Summary

This thesis focuses on the deterministic design of metasurface antennas.

Metasurfaces are metamaterial-inspired surfaces composed of sub-wavelength elements; they possess the ability to manipulate electromagnetic waves with unprecedented flexibility and have been employed in a wide range of antenna applications.

Metasurface design relies on the macroscopic approximation of its electromagnetic response by means of a homogenized Impedance Boundary Condition (IBC). The determination of the impedance profile that may guarantee the desired antenna performance constitutes the first crucial step in the design process.

The research work involves both static and reconfigurable antennas.

A novel beam-scanning dual-metasurface antenna is designed, where beam steering is achieved by pairing a sinusoidally-modulated reactance surface with a varactor-loaded reconfigurable metasurface.

A new, generalized deterministic numerical method for the full design of metasurface antennas is developed that allows to self-consistently include 3D metallic feeding structures inside the optimization instance, thus enabling accurate estimation of the antenna performances, e.g. the peak realized gain. This method is successfully applied to the design of several edge-fed rectangular metasurfaces and center-fed circular antennas, and the results are validated with full-wave simulations. The most difficult designs involving broadside-radiating leaky wave antennas are also fabricated and measured.

Finally, the proposed automated design method, initially developed to deal with isotropic metasurfaces, is modified to be able to synthesize fully tensorial metasurfaces, without any a priori assumption on the tensor impedance profile.