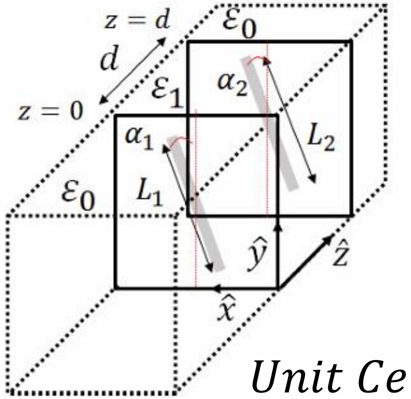
Analysis, design, and optimization of new periodic cells with improved transmission and reflection performance.

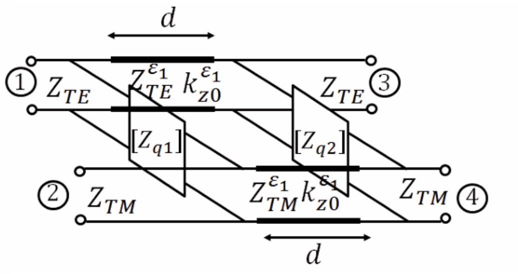
Planar Periodic Unit Cell: Base element that describes a planar periodic structure. The planar periodic surface is an infinite array of metallizations that allows modifying the reflection and transmission response on an incident plane wave. These surfaces, properly combined in a stacked structure and/or under quasi-periodic configurations, allow the development of all types of free-space planar RF devices (IRS, reflectarrays, FSS filters, polarizers, etc.).

- Design of Passive Unit Cell: Different passive periodic cell geometries have been designed to achieve complex functionalities (independent phase control in each polarization and frequency band, multi-frequency, ultra-wideband, polarization control, filtering, etc.).

- Design of Electronically Tunable Unit Cells: Several periodic cells have been designed for electronically reconfiguration using liquid crystal technology (LC) and liquid metal (Galinstan), as well as new functionalities have been achieved (independent dual band, independent dual polarization, etc.)

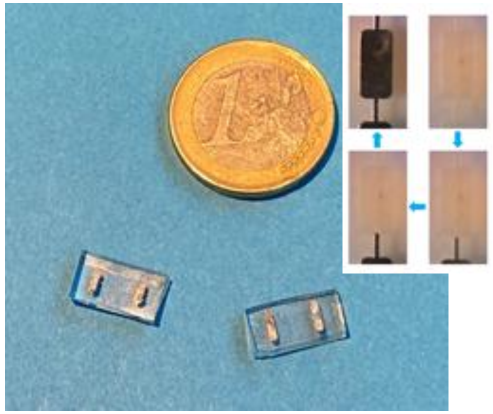


Unit Cell



Equivalent Circuit

- Modeling and Simulation: Unit cells have been modeled using trained Support Vector Machine (SVM) and also equivalent circuits for performing efficient designs



Liquid Metal – based Unit Cell

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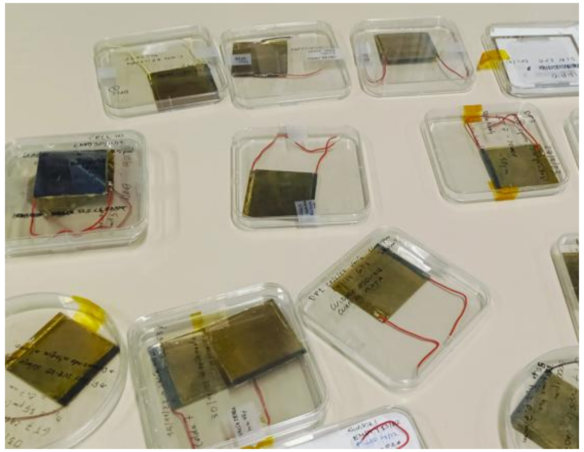
Enabling technologies: Liquid crystal (LC) materials, planar LC device fabrication, and control circuits.

