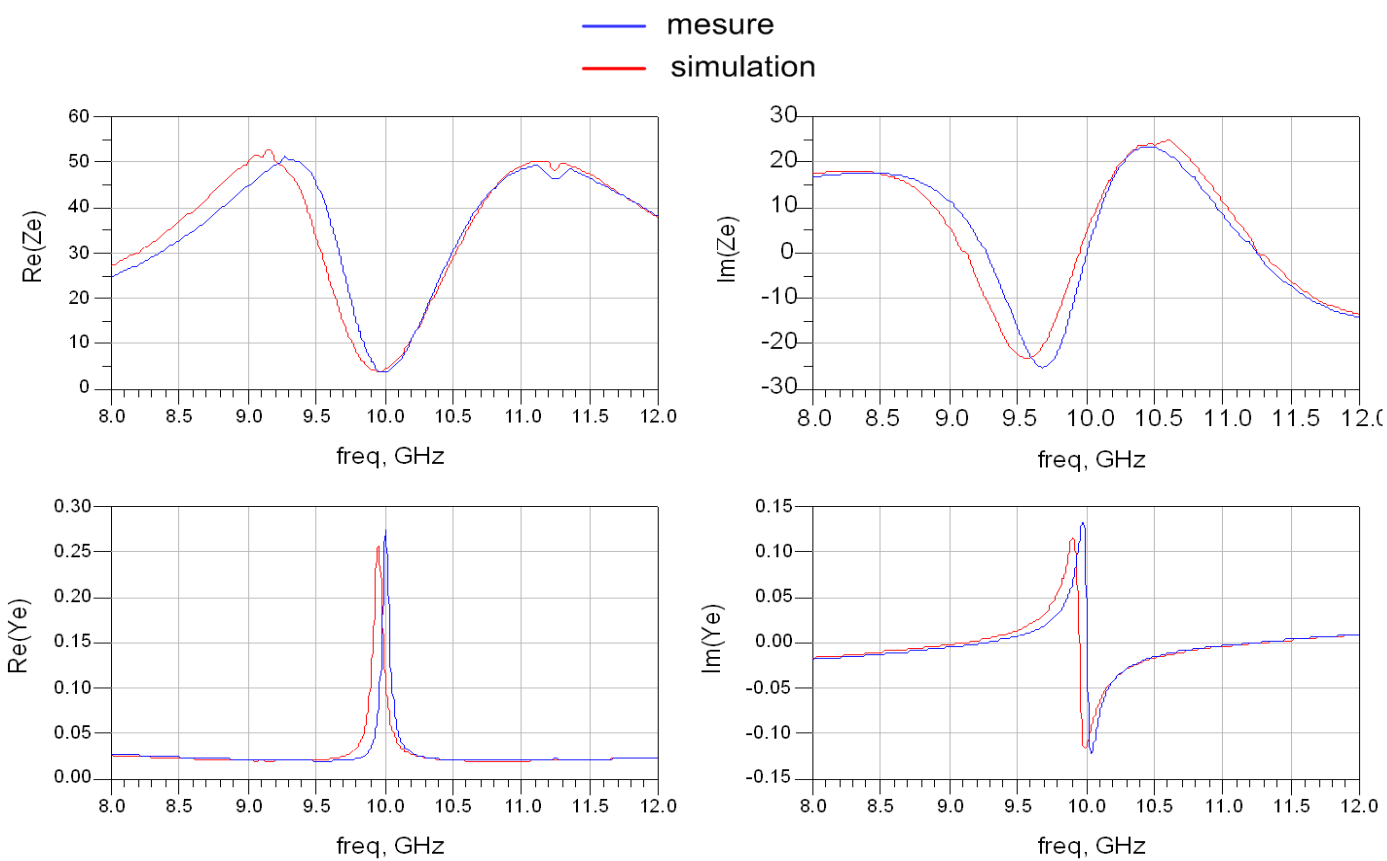


Design and characterization of a coupled line ressonator

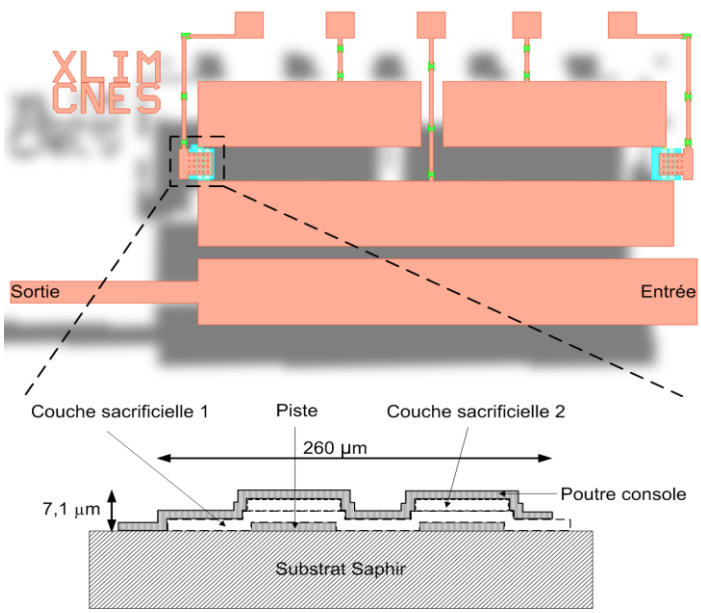
@10 GHz

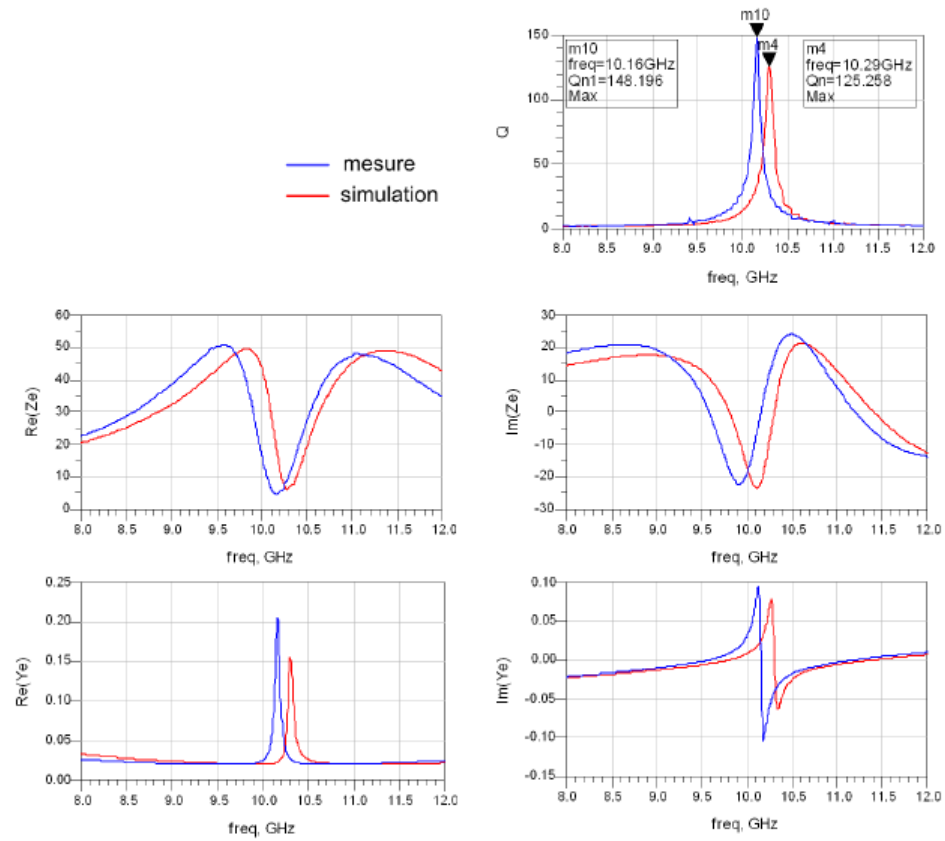


Rs = 3,5 Ω
Ls = 8.1 nH
Cs = 31 fF



Design and characterization of a coupled line ressonator capable of incorporating the MEMS varactor

