Summary

This Thesis work has been devoted to numerical methods for the design of metamaterial antennas, and in particular to its relevant meta-surface (MS) version. Metamaterials, and especially metasurfaces, have been one of the most relevant recent additions to the design of electromagnetic devices, and in particular antennas.
Metasurface antennas are based on sub-wavelength textures- usually called *unit cells* - and extend to sizeable electrical lengths. This makes their full-wave (i.e. unapproximated) analysis challenging. However, the effect of the sub-wavelength texturing is well approximated, on the relevant wave scale, by a homogenized impedance boundary condition (IBC). Numerical analysis with the IBC is a lot less demanding than the analysis of the actual layout of the antenna, but IBC is especially important in the design phase of the antenna.
Designing the antenna via the spatial profile of the IBC allows to break the design task in two: 1) design of the IBC distribution; 2) design of the individual unit cells that locally yield the desired value of the surface impedance.
Throughout, the background numerical formulation of the problem has been in terms of surface integral equations (IEs), that is commonly called "Method of Moments" (MoM); it is discretized with finite elements defined on triangles and known as Rao-Wilton-Glisson (RWG) functions. The MoM operations are carried out with an FFT-based fast factorization.
The design is approached as an optimization process for the spatial distribution of the IBC; use of full-wave simulation in this optimization cycle is made possible by aggregating the underlying RWG functions into entire-domain basis functions, in the form of waveguide modes. It is shown that this is advantageous in terms of the total numerical resources required in the optimization process. The scheme is applied to the design of two relevant classes of metasurface antennas.
The important issue of the structure needed to launch the wave that then propagates on the IBC radiating surface is then addressed. Finally, solutions obtained with the IBC and the full layout are compared with one another, and against measured data of realized antennas.