IC1301 -WiPE

Wireless Power Transmission for Sustainable Electronics

SWG4.1: Space Applications

25 March 2014

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WIPE

COST IC1301

EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

Outline

- Energy Harvesting (EH) and low power Wireless Power Transfer (WPT) for satellite health monitoring
- WPT for Space Solar Power (SSP)
- WPT for remotely power unmanned aerial vehicles (UAV)
- Others applications/ideas ??
- Short presentation of CNRS-LAAS

EH & WPT for satellite health monitoring

- One sensor –> one wire
- Deploying long wire in harsh environment (satellite panels) is prohibitive
- Wireless sensors networks needs DC power
- EH for antenna panels
- WPT/RFID/MMID technique for panels on dark side (except antenna panels)
- Solar DC powering for panels on Sun side

EH & WPT for satellite health monitoring

» Due to the spill-over losses of broadcasting microwave antennas some regions of satellite external surface are illuminated with a medium/strong E-field; ***this field is available and stable as long as data links are functional****

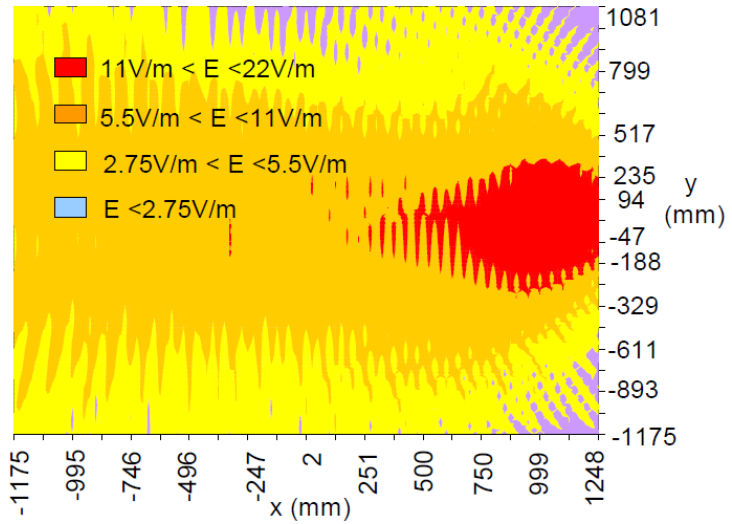


Fig. 1. E-field distribution (peak value) on a lateral panel at 3.5 GHz (C-band). Radiated power: 90 W. The x- and y-coordinates are in millimeter.

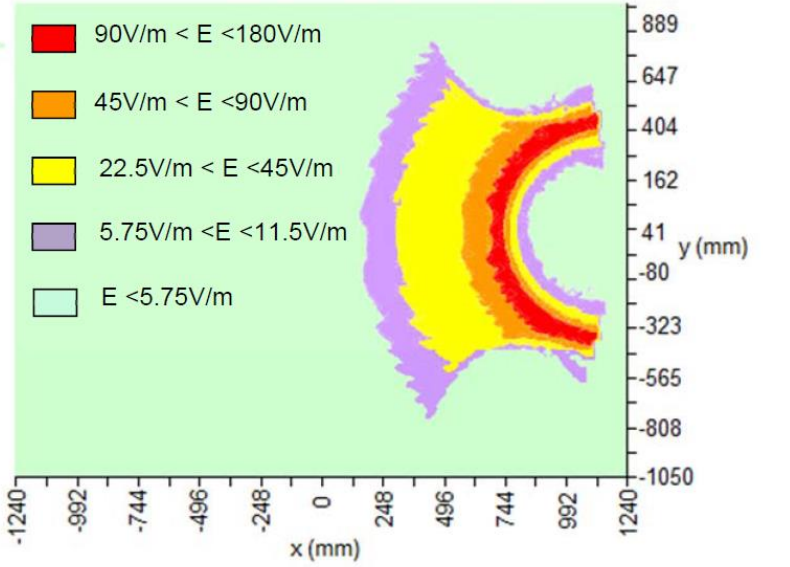


Fig. 3. E-field distribution (peak values) on Earth side of satellite at 17.7 GHz. Radiated power: 70W. The x- and y-coordinates are in millimeter.

