TeraSense

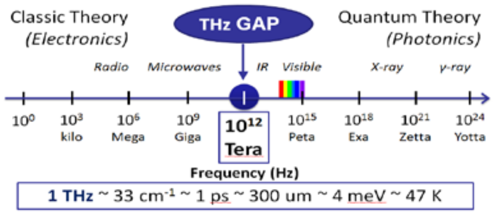
What is Terasense?

Terasense is a CONSOLIDER research programme supported by the "Ministerio de Ciencia e Innovación"(MICINN) that combines the experience of 11 universities and 16 research teams, with specialization in areas of science and technology such as electrodynamics, numerical simulation and high frequency technology and design and information fusion. Terasense aims to disseminate developments in investigation and experimentation with novel prototypes of terahertz sensing systems. Partners include: Universitat Politècnica de Catalunya, Universidad Politécnica de Madrid, Universitat Politécnica de Valencia, Universidad de Cantabria, Universitat Autònoma de Barcelona, Universidad de Granada, Universidad Autónoma de Madrid, Universidad Alcalá Henares, Universidad Carlos III, Universidad de Oviedo, Universidad de Vigo.

Terasense aims to create a unique base of expertise in Terahertz sensing, to attract senior and junior experts at international level who will participate through seminars, stays and conferences that will create the concentration of knowledge and international impact necessary to position Spain as one of the leading European countries in terahertz sensing and imaging in the midterm.

What is Terahertz?

Terahertz electromagnetic radiation (from 100GHz to 10 THz) that lies in the boundary region between light and radiowaves has attracted a great deal of attention in recent years due to its ability to achieve innovative sensing systems.



APPLICATIONS
- Security
- Space
- Biomedicine
- Material Research

NOVELTY "New" and expanding field and knowledge
TRANSVERSAL/HYBRID Influence from and to many other fields
KNOWLEDGE New means to understand physical and chemical phenomena
APPLICATIONS Opens the door for new products and methods
FINGERPRINT Molecular identification (rotational/vibrational modes)
SEE-THROUGH Dry-non-metallic materials are transparent
RESOLUTION ~mm; detailed images; localized data
SAFETY Non-ionizing; low-energy radiation

Activities in Terasense

The Terasense programme stimulates research by the electromagnetic visualization community into the use of the Terahertz spectrum.

More precisely, the activities initiated by the Programme have been:

- The definition and construction of a terahertz networked laboratory infrastructure at national level able to support the development of the different devices and subsystem:
  - THz Physical and Numerical Modeling Joint Laboratory
  - THz Device Measurement Joint Laboratory
  - THz Radiation Measurement Joint laboratory
- The construction of the three prototype instruments:
  - A 0.1 THz band THz Short-Range Real Time 2D Imaging Camera for Security Applications.
  - A 0.3 THz band High Resolution Remote Sensing Imaging Radar for Environmental Monitoring.
  - A 0.5-3 THz Near-Field System for Biostructures Sensing and Imaging.

Prototypes 100/300 GHz

94 GHz Passive Imager with Mechanical Beam-Scanning

A 94 GHz passive imager prototype has been developed. The imaging system is based on a Total-Power Radiometer with a mechanical beam-scanning antenna.
The main performance parameters of the system are summarized in the following points:

- Spatial resolution: 35mm
- Radiometric resolution: 0.3 K (70 ms integration time)
- Integration time per pixel: Adjustable (1ms - 500 ms)
- Scanning time: 7 minutes (100x50 pixels image with 70 ms integration time)

With this system, concealed objects under obscurants like clothes or luggage bags are revealed either in indoor or outdoor environments.

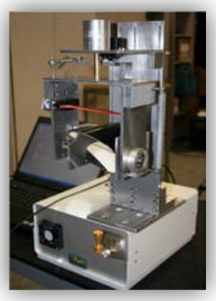


Fig. 1 Imaging system with the radiometer and the scanning antenna

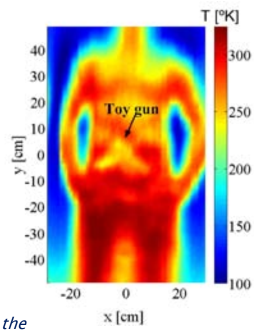


Fig. 2 Radiometric image

Fig. 3 Security scanner

92 GHz FMCW Radar

A Frequency Modulated Continuous Wave (FMCW) radar at 92GHz is being developed. Experimental measurements have been performed in order to assess the capabilities of the system.