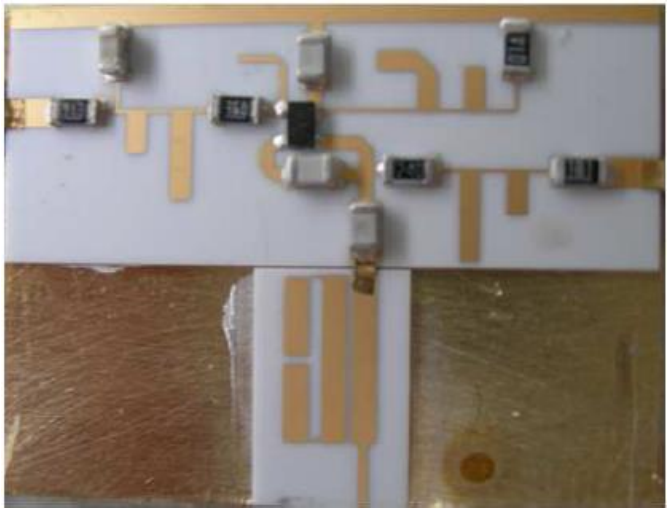


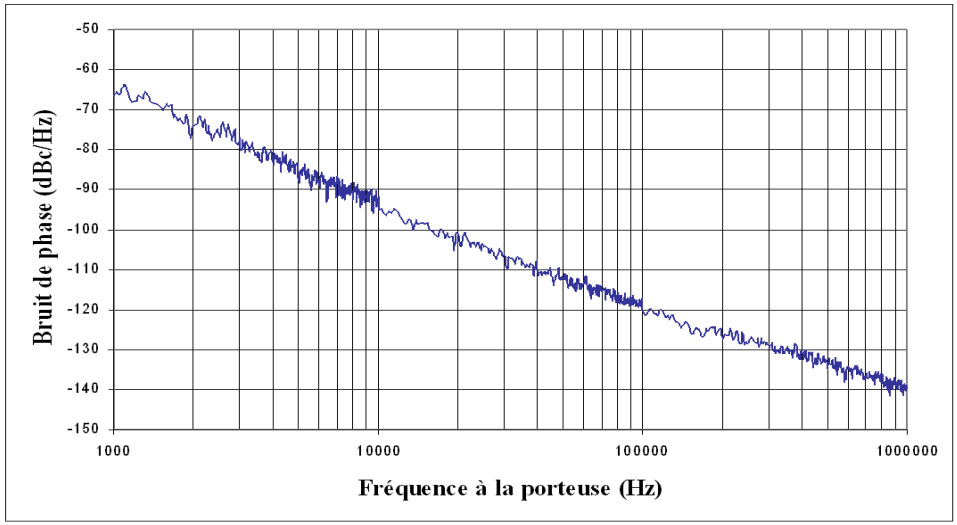


Oscillator Design & Characterization

Design and characterization of a (fixed frequency) oscillator

Phase noise well below target of -110 dBc/Hz @ 100 KHz





Design and characterization of the MEMS based VCO

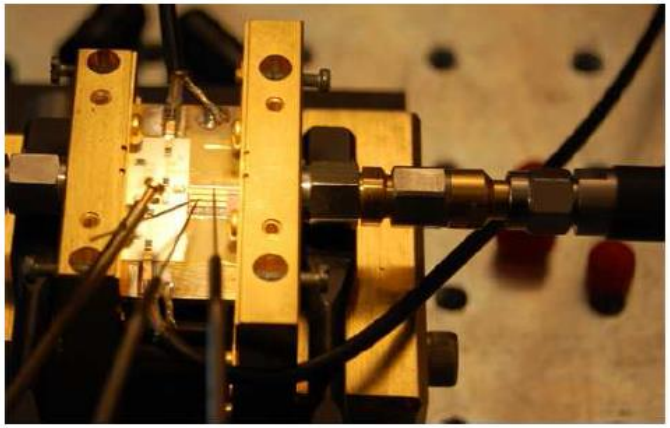
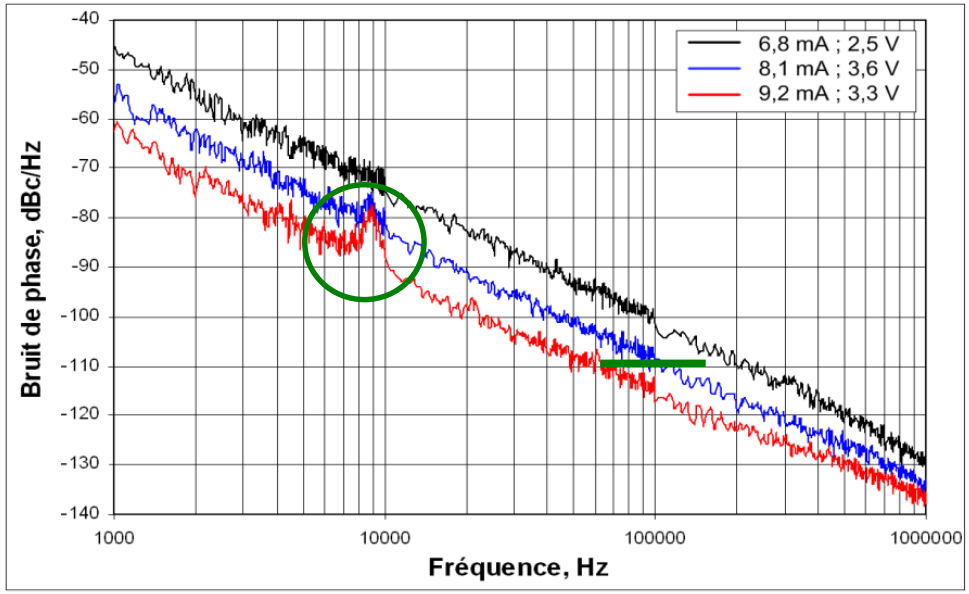


FIG. 3.48 – Photographie du VCO à varactor MEMS

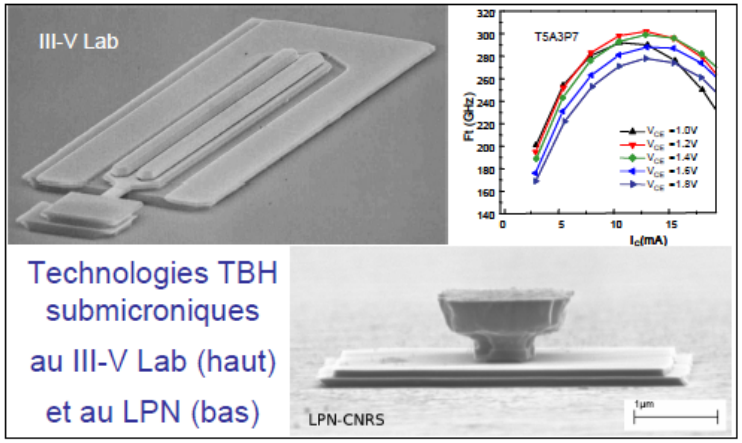


Characterization and Modeling of a 200+ GHz active device (Antonio Augusto, during his Ph.D thesis at the XLIM laboratory)

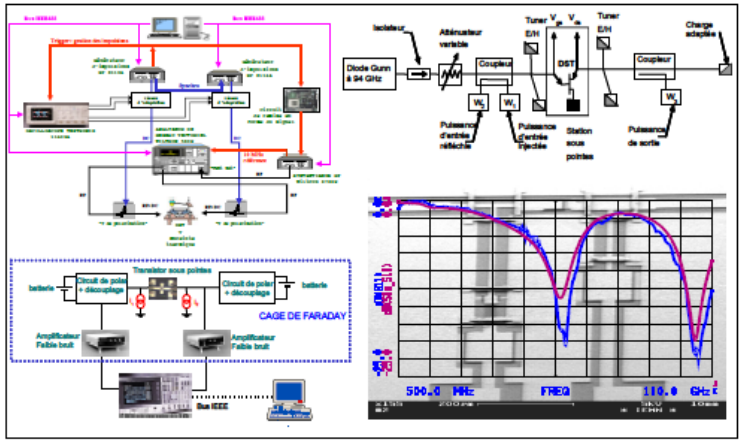
Active Devices
Charact. & Modeling

Objective: to build a compact model of an InP Double Heterojunction Bipolar Transistor (DHBT) up from measurements. The model should be suited to the design of microwave circuits (PA, VCO,...) operating in dozens of GHz.

Du dispositif au circuit : technologie – mesure – conception



La technologie TBH 0,7 µm InGaAs/InP existante sera adaptée au TBH GaAsSb/InP (cible : 0,4 THz) ; une optimisation plus agressive visera 0,5 THz.



La conception de circuits >0,1 THz s'appuie sur une caractérisation et une modélisation fines des transistors et des passifs, au-delà de 100 GHz.