Liquid Crystal: A dielectric material whose electrical permittivity changes in RF as a function of the AC voltage applied to it. They allow electronic reconfigurability in RF devices (antennas, guided devices, free-space devices, etc.).

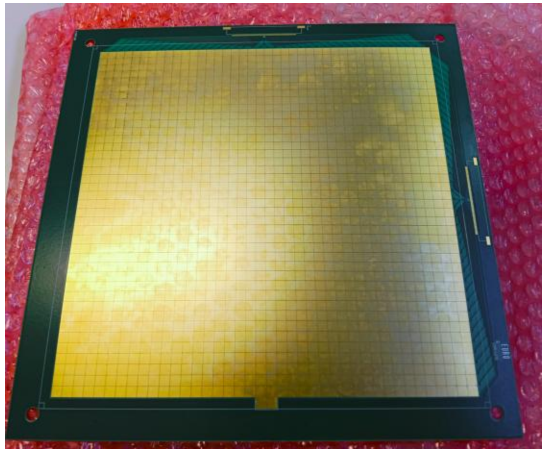
- The complex permittivities of LC mixtures have been characterized in mm-wave bands: Nematic LC, dual frequency.
- LC materials mixed with polymeric networks (ONLC) have been characterized and developed to improve switching times.
- Research in the development of manufacturing techniques for electrically large LC antennas (200 mm x200 mm) and multi-panel segmentation.
- Implementation of circuits for addressing the voltages of NxN elements and appropriate interfaces for LC antennas/RIS. Direct or active-matrix voltage addressing for LC antennas.

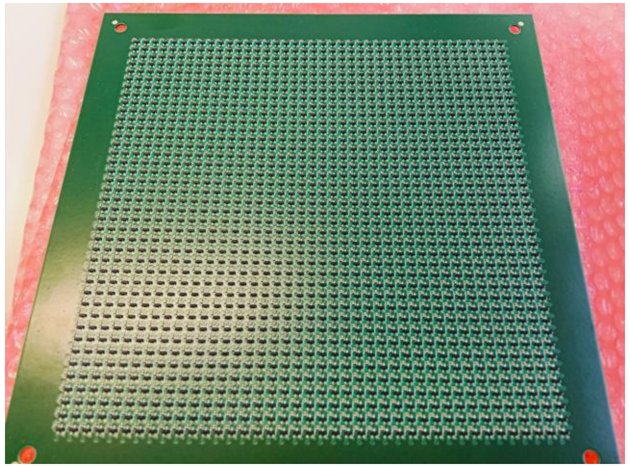


$LC - unit\ cells$

	$3\ GHz$	$10\ GHz$	$19\ GHz$ [1]	$28\ GHz$	$100\ GHz$	$200\ GHz$
$\varepsilon_{//}$	2.97	3.51	3.53	3.5	3.51	3.50
$\varepsilon_{\perp}$	2.13	2.64	2.46	2.44	2.47	2.43
$tand_{//}$	0.033	0.049	0.0064	0.021	0.018	0.015
$tand_{\perp}$	0.008	0.059	0.012	0.024	0.02	0.031