*A. Takacs, H. Aubert, S. Fredon, L. Despoisse, H. Blondeaux, 'Microwave Power Harvesting for Satellite Health Monitoring', *IEEE Trans. Microw. Theory Tech., Special Issue on Wireless Power Transfer*, March 2014

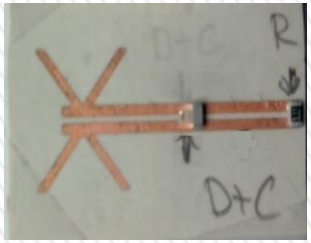
WPT for SSP & UAV applications

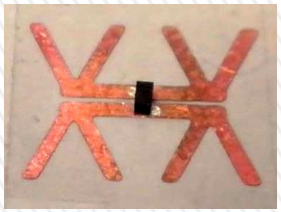
- No major research in EU
- Most of the research was performed in US (NASA funding) & Japan (JAXA funding)
- Feedback from MC observators (Prof. Tentzeris and Prof. Kawasaki) will be welcome in order to evaluate the real impact of this research

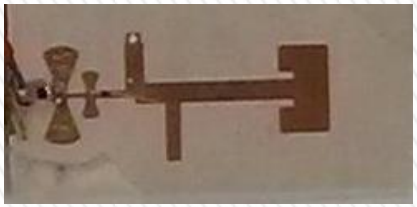
Others ideas ?

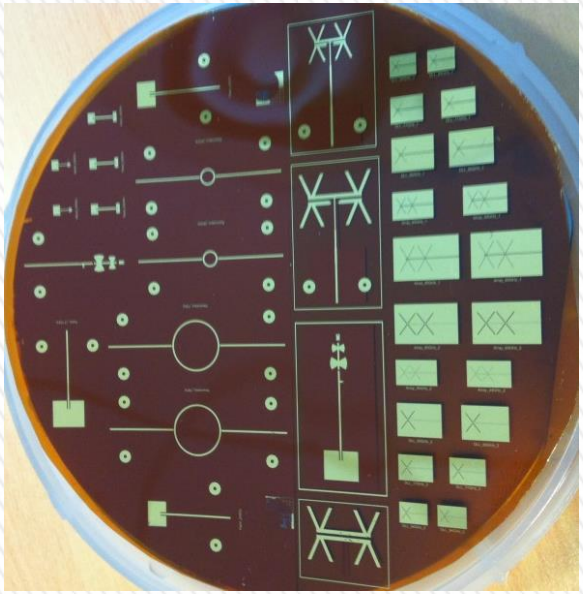
» WPT for Cubesat satellites ??