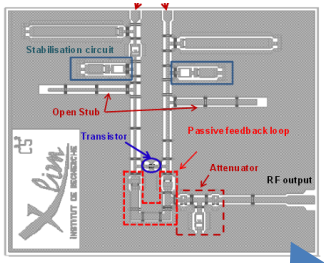
Active Devices
Charact. & Modeling

RFWild
Measurements & Microelectronics

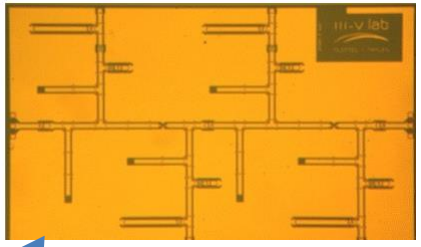
ATTHENA
Antimoine pour TBH (*) THz optimisé pour une ÉlectroNique Analogique

GaAsSb/InP Heterojunction Bipolar Transistor

40 GHz Oscillator*



60 GHz Power Amp.**



Characterization setup

$$Ibfe = Isfe(T).\left(\exp\left(\frac{q.Vbe}{Nfe.k.T}\right)-1\right)$$

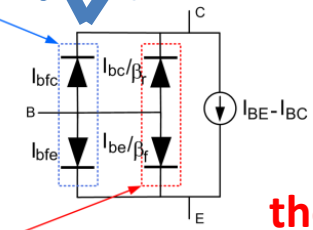
$$Ibfc = Isfc(T).\left(\exp\left(\frac{q.Vbc}{Nfc.k.T}\right)-1\right)$$

$$Ibe = Ise(T).\left(\exp\left(\frac{q.Vbe}{Ne.k.T}\right)-1\right)$$

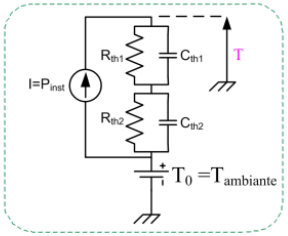
$$Ibc = Isc(T).\left(\exp\left(\frac{q.Vbc}{Nc.k.T}\right)-1\right)$$

$$Is(T) = Is.e^{(-Ts/T)}$$

$$\beta_f = \beta_{f0}.(1-(K_\beta.(T-T_0))^{\eta_\beta})$$



Circuit thermique associé

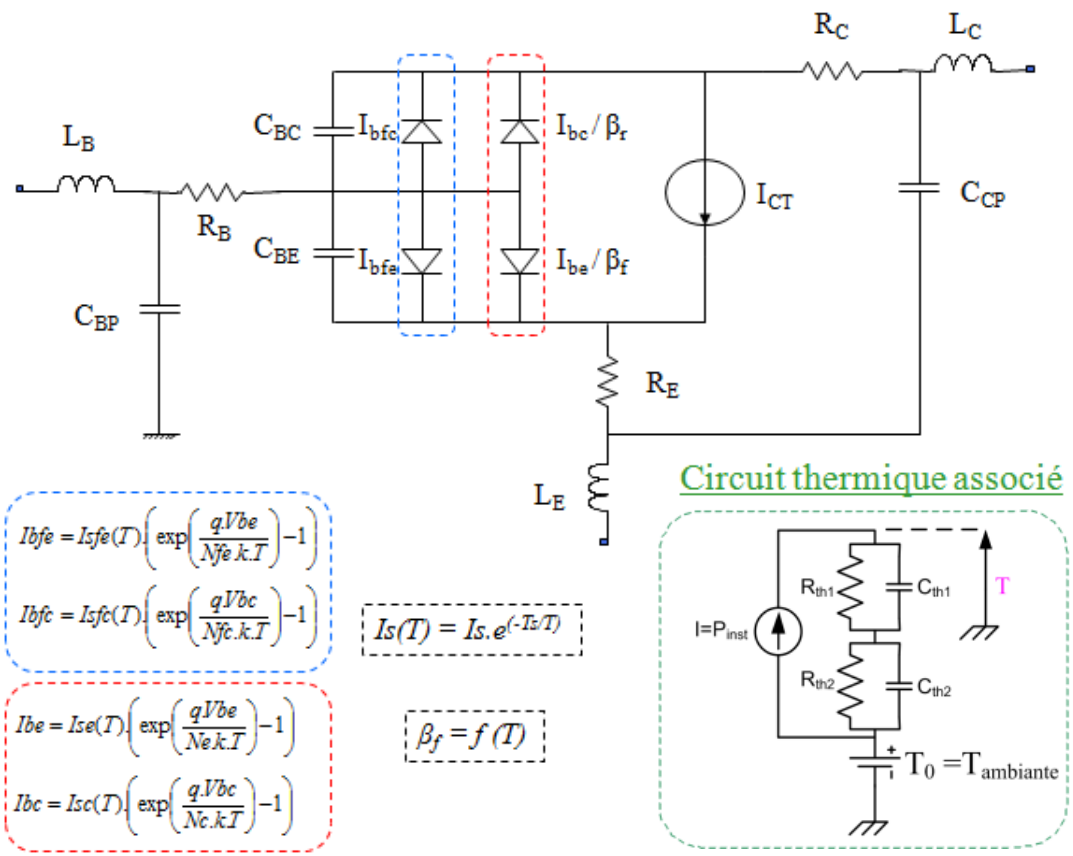


Electro-thermal model of the transistor

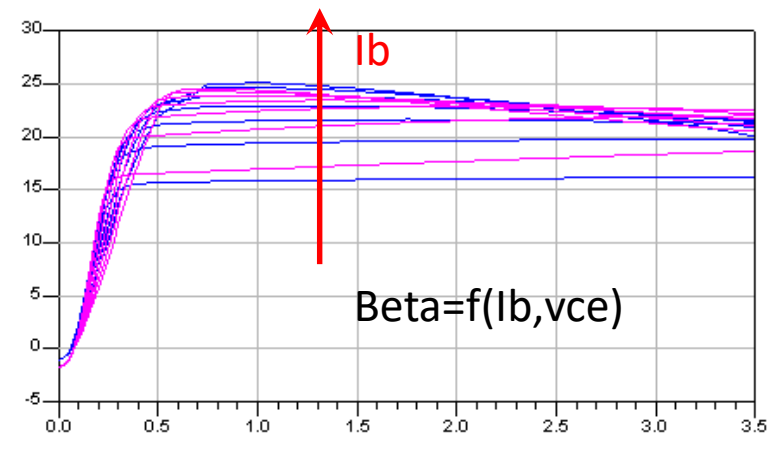
* S. LAURENT et al. Design and fabrication of a 45GHz MMIC oscillator based on InP/GaAsSb/InP DHBT. DOI: 10.1109/INMMIC.2010.5480139
** L. Godin et al. V-Band Amplifier MMICs Using Multi-Finger InP/GaAsSb DHBT Technology. DOI: 10.1109/csics.2009.5315658

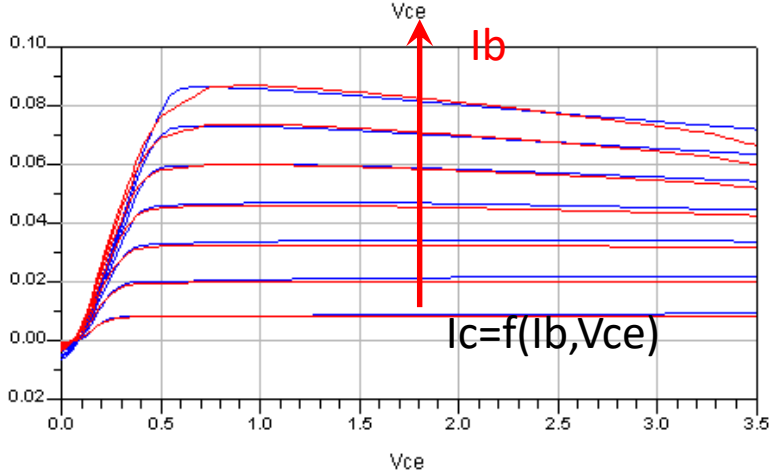
Active Devices
Charact. & Modeling

The model topology adopted is shown here. It had about 50 parameters (constants) to be characterized from DC, S-Paramaters (up to 65 GHz) and low-frequency (up to 1MHz) AC measurements.