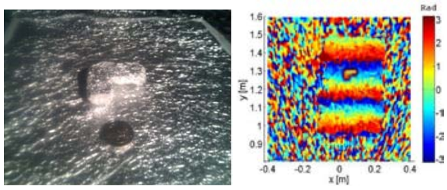


Fig. 4 (Left) Target to be detected (Right) Resultant interferometric image

100 GHz Near Field imaging system

A near field imaging system for THz tomographic imaging based on a retina is being studied. This system will allow performing real time imaging

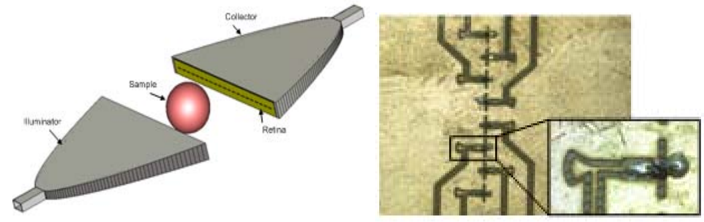


Fig. 5 (Left) Near Field imaging system. (Right) Fabricated retina of 8 slot elements with a PIN diode

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Prototypes 100/300 GHz

❖ *300 GHz Radar for Environmental Remote Sensing*

A radar at 300 GHz is being developed for the study of the attenuation due to atmospheric gas and clouds. The objective is to design, fabricate and test an all-solid-state active sub-millimeter imager that utilizes the swept-frequency FMCW radar technique to map a target in three dimensions with centimeter-scale resolution in both range and cross range.

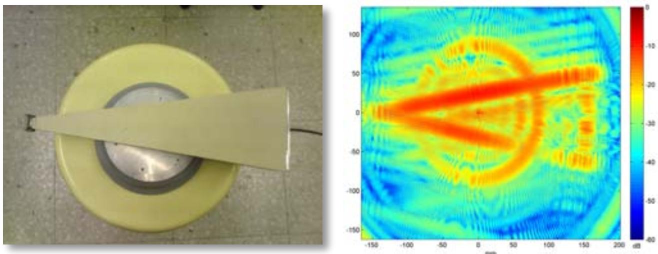


Fig. 6 (Left) Photograph of the horn-antenna target located on the turntable platform (Right) ISAR image of the horn-antenna target obtained from the data measured by the radar prototype.

Circuit Laboratory

The device technology lab has developed several tools for analysis and design of devices at THz bands

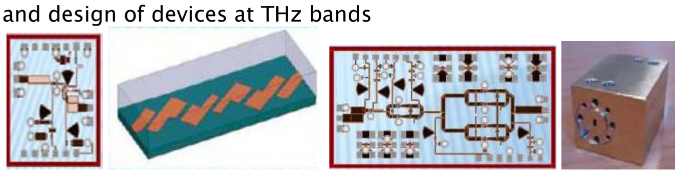


Fig. 7 From left to right - a) Low Noise Amplifier (LNA), b) High power Amplifier (HPA), c) Band Pass Filter, d) Transition Back to Back WR-10

Custom-made waveguide-microstrip transition manufactured with standard PCB prototyping machinery. Adaptation is achieved in all the range of interest and losses are below 2dB.

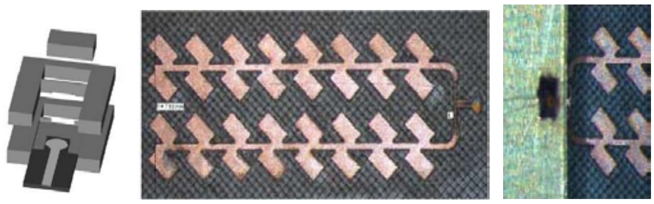


Fig. 8 From left to right - a) Waveguide-microstrip transition, b) Submillimeter wave antenna array for beem-Steering through frequency scanning, c) Array (b) with the transition (a).