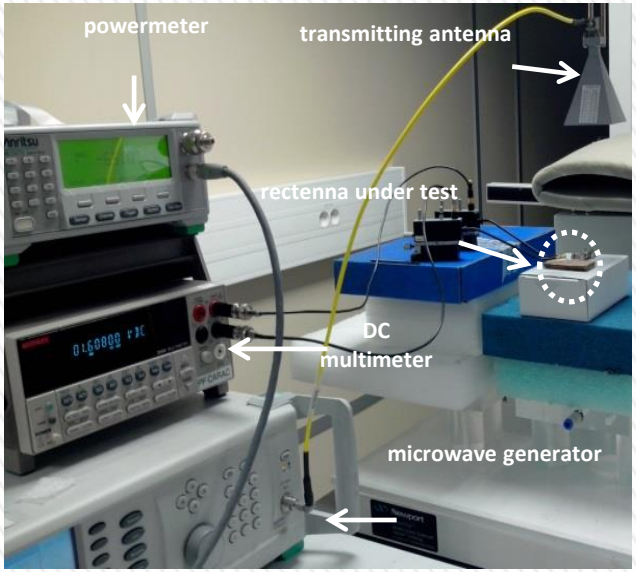
EH & WPT research at CNRS-LAAS







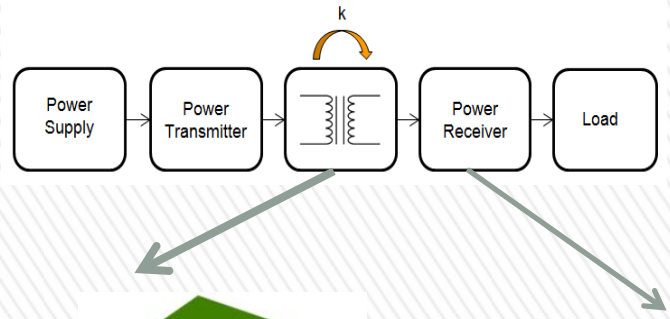


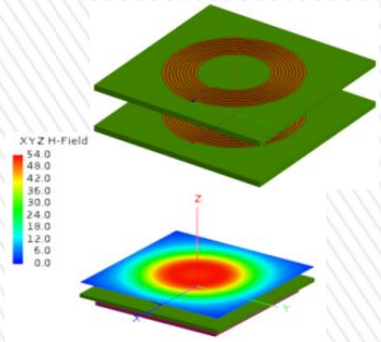


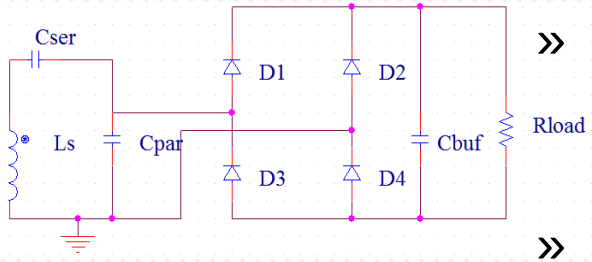
Flexible electronics on kapton: from VHF to W-band application

Rectennas for space application: partnership with French Space Agency and Thales

WPT research at CNRS-LAAS





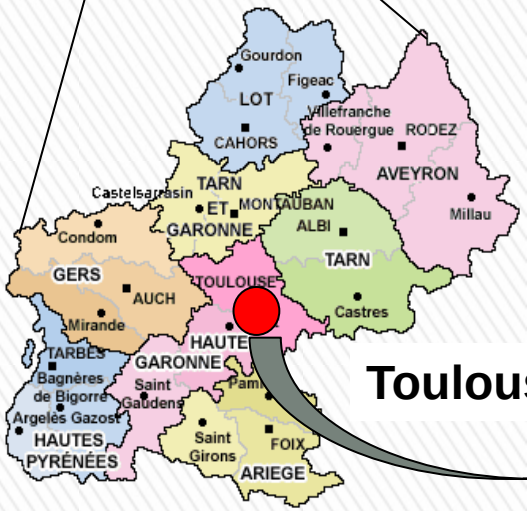


Modeling, design methodology and optimization technique for inductive (non resonant) WPT for automotive application

partnership with Continental Automotive

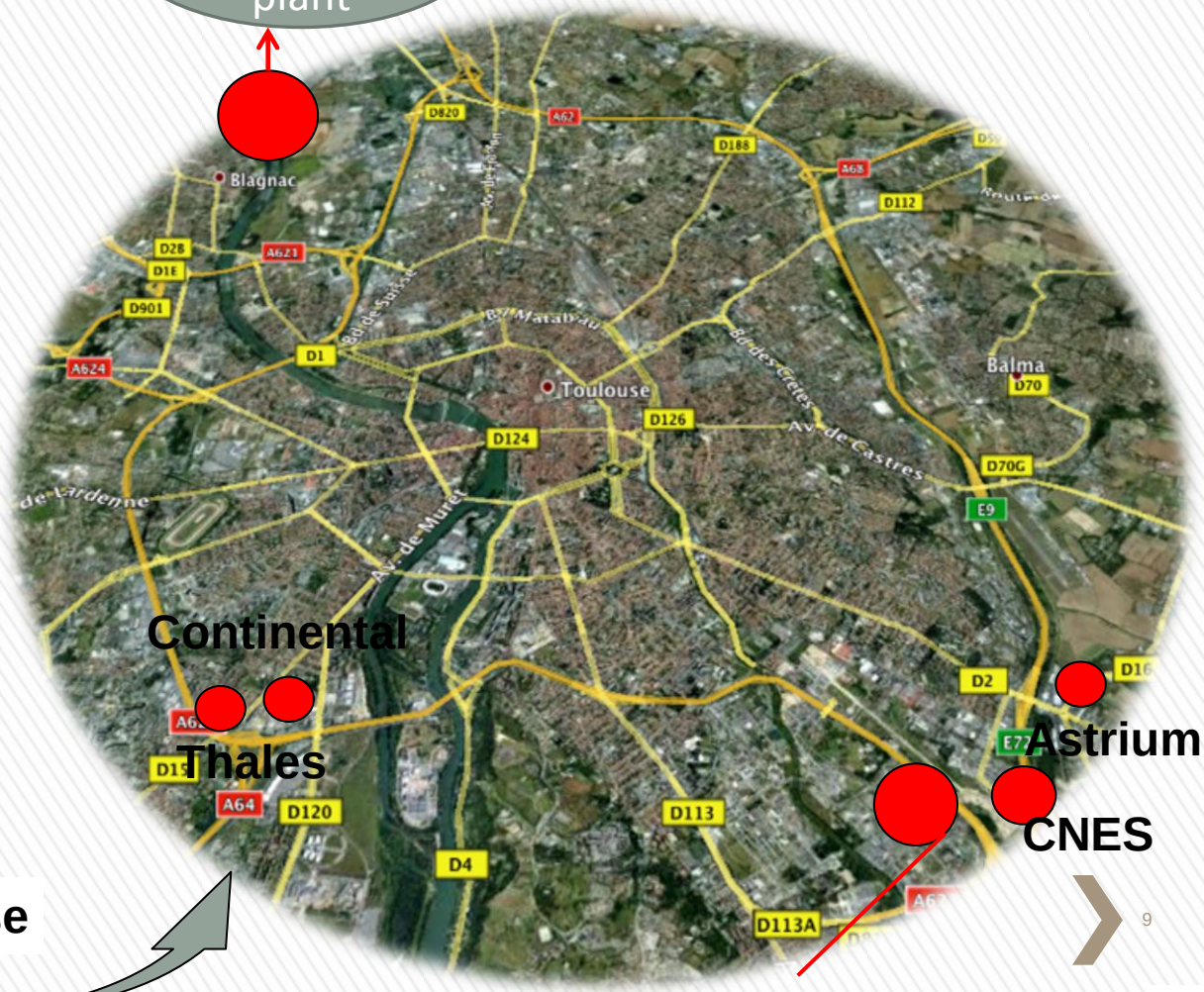
- Rigourous EM modeling/simulation of coils including ferrite by using commercial EM solvers (error < 10%)
- Co-simulation technique and design methodology for the entire WPT systems
- Multi-functional WPT systems including NFC, Bluetoth, GSM/3G/4G relay and FoD functions
- EMC problems adressed