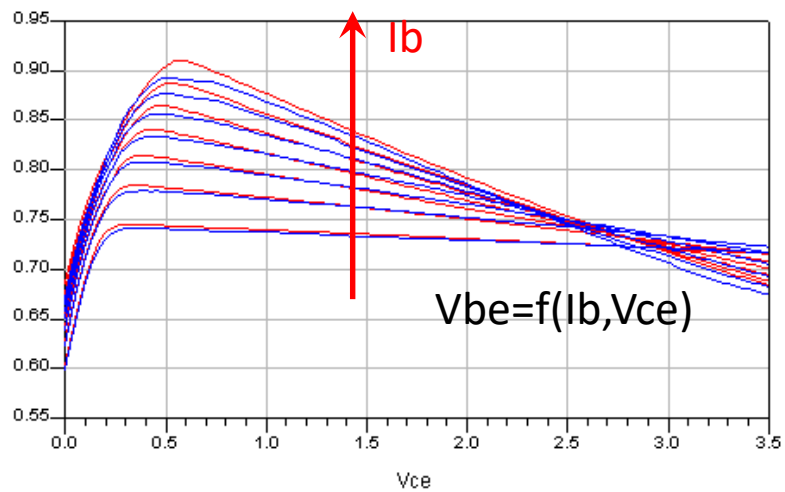


DC: Comparison between measurements and simulation results

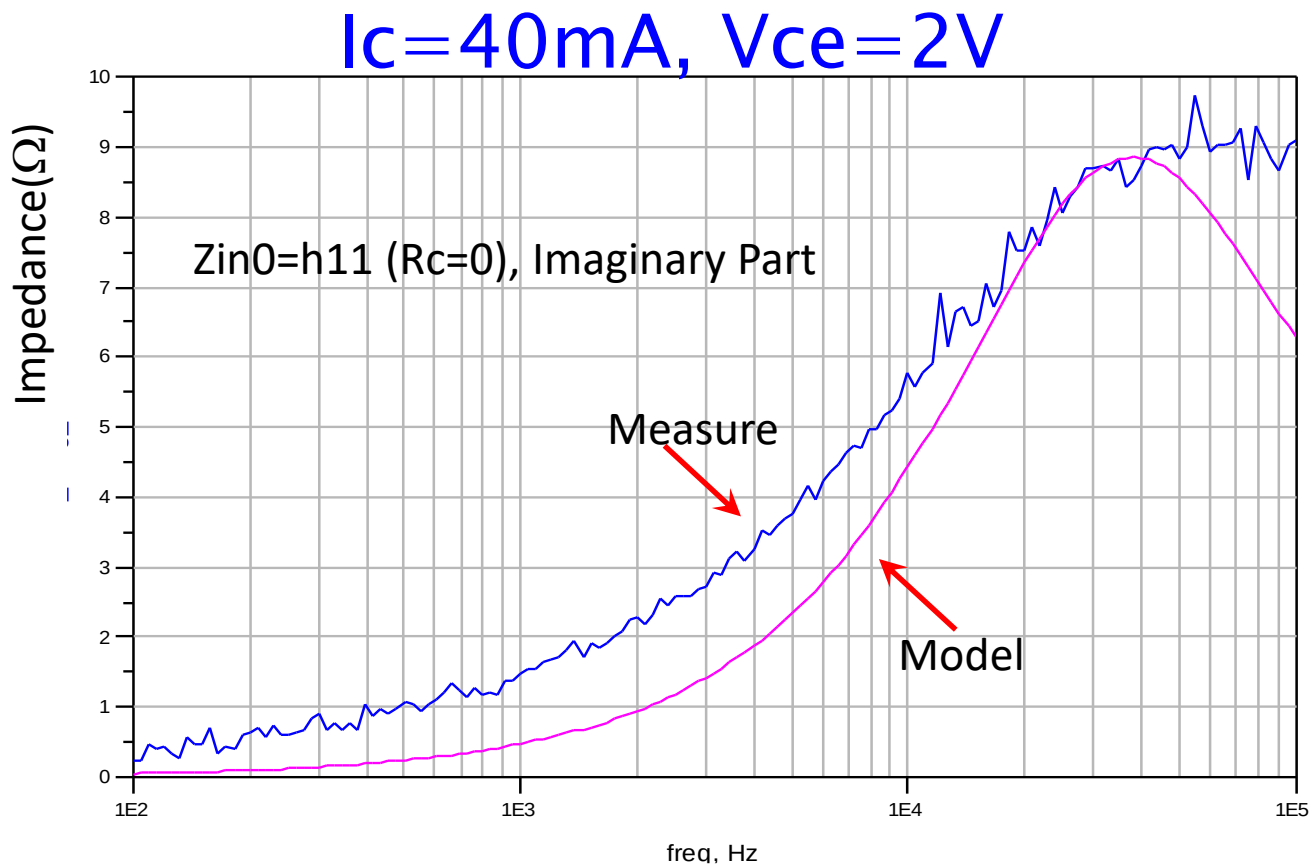




Ib=0.5 to 3mA in 0.5mA steps T=45°C



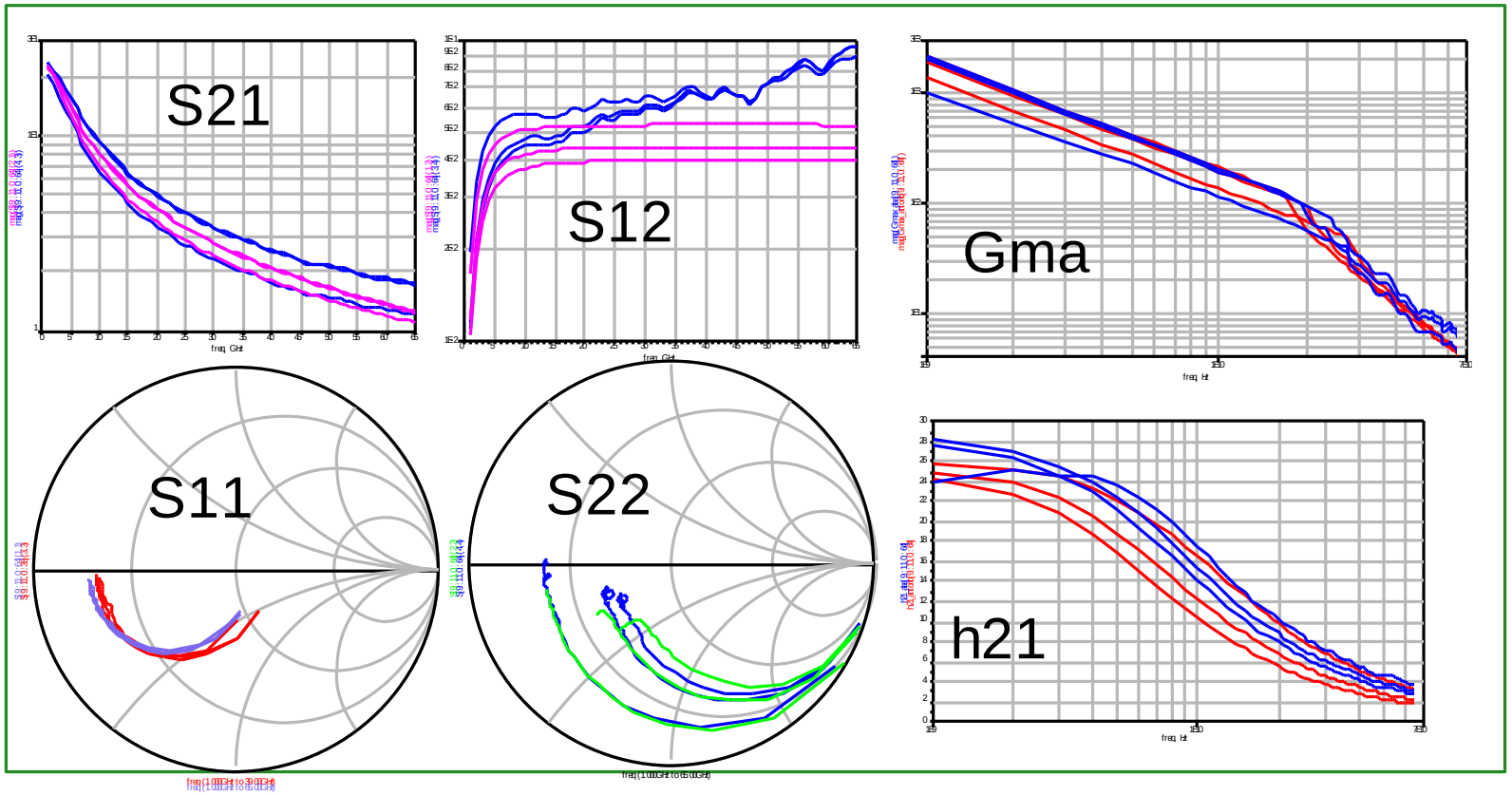
Low Frequency AC: Comparison between measurements and simulation results



