3D- printed multiband electrically small antennas for small satellites

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Context

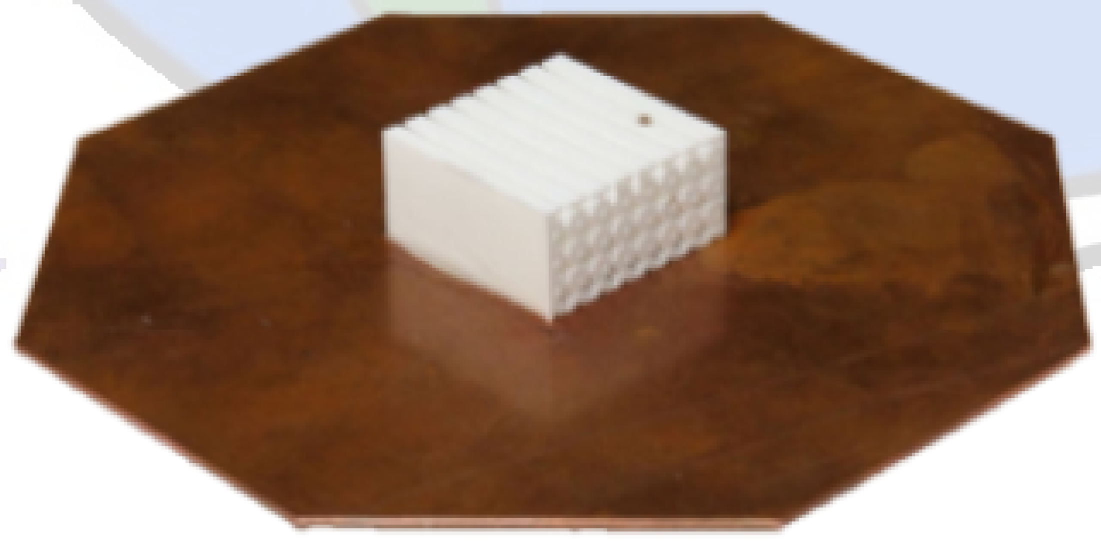
- The reduction of the size of platforms and payloads is a major issue for the development of UAVs and nanosatellites.
- This constraint of miniaturization of payloads also applies to onboard antennas.
- To minimize their number, while covering the different frequency channels useful to the mission, it may be interesting to use compact multi-band antennas.
- Among the antenna solutions proposed in the literature, one finds mainly printed antennas or dielectric resonator antennas.

Objectives

- Evaluate the potential of periodic structuring of ceramics by 3D printing to design compact and multi-band (L, S and X) antennas.

Dielectric resonator antenna

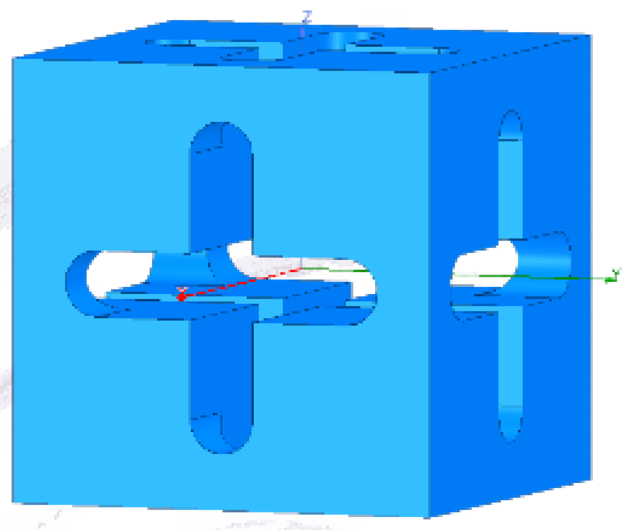
- Dielectric Resonator Antenna (DRA) is characterized by its high permittivity and its low loss tangent.
- Operating principle : the permittivity of the dielectric is much greater than that of the air that surrounds it, so the waves that are introduced into the DR are confined. Walls of the DR are also partially transparent to radio waves, allowing the radio power to radiate into space.



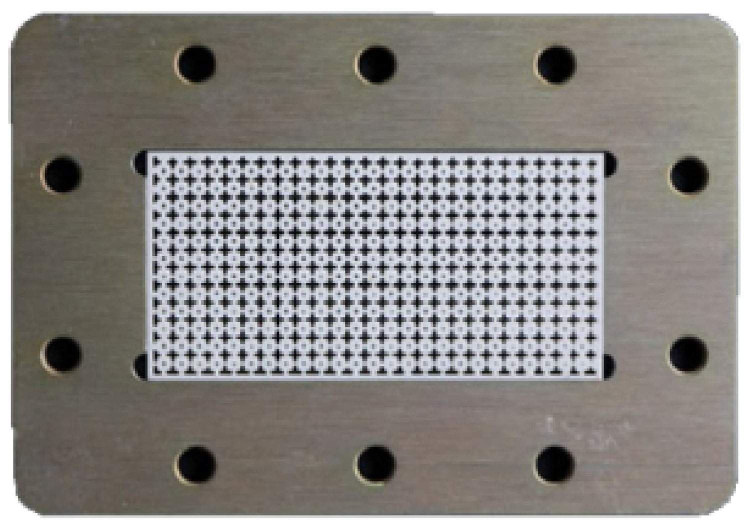
Circularly polarized dielectric resonator antenna using anisotropic ceramic obtained by 3D printing [1]

