ABSTRACT

Transmitarray antennas have attracted a lot of interest in the antenna research field, since they represent an emerging alternative solution for many micro- and millimeter-waves applications, such as radar or satellite communication systems. Thanks to its characteristics, exploiting at the same time the advantages of lenses and phased arrays, transmitarrays are able to provide high gain, high efficiency and versatile radiation performances. In addition, the absence of feed blockage and the low cost of manufacturing are other advantages making them a very efficient antenna for many applications. A Transmitarray (TA) antenna is typically composed of a feed source that illuminates a single or multilayer quasi-periodic planar array of different cells. Each cell is individually designed to provide the required phase-shift allowing to transform the wave radiated by the feed in the desired radiation pattern. Various possibilities can be adopted for the TA realization, ranging from more traditional configurations, which consist of several dielectric layers with printed patches, to metal- or dielectric-only solutions. The designed antenna generally represents a trade-off between its performances, especially for what concerns the TA bandwidth and the possible scanning capabilities, and its complexity.

Recently, Additive Manufacturing, also called “3D-printing”, has received a great attention in many different sectors including electrical engineering, biomedical engineering, mechanical engineering, civil electrical, architecture and art. This is mainly due to several advantages compared to standard manufacturing, such as the less prototyping time, cost reduction, flexible design and digital manufacturing. Due to its capability to realize objects with arbitrarily geometry, 3D printing is also becoming the enabling technology to manufacture very complex EM structures and antennas.

Transmitarrays with enhanced performances and their fabrication with Additive Manufacturing are the main topics tackled in the work here presented. This dissertation proposes two novel unit-cells for the realization of dielectric transmitarrays with improved bandwidth and beam-scanning capabilities, which can be manufactured with 3D printing techniques. The basic idea is to use one (or more) dielectric layer(s) perforated with holes, whose size is used to control the effective permittivity and the transmission coefficient. The first considered unit-cell consists of a single dielectric layer with a central square hole: even if its performances are good, it presents a reduced bandwidth. For this reason, a second cell is introduced: two external tapered matching

layers are added on top and bottom of the first unit cell, with the objective to have a larger bandwidth, a higher efficiency and to implement a scanning beam transmitarray without the use of active components. For both the cells, equivalent transmission line models are derived through the effective medium theory and the Maxwell Garnett formulation for composite materials. These unit-cells are exploited to design several dielectric transmitarrays working in Ka- and Ku-band.

The physical realization of the proposed structures has been enabled through the use of Additive Manufacturing processes, and in particular of PolyJet and Fused Deposition Modeling. The dissertation includes a detailed description of the procedure and the some guidelines to realize a 3D-printed prototype in different frequency bands. To validate the proposed innovative dielectric elements, the 3D-printed prototypes have been finally experimentally characterized. The measurements have confirmed the improvements achieved with the new structures in terms of bandwidth and scanning capabilities, and the possibility of their realization with Additive Manufacturing processes.