Short presentation of CNRS-LAAS



Toulouse

A380 assembling plant



Continental

Thales

Astrium

CNES

LAAS-CNRS
7 av. Col. Roche

Short presentation of CNRS-LAAS

- Systems
  - Micro and nano systems
  - Integrated Systems
  - Embedded Systems
  - Distributed and networked Systems
  - Mobile Systems
  - Autonomous Systems

- Application Fields
  - Aeronautics
  - Space
  - Transports
  - Energy
  - Services
  - Health
  - Telecommunications
  - Environment
  - Production
  - Defense
  - Cyber security

- **Permanent staff**
- 202 Researchers and Faculty Members
  - 92 CNRS researchers
  - 110 Faculty members
- 89 engineers, technicians and administrative clerks

- **Temporary personnel**
- 7 contractual researchers
- 16 Visiting and associate researchers
- 44 Post-docs
- 248 PhD students

Over 650 persons in average

And ~ 200 interns/year

Short presentation of CNRS-LAAS: clean room facilities

From Mask fabrication

Optical photolithography

Electronic lithography

Thin film deposition

Electrochemical deposition

Metallization

M.B.E.

Wet Etching

Plasma Etching

Chemistry

Ion implantation

Packaging

To Characterization

Infrastructure and support

– 20 M€ equipment total value

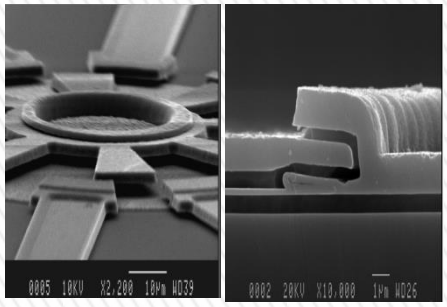
– Flexibility

• Manual / Semiautomatic /Automatic equipments

– Si and III-V technologies

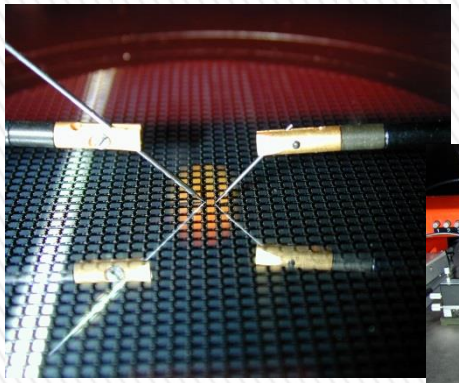
– 4'' Si wafers (upgradeable to 6 '')