Active Devices
Charact. & Modeling

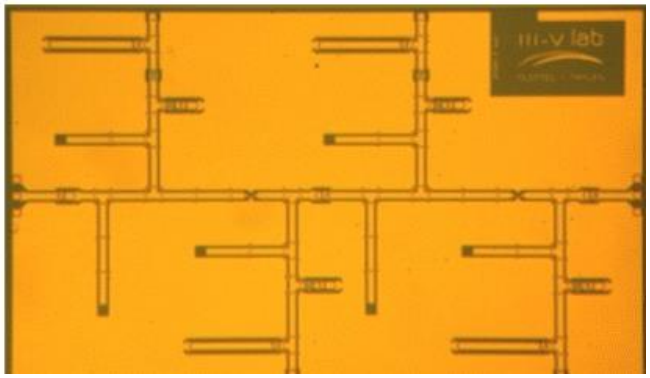
S-Parameters up to 65 GHz: Comparison between measurements and simulation results

IB=2mA, Vce=1, 2 and 2.5



Active Device Charact. & Modeling

The model was used in the design of a 60 GHz 2-stage Power Amplifier



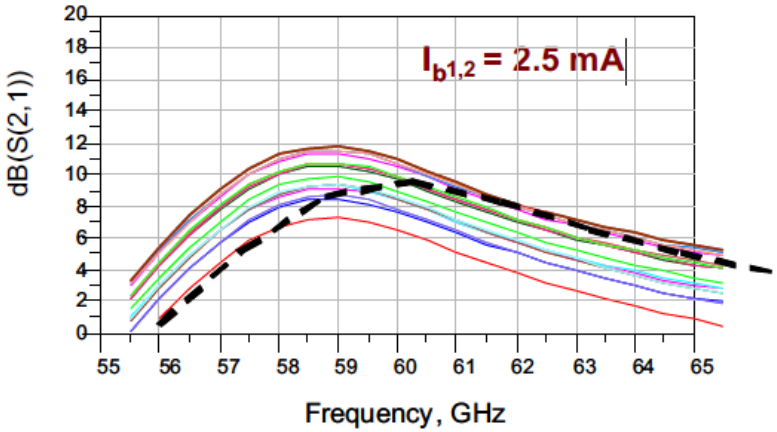
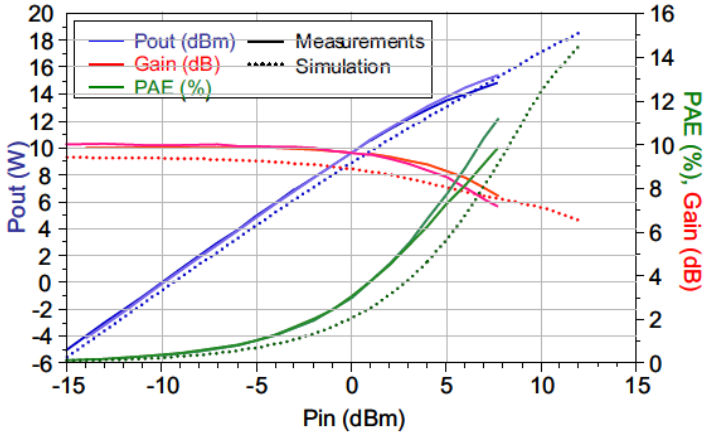


Figure 11: S_{21} measurements compared to simulation



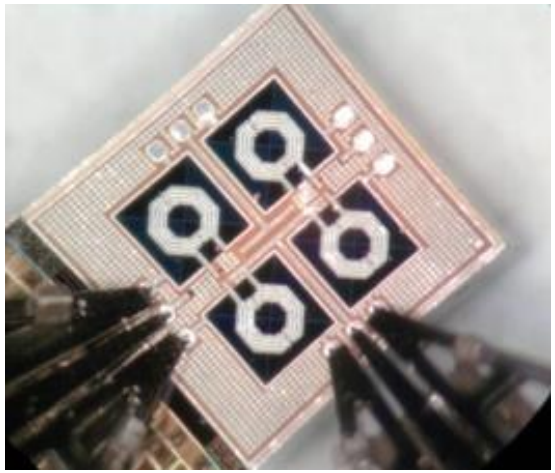
Quoted from the paper: "A multi-finger InP/GaAsSb DHBT process has been developed, with frequency characteristics suitable for RF applications. Thanks to accurate modeling, MMIC amplifiers operating at 60 GHz have been designed and characterized".

L. Godin et al. V-Band Amplifier MMICs Using Multi-Finger InP/GaAsSb DHBT Technology. DOI: 10.1109/csics.2009.5315658

Activities accomplished

- Microelectronics:

2012

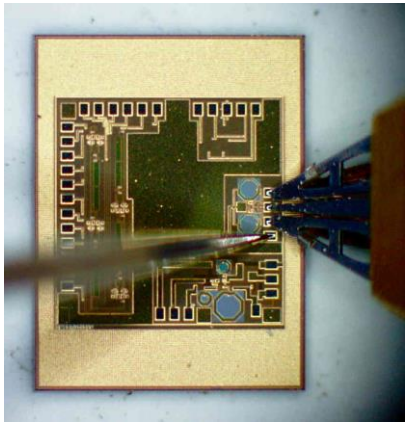


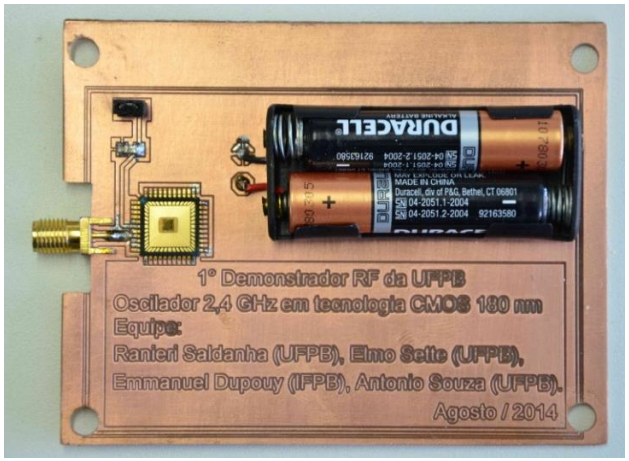
1st RF IC completely designed in Paraíba (VCO 2.4 GHz)

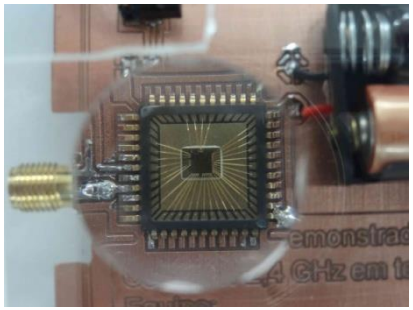
Phase noise was better than what we could measure at that time. Simulations showed -115 dBc/Hz @ 100 KHz. We recently measured about -110dBc/Hz @ 100 KHz under non ideal conditions.

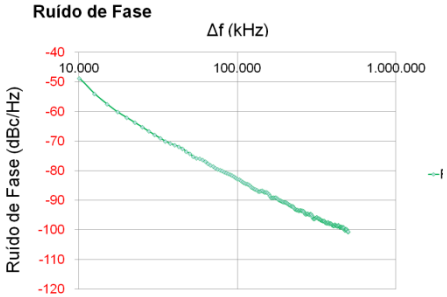
Activities accomplished

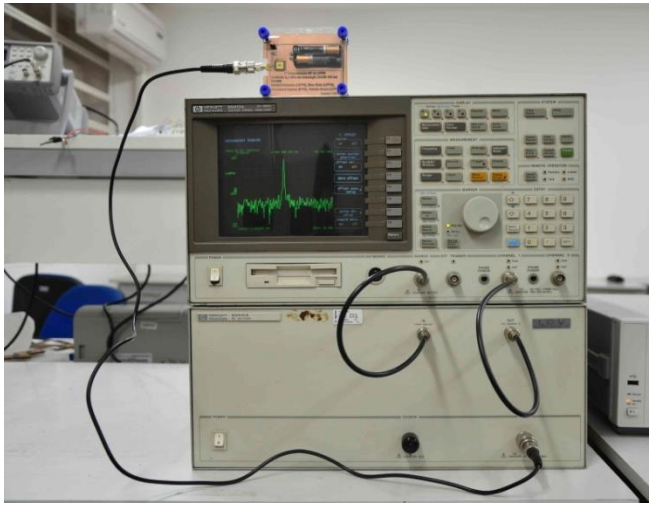
- Microelectronics: 2014











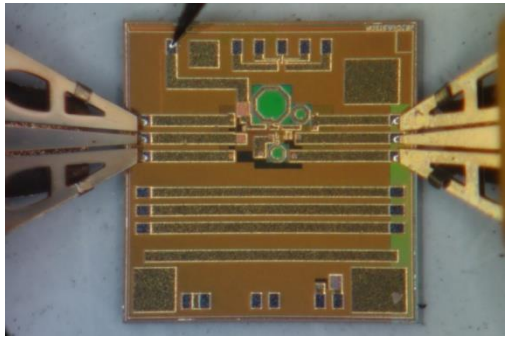
1st Demonstrator of a 2.4 GHz Oscillator at UFPB. To the best of our knowledge, it was **the 1st Demonstrator** of an **Integrated RF Oscillator** designed in the Northeast of Brazil!

