# Realization of all-metal modulated metasurface antennas

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The development of medium and high-gain telecommunications antennas is of crucial importance in any spacecraft. Classical architectures rely on reflector antennas and phased arrays. However, reflectors are heavy and bulky, and they might not be the best option when lightweight and low-profile are required. Phased-arrays constitute an alternative, but they require complex feeding networks and their R/T modules are costly and energy-hungry. Since a reduction of weight, volume, complexity and cost is of great interest for spaceborne antennas, significant efforts have been carried out along these lines. Among the most noteworthy solutions, one can find deployable reflectarrays (R. E. Hodges, et al., *IEEE Antennas Propag. Mag.*, 2017, 59.2: 39-49) and meshed deployable reflectors (N. Chahat et al., *IEEE Trans. Antennas Propag.*, 2016, 64.9: 2083-2093). More recently, with the advent of planar metasurface (MTS) antennas (Minatti et al., *IEEE Trans. Antennas Propag.*, 2015, 63.4: 1288-1300), the integration of such antennas on the spacecraft chassis is under investigation as low-profile, non-deployable solution.

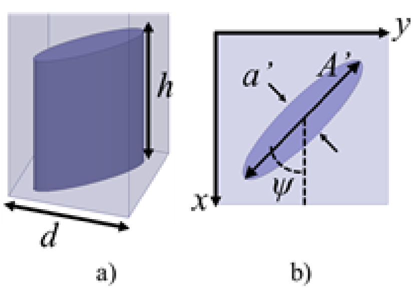


**Fig. 1.** a) MTS element consisting of a cylinder with elliptical cross-section. b) Geometrical parameters used in the modulation of the reactance tensor.

In modulated MTS antennas, a surface-wave (SW) is gradually radiated by modulating an equivalent reactance tensor in the aperture plane. Such modulation results in the (-1) indexed Floquet mode entering the visible region, thus becoming a leaky-wave (LW) mode with curvilinear phase-contour. In this contribution, we will present the use of a class of metallic MTS in the synthesis of the reactance tensor required to obtain the objective radiation patterns. The absence of dielectric is useful to survive harsh environments in space exploration. This includes large thermal ranges and high radiation levels. An all metal design (e.g. aluminum) will be less susceptible to thermal variation and will not suffer for dielectric property change due to high level of radiation.

The proposed element consists of a metallic cylinder with elliptical cross-section, placed on a ground plane and arranged in a square lattice with subwavelength unit-cell side. Fig. 1a) shows the MTS constitutive element, whereas Fig. 1b) presents the parameters used to modulate the reactance tensor. We have applied this structure to the design of several MTS antennas. In particular, a right-handed circularly polarized (RHCP) antenna with a broadside pencil beam has been developed to operate in the 31.8-23.3 GHz downlink band of the Deep Space Network. The obtained performance was initially verified by full-wave simulations. Then, a prototype (see Fig. 2) was manufactured and tested. The measured data show a very good agreement with the simulated results.

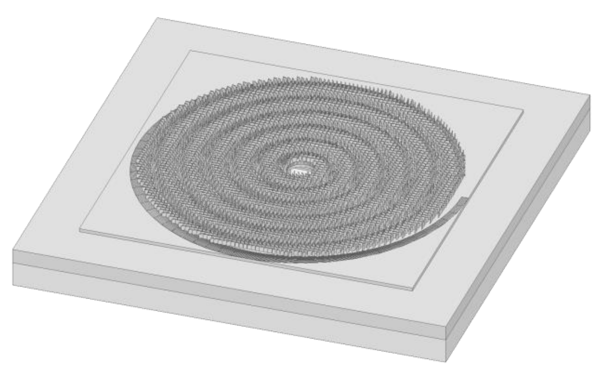

**Fig. 2.** CAD model of the fabricated RHCP broadside beam MTS antenna.