– Developments in substitution technologies

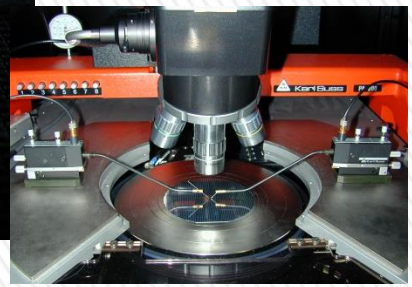


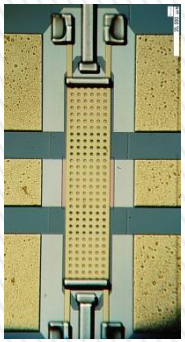
Short presentation of CNRS-LAAS

☞ Tests and characterizations of materials, components and systems:



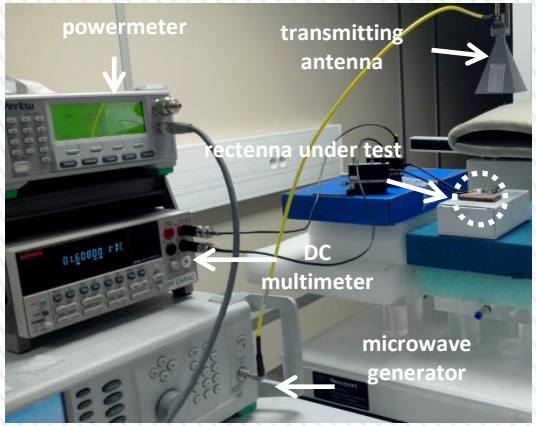
- Electronics

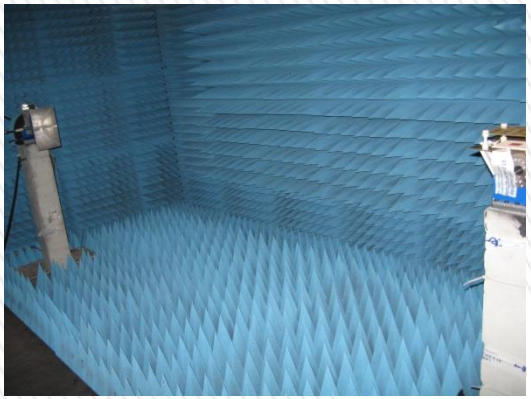




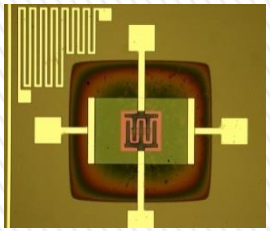
- Mmwave VNA (up to 110 GHz)

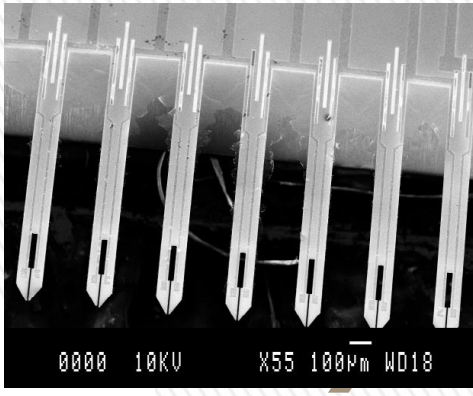
- RF, Microwave & Antennas, Optics





- Micro & Nano Systems



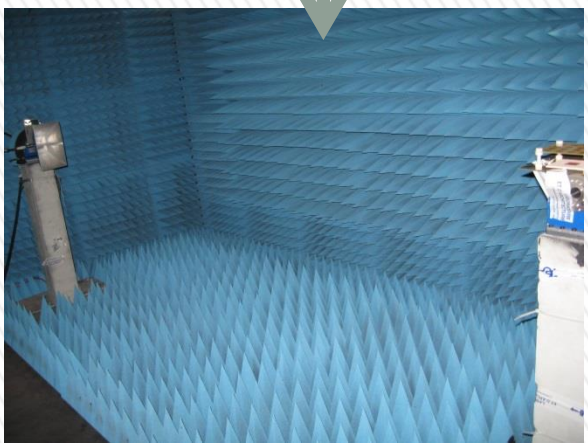


Surface: 500m²
55 test benches

- 6 engineers and technicians
- Operational budget ~80k€/year

Short presentation of CNRS-LAAS

- On wafer S parameters measurements
  - Room T° to 120° C
  - Frequency band : 0.1 GHz – 110GHz
- On wafer S parameters measurements
  - Vacuum, controlled atmosphere
  - - 77° K to Room T°
  - Frequency band : 1 GHz – 67GHz
- On wafer radiation pattern measurement
  - Frequency band : 1GHz – 67GHz
- Anechoid chamber
  - Frequency band : 1GHz – 30GHz