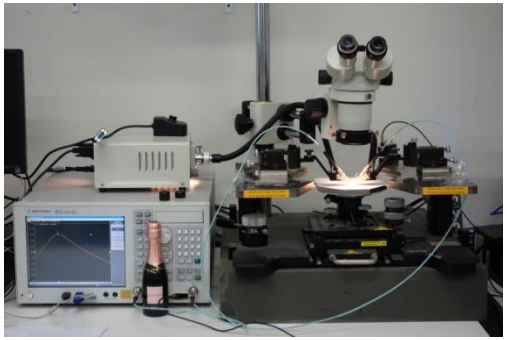
Activities accomplished

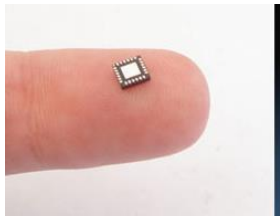
RFWild
Measurements & Microelectronics

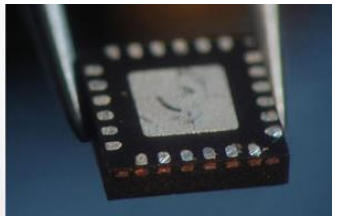
➢ Microelectronics:

2015

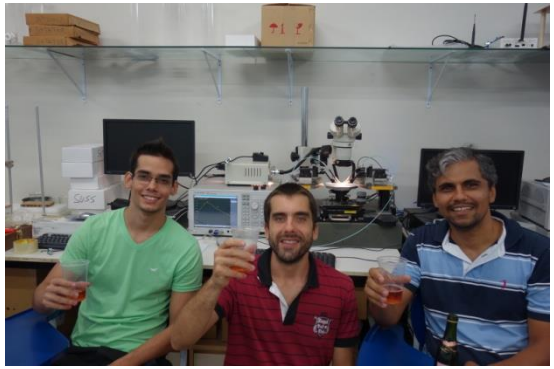


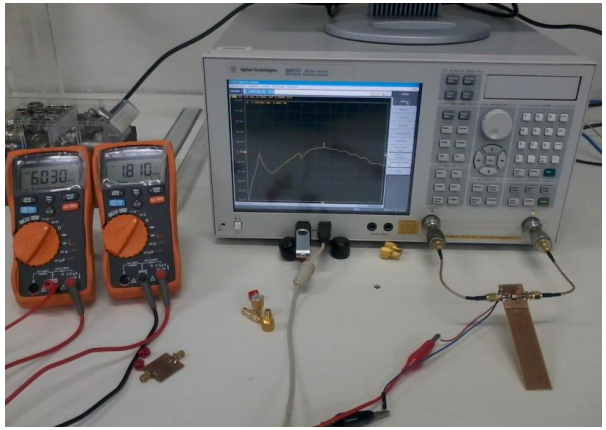






1st Demonstrator of a 2.4 GHz LNA at UFPB (Gain = 8 dB, NF≈3 dB)
To the best of our knowledge, it was **the 1st Demonstrator** of an **Integrated LNA** designed in the Northeast of Brazil!





Activities accomplished

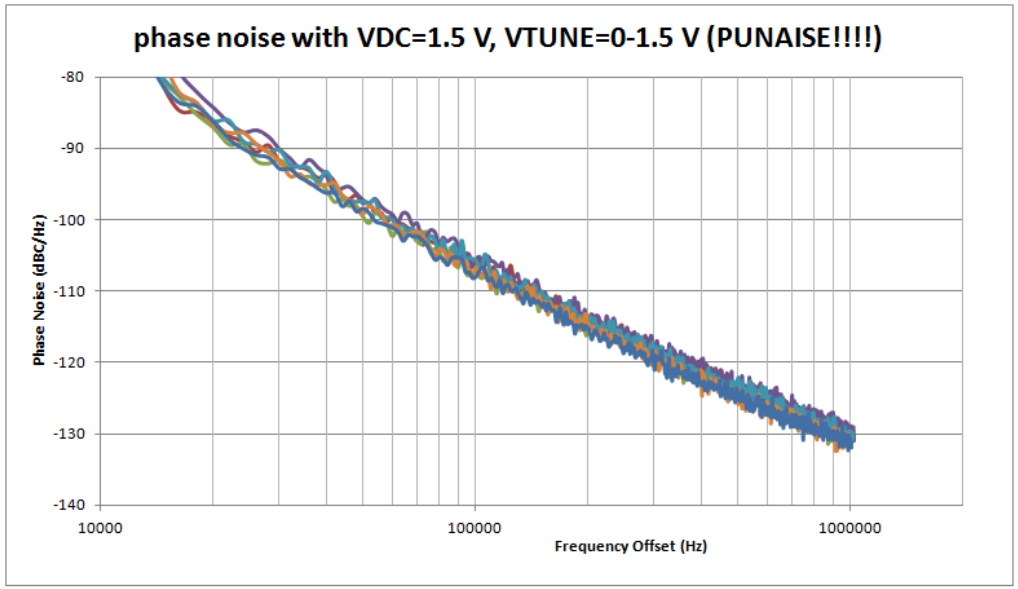
RFWild
Measurements & Microelectronics

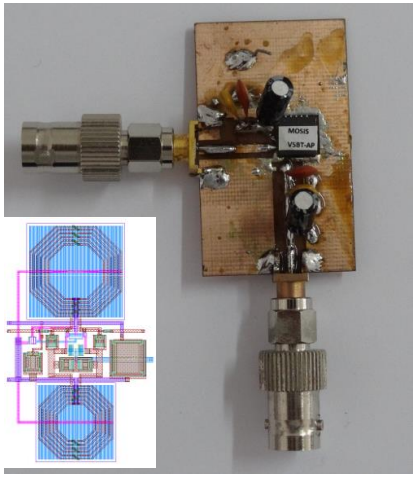
- Microelectronics:

August/2016

STATE OF THE ART NUMBERS				
	L @ 100 kHz (dBc/Hz)	P (mW)	f_c (GHz)	FOM
[1]	-112	9,25	1	-182
[2]	-100	4,4	3,36	-184
[3]	-104	5,4	2,53	-185
[4]	-102	2,7	4,9	-191
This work	-108	11	2,47	-186

1st Demonstrator of a "GSM Compliant" 2.4 GHz VCO (phase noise: -125 dBC @600kHz) To the best of our knowledge, this is **the best FOM@100kHz of a VCO Demonstrator** reached in BRAZIL, **the 3rd in the world**!!!

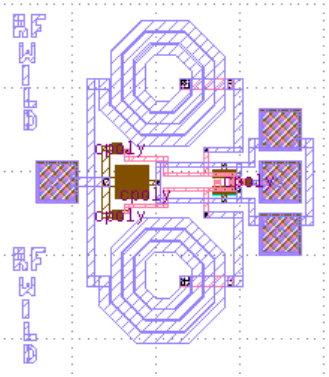


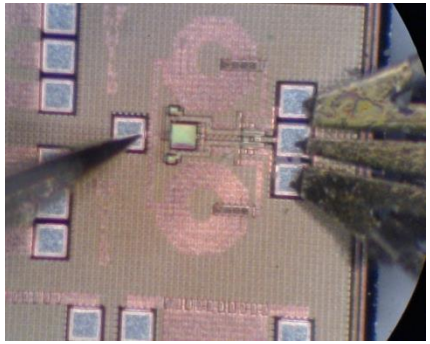


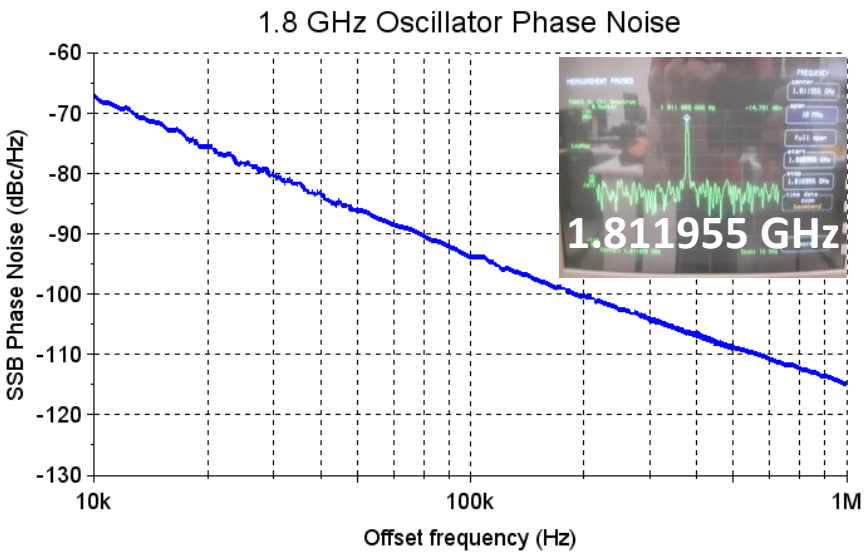
Activities accomplished

➢ Microelectronics:

November/2016







RFWild´s **1.8 GHz** oscillator in XFAB 0.6 µm CMOS (**PMU CEITEC**) (phase noise: -115 dBC @1 MHz)

This RF oscillator uses **in-house designed inductors** (to be characterized and modeled)

Activities accomplished

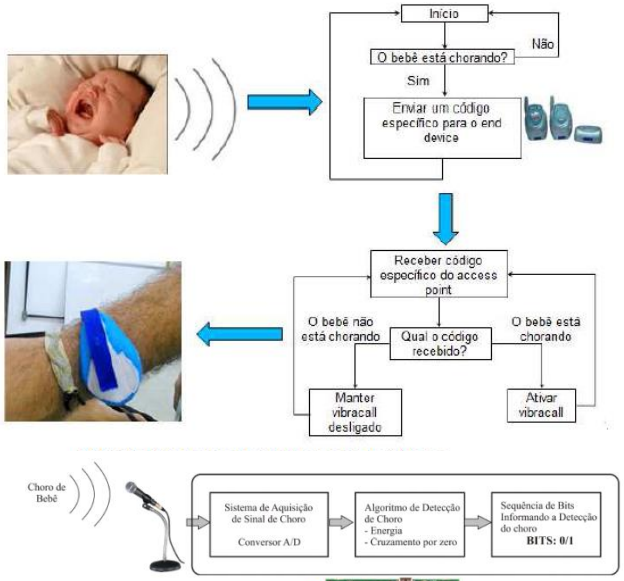
- International collaboration:

June/2016: RFWild receives its first international student for an internship

Activities (almost) accomplished

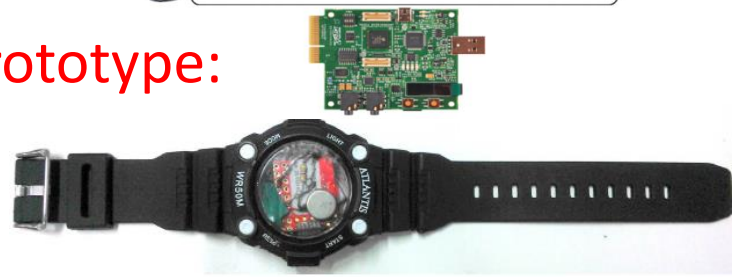
- R&D project for directly helping people:

Patent deposit of a System to help deaf parents to know when their child is crying



DISPOSITIVO PARA RECONHECIMENTO DE CHORO DE BEBÊ ATRAVÉS DE PROCESSAMENTO DIGITAL DE SINAIS COM UNIDADE VIBRATÓRIA PARA ALERTA DE RESPONSÁVEIS: **BR102015012753-7**

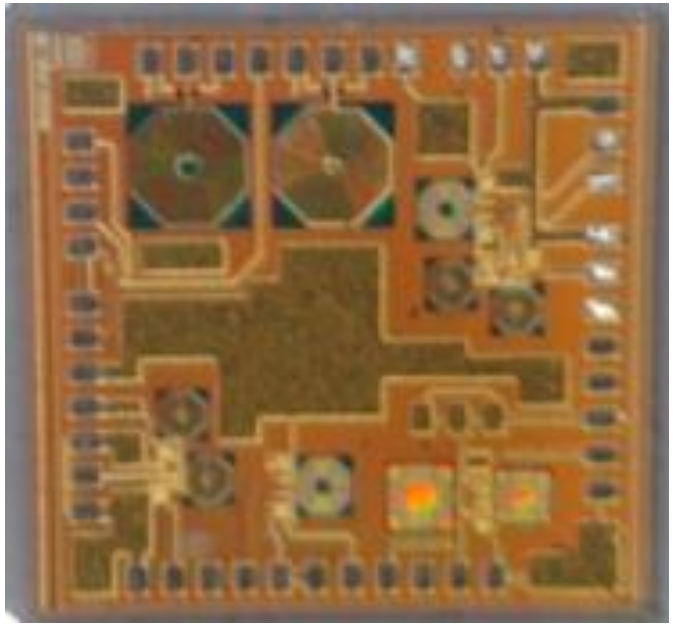
Prototype:

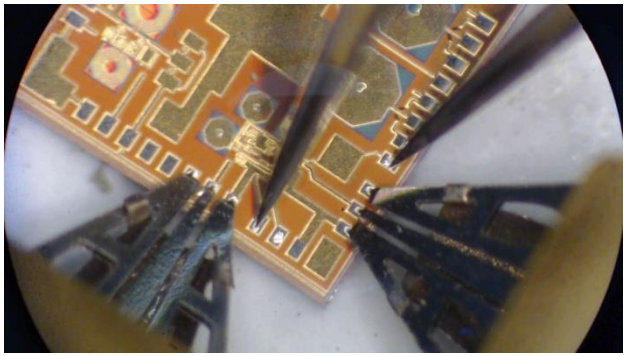


Activities under development

RFWild
Measurements & Microelectronics

- Microelectronics:

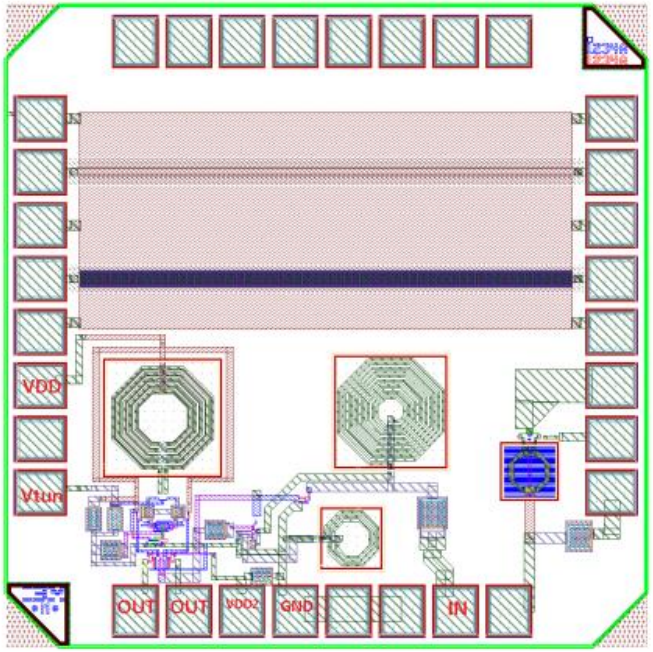




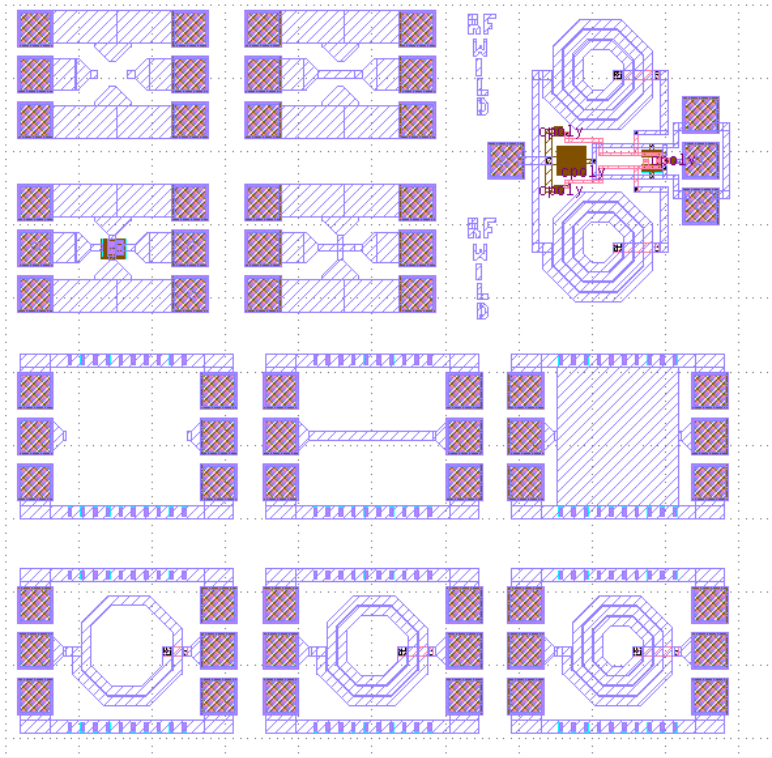
Low Power 2.4 GHz front-end: LNA, VCO, Mixer
(Conversion Gain ≈ 20 dB, P_{DC} ≈ 850 µW, CMOS 0.18 µ)
Everything up and running,
a complete characterization is in progress!