3-D printing

- In order to control the effective permittivity of the DRA, 3-D printing can be used.
- Inclusion of air in the dielectric unit cell allows to vary its effective permittivity and the shape of this inclusion allows to control its anisotropy, dispersion, or inhomogeneity.
- Anisotropy and inhomogeneity were studied during previous thesis. My work will focus on the dispersion.

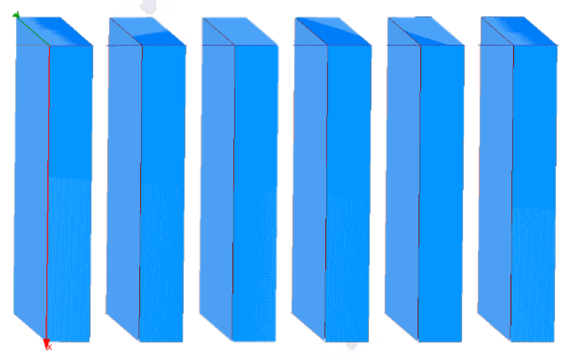


3D unit cell with cross air inclusion

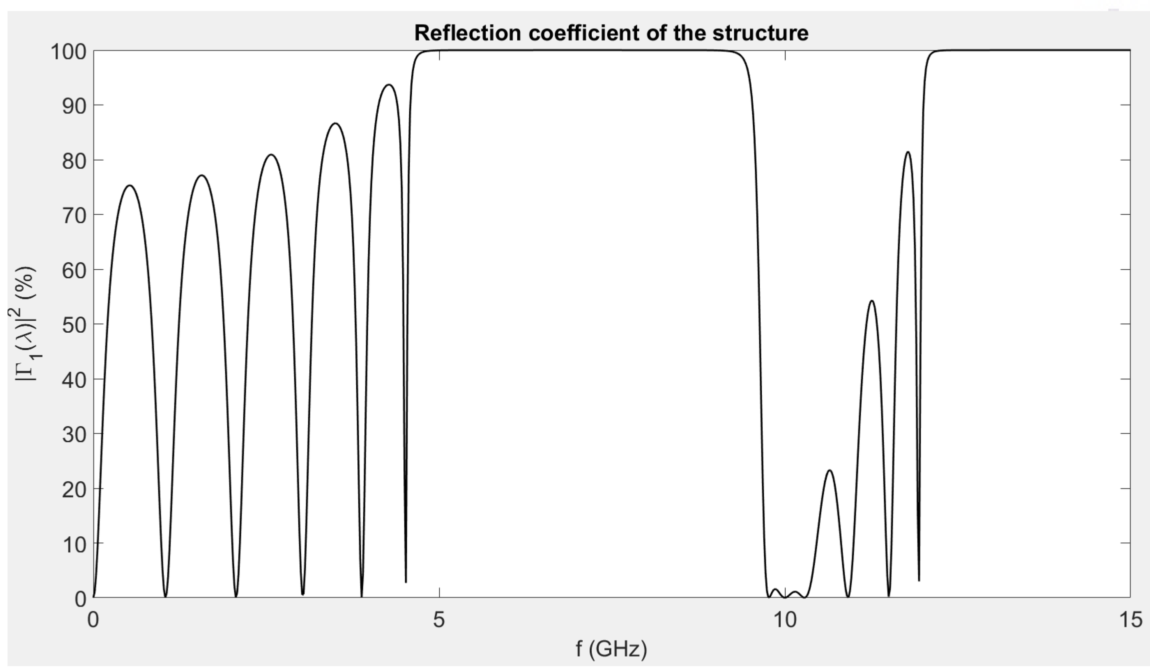


Pictures of 3D-printed ceramic sample within a WR340 sample holder [1]

Frequency dispersion



Succession of zirconia and air layers



Reflection coefficient of the structure

- Before trying to study dispersion of 3D unit cell, we are working on a much simpler 1D structure.
- Dielectric mirrors are composed of multiple thin layers of dielectric material and air. Depending the type and thickness of the dielectric layers, the reflectivity of the structure can be changed at different frequencies.
- By choosing the proper dimensions for our structure, it will behave as a homogeneous structure at low frequencies and as a dispersive structure at high frequencies.

Reference

- [1] Carlos David Morales Peña, Christophe Morlaas, Alexandre Chabory, Romain Pascaud, Marjorie Grzeskowiak, et al.. "3D-printed ceramics with engineered anisotropy for dielectric resonator antenna applications." Electronics Letters, IET, 2021.