[1] Nominal from manufacturer





$LC - active\ matrix\ for\ reflectarrays$

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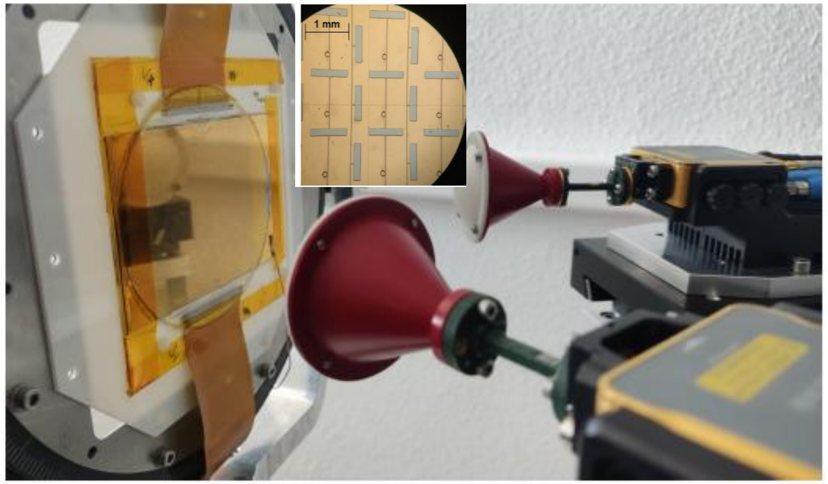
Design of passive and reconfigurable intelligent reflective surfaces (IRS).

IRS (“Intelligent Reflective Surface”): Reflective surface in free space illuminated under far-field conditions and capable of shaping the reflected radiation with a specific required spatial distribution, thus improving the communications link performance

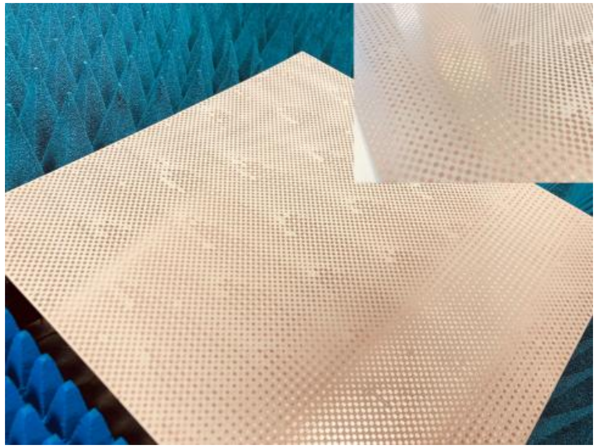
- Passive and Reconfigurable Liquid Crystal-based IRS design techniques have been developed
- Several passive RIS have been fabricated and measured at 26-28 GHz to cover different functionalities such as dual band or dual polarization and different coverages.
- Electronically reconfigurable Liquid Crystal (LC) RIS’s have been designed, fabricated and measured at 26-28 GHz, 100 GHz and 200 GHz, exhibiting several functionalities (i.e independent dual polarization control).
- The manufactured RIS have been measured in a real scenario with 5G signal, improving data link rates compared to other scatters.

$LC - RIS\ 28\ GHz$ (200mm x200 mm)

$Dual\ Pol\ LC - RIS\ 100\ GHz$ (80 mm x80 mm)



$Passive\ RIS\ (400\ mm\ x400\ mm)$



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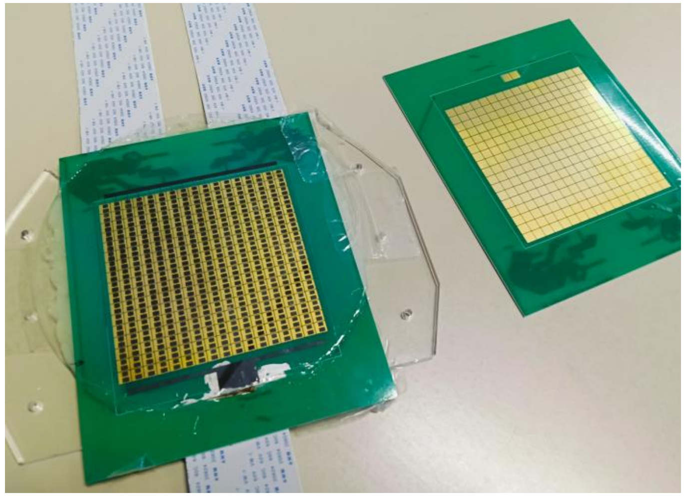
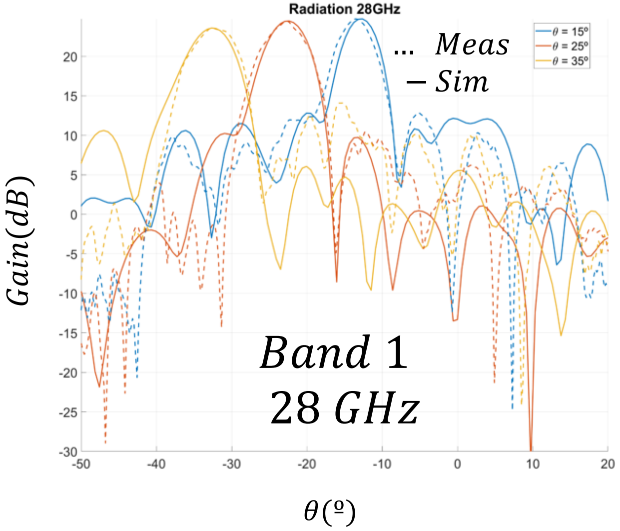
Demonstration of electronically scanned LC-Reflectarray antennas for base stations in 5G and B5G