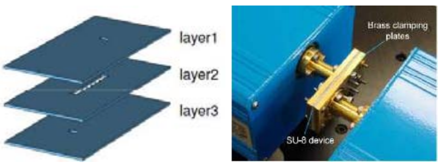


Fig. 8 Band Pass Filter

Design and analysis of a liquid crystal reflectarray demonstrator. The reflect array is designed in different architectures and stacked together.

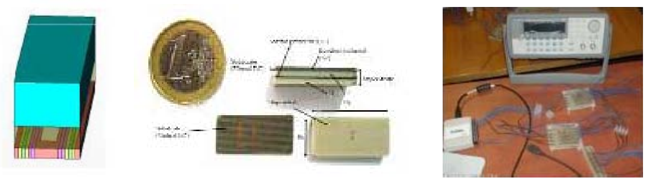


Fig. 9 Liquid Crystal Reflectarray

Antenna Design/Measurement Laboratory

The radiation sensor and measurement lab set is currently setting up the configuration that will allow the measurements and material characterization at 100 GHz and 300 GHz.
Reflector design and analysis measurement set up in the submillimeter frequency band.

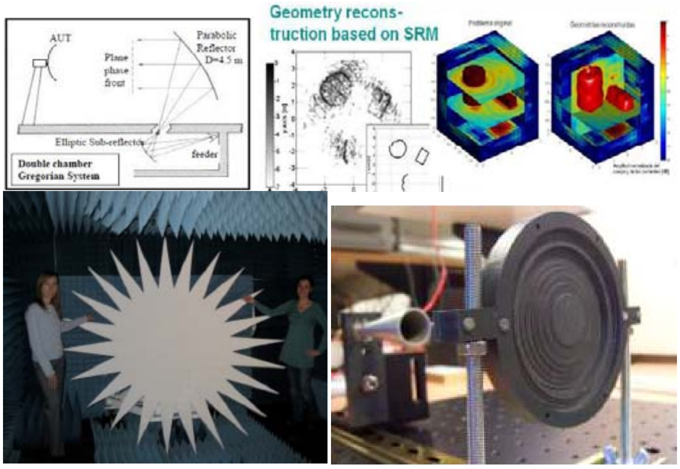
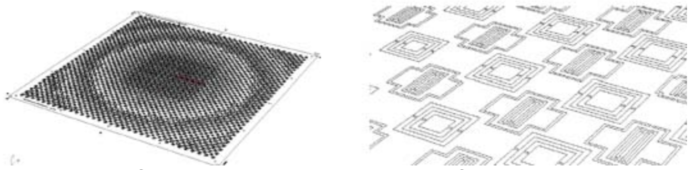


Fig. 10 Measurement set up

Simulation/Modelling Laboratory

1. Software MONURBS for the analysis and design of structures in THz. MONURBS can solve the EFIE (Electric Field Integral Equation) and the CFIE (Combined Field Integral Equation). It can also deal with conductors, dielectric and magnetic materials. The program uses a highly parallelized version of the Multilevel Fast Multipole Method.



2. Modeling of THz scenes using Blender (a free open-source 3-D content creation suit) to assess the performance of a MMW imaging system and determine if certain patterns will be distinguished for a given set of scene temperatures and image system parameters.

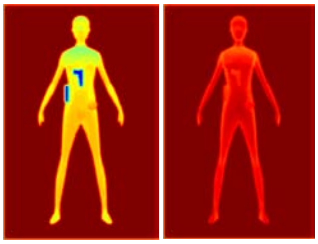


Fig. 11 Simulated passive millimeter-wave images, temperature in ºK, resolution 500 x 300 pixels (a) Outdoor, (b) Indoor

3. Study of face recognition protocols - VeriLook SDK, PCA-SVM system, DCT-GMM system in different environments (short, mid and long distance) in order to create a recognition method good enough to be applied in a not monitored scenario in the THz band.

4. Development of a high performance FDT parallel simulator. It has been included in a synthetic environment to simulate the effect of high intensity radiated fields on modern aircrafts and rotorcrafts. It gives a reduction of the computation time in the order of thousands without losses of accuracy

5. Development of computational algorithms that increase the range of applications of microwave simulation tools. Adjustment of techniques in low frequency for their use in high frequency and use of programming tools to accelerate the electromagnetic calculus in high and low frequencies.

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