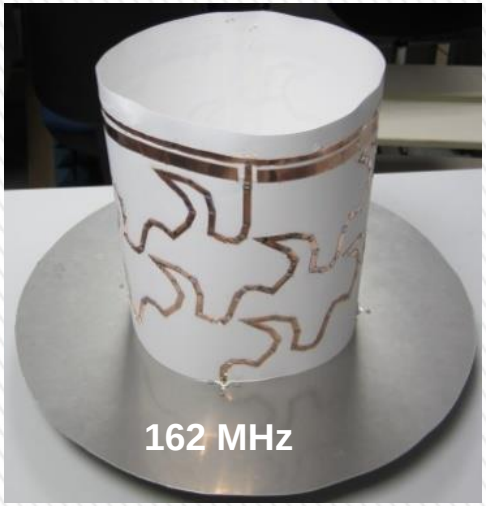


Short presentation of CNRS-LAAS

- Very compact VHF & UHF antennas

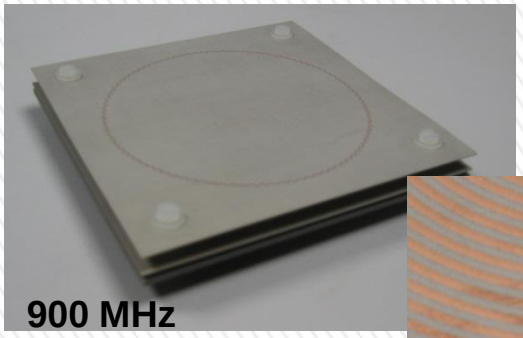
Patent WO 2009/034125

Patent WO 2008/142099

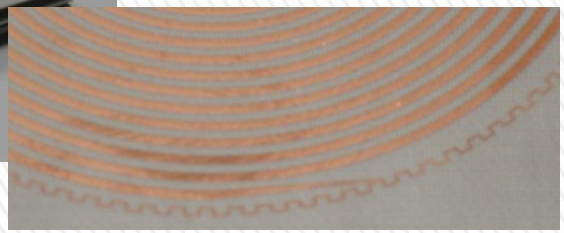


Antenna on paper

Spiral antenna



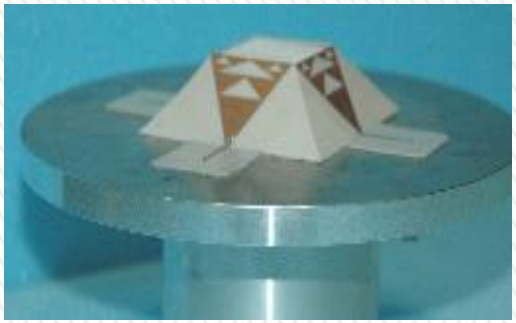
Patent WO 2013/121118

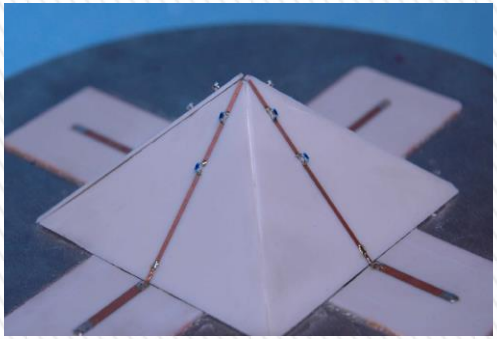


Short presentation of CNRS-LAAS

- **Multi-bands / Broad-band antennas**

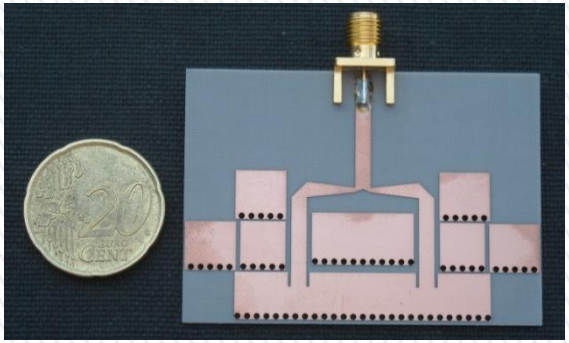
Multi-bands : 1.5 GHz / 1.9 GHz / 2.5 GHz