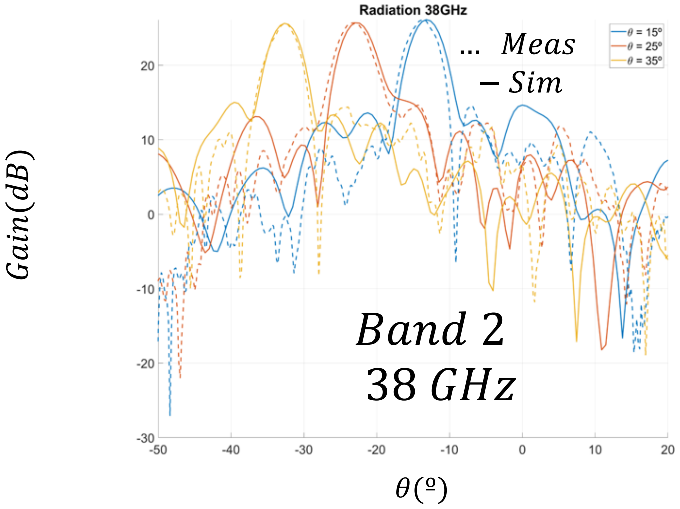
Reflectarray: A low-profile, high-gain reflective planar antenna that combines the technologies and performance of reflectors and arrays. They are illuminated by spherical sources in near field and are capable of producing a desired collimated or shaped radiation pattern with enhanced functionalities in terms of band and polarization.

- Design techniques for electronically reconfigurable liquid crystal (LC) reflectarrays have been developed, which account the angles of incidence to accurately calculate the voltages to be applied to the cells.
- Reconfigurable LC-RA prototypes for 5G base stations at 26-28 GHz and W-band have been designed, fabricated and measured. The prototypes were designed to produce reconfigurable independent dual-band, 2D steering and high gain in dual-reflector configuration.
- Cells have been designed, manufactured and measured to improve switching times using dual frequency LC and polymeric PNLC networks, obtaining times of ms