Activities under development

- Microelectronics:



Low-Power 2.4 GHz front-end, 60 GHz oscillator, **Slow-Wave structures** (GF CMOS 0.13 µm, samples received!)



Transistor and inductor modeling, targeting low-power DC/DC converters (XFAB CMOS 0.6 µ, samples received)

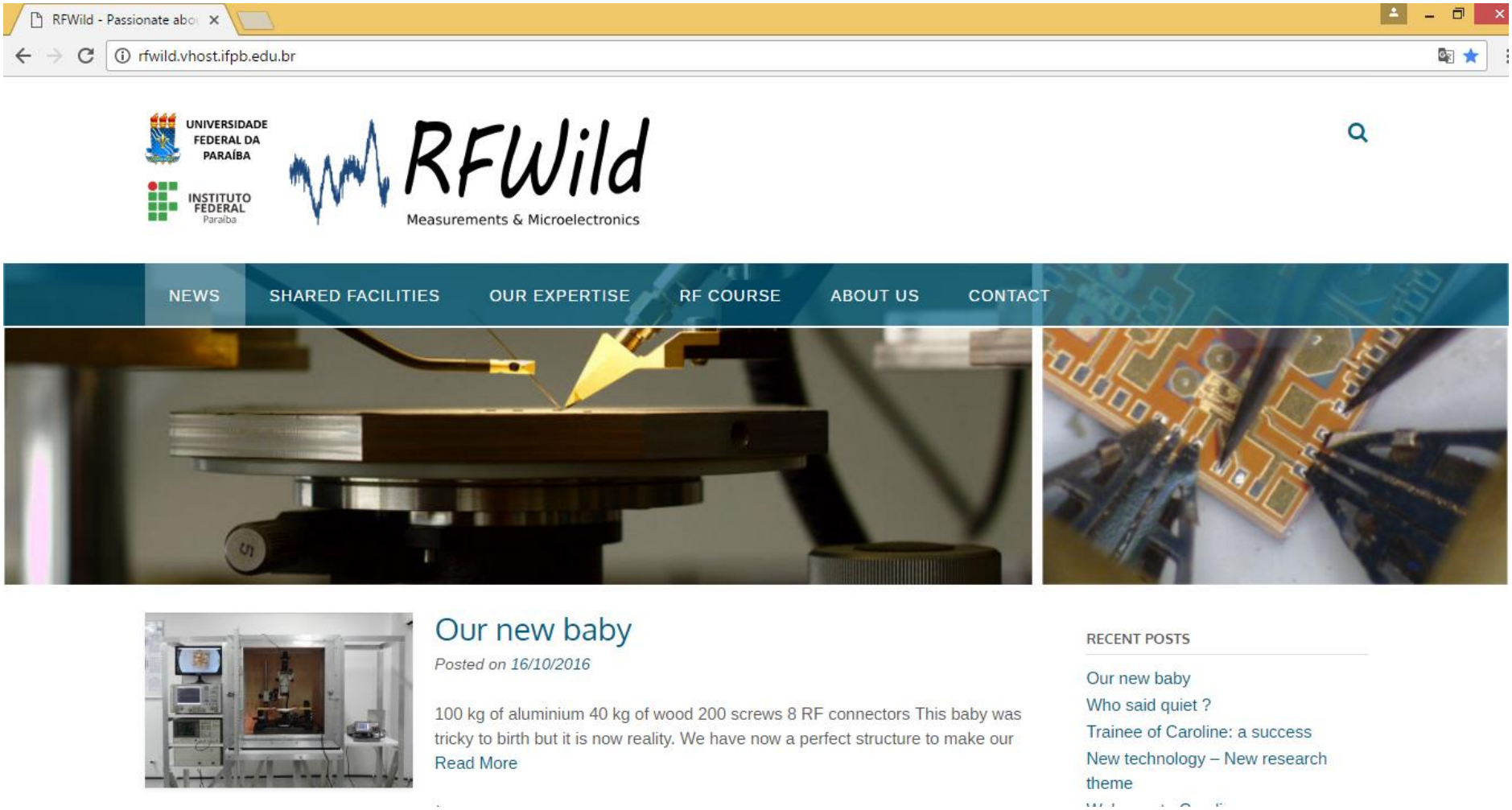
Conclusion

Main conclusion: we like to celebrate! And we are ambitious and motivated to move to more complex and applied topics!

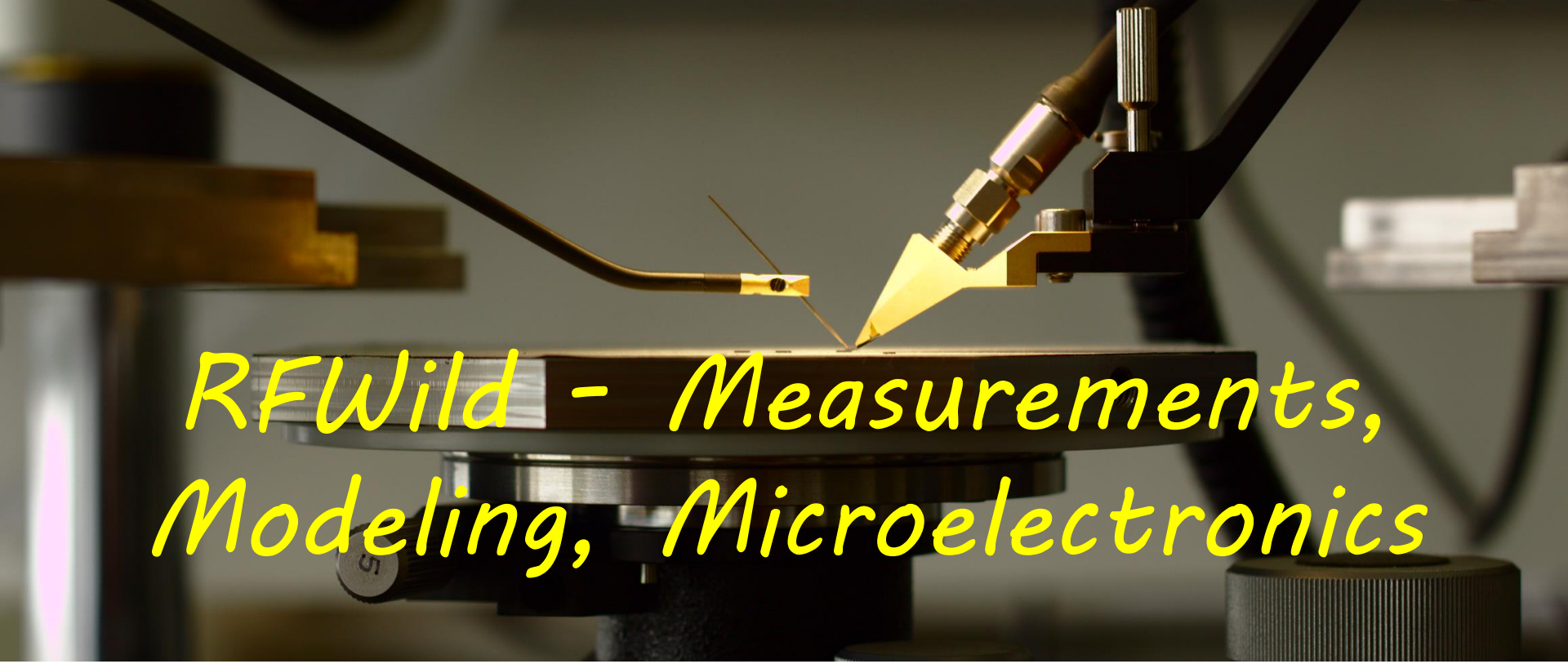
Collaboration for mutual benefits are welcome.

Our website

RFWild
Measurements & Microelectronics



http://rfwild.vhost.ifpb.edu.br



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Thank you!