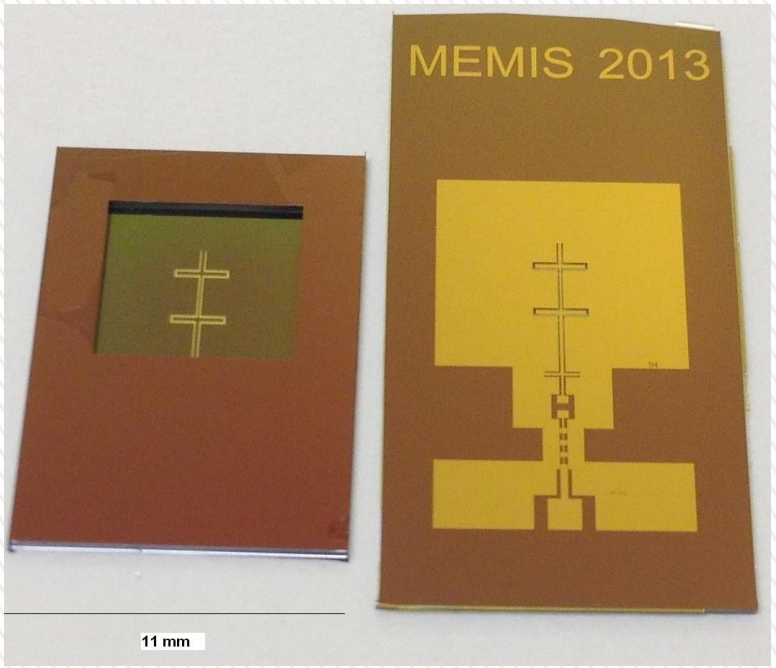
Patent WO 2008/125662

Broad-band : 6 GHz → 8,5 GHz



Short presentation of CNRS-LAAS

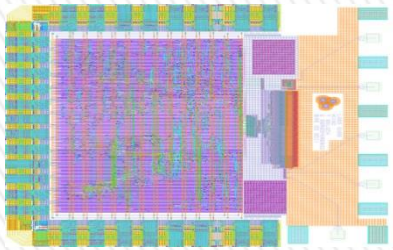
- V-band and W-band antennas



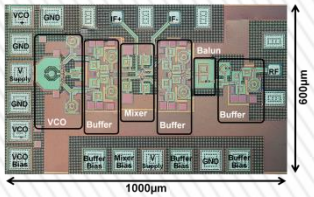
Short presentation of CNRS-LAAS

- **Low-power CMOS transceivers for V-band, UWB-IR and wireless sensors network application using ST and IHP technology**

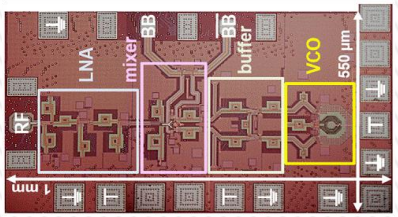
MAC layer and IR-UWB PHY layer with DAC/ADC (50mW)



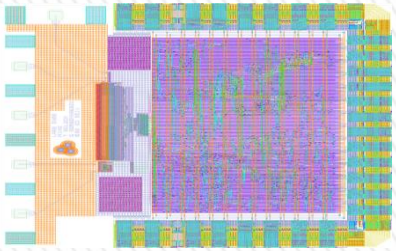
CMOS Emitter(≈53 mW)



CMOS Receiver (≈ 43mW)

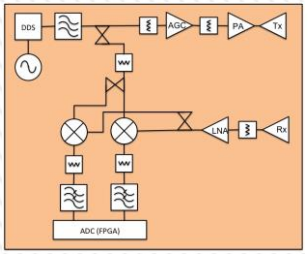


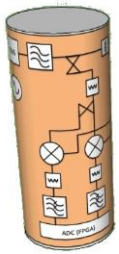
MAC layer and IR-UWB PHY layer with DAC/ADC (50mW)



Tx Rx

- **UWB Ground Penetrating Radar for soil water detection**





- **Electromagnetic transducers**
- **Passive sensors networks by using radar interrogation technique**
- **Nano-RF and graphene based devices/systems**