$LC - Reflectarray$





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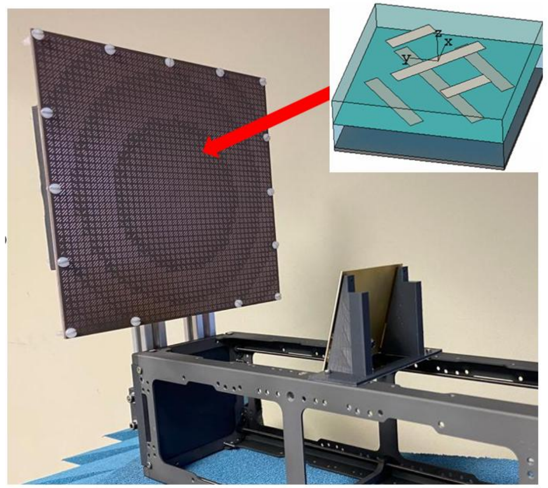
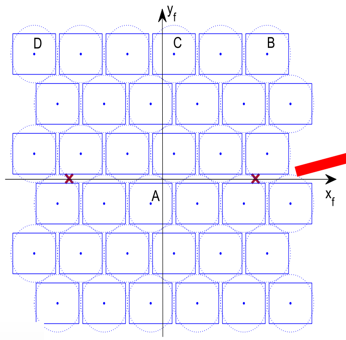
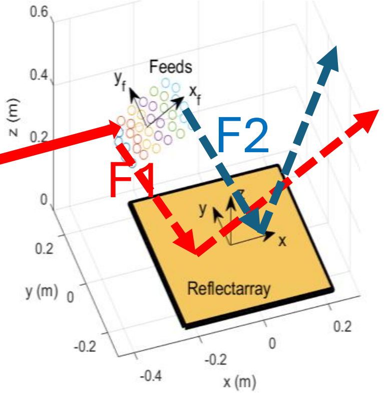
Multi-beam passive reflectarray antennas for generating cellular coverage from high altitude platforms (HAPS) or LEO satellites.

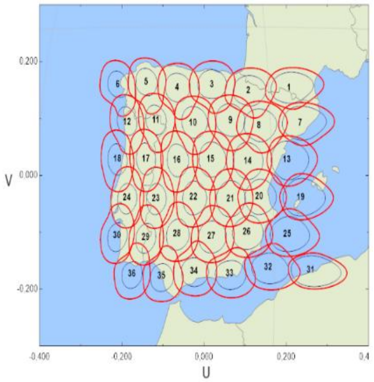
HAPS: High-altitude platforms located very close to the Earth's surface, requiring stringent antenna and beam generation characteristics. LEO: Low-orbit satellites at higher altitudes than HAPS.



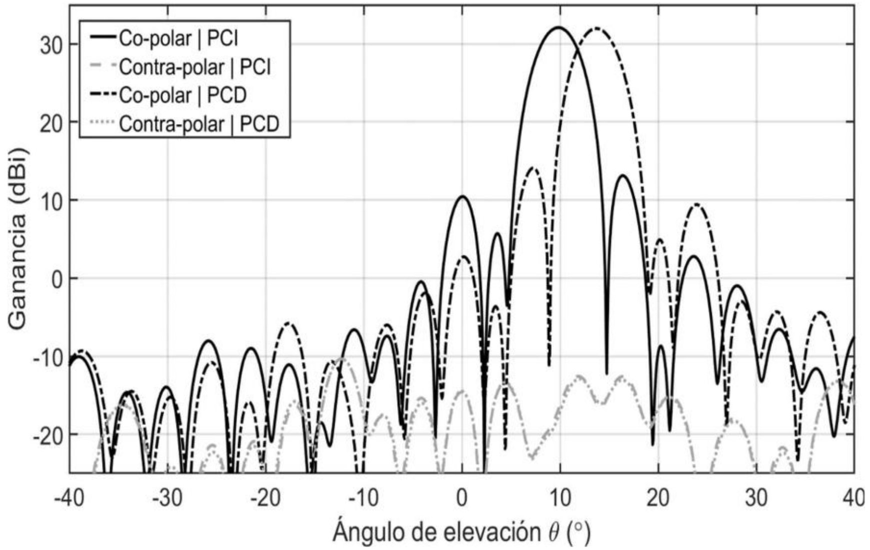
- Multibeam antenna specifications have been defined for HAPS and LEO platforms: Number of beams, antenna size, beam separations, etc
- Different antenna configurations have been studied and designed for both platforms in different frequency bands: Ka band, 28/31 GHz and V band, at 60 GHz, including polarization control performance
- A multibeam antenna demonstrator has been implemented, which performs polarization conversion from dual linear to dual circular in Ka band (20/30 GHz).







Cobertura Multi − spot



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