SPECIAL SESSION : "Prospective co-operative research directions on metamaterials: the Metamorphose network" (Ari Sihvola and Sergei Tretyakov)

RESEARCH ON METAMATERIALS FOR ANTENNA APPLICATIONS

R. Gonzalo. I. Ederra, J. C. Iriarte, B. Martinez, E. Saenz, A. Cantora and P. de Maagt(2)

(1) Antenna Group, Electrical and Electronic Engineering Department, Universidad Pública de Navarra
Campus Arrosadia, E-31006, Pamplona, Navarra, Spain.
E-mail: ramon@unavarra.es

(2) Electromagnetics & Space Environments Division, European Space Agency, ESTEC, PO Box 299, 2201 AG Noordwijk, The Netherlands

During the last 20 years a lot of attention has been paid to apply Electromagnetic Band Gap (EBG) technology in different frequency ranges, from microwaves to optics. EBG technology is based on the use of periodic structures to prevent the electromagnetic propagation in certain frequency ranges, known as the bandgap [1]. In the last years the new and revolutionary field of Metamaterials is trying to be applied to similar applications. Although different, both technologies have some similitudes as it has been proven for different authors. For instance when working with EBG structures Left-Handed properties can be obtained in some frequency ranges. In this paper, research efforts focussed on applying EBG technology and the more recent Metamaterials, in particular, left-handed materials, to antenna subsystems at microwave and (sub)millimetre wave frequencies are introduced.

At microwave frequencies, improvements on array configurations have been obtained by using EBG technology. For example, by means of using high dielectric materials, very compact sub-systems with suppression of scan blindness and grating lobes effects when phased arrays are used haven been achieved. Developments carried out together with RWTH (Germany), European Space Agency (ESA) and Universidad Politécnica de Cataluña (Spain) in the framework of different collaborations will be presented. Measurements of near electric field on EBG antennas have been performed in collaboration with RWTH.

First steps on using left-handed media as superstrate and substrate to improve radiation performances of array antennas will be included. In particular, our initial results show that very efficient radiating configurations can be created by means of combining dipole antennas and metamaterial superstrates. Moreover, this technology has also been applied to the design of microwave devices (transmission lines, quarter wavelength transformer, etc). The improvements in the performance of these devices with respect to conventional ones will also be introduced.

In the millimetre wave range imaging applications are getting considerable attention. Among the different technology routes that could be explored in order to develop these systems [3, 4], Electromagnetic Band Gap (EBG) technology is a good candidate [3, 4]. The use of EBGs for imaging array applications can bring some advantages with respect to conventional solutions. For instance, problems related to surface wave excitation that arise in planar antennas can be overcome using EBG substrates [3]; this provides, in theory, the means to isolate individual pixels from their respective neighbours. With respect to the fabrication of systems based on EBG technology, it may involve less processing steps than conventional micro machined solutions while preserving system performance. It is also foreseen that by using this technology it should be possible to make fully 3-dimensional circuitry allowing one to build more complex systems [5].

Development of imaging array systems in EBG technology are in progress. Direct detection and heterodyne sub-systems have been already implemented. High sensitivity detectors are being developed. Results obtained in close cooperation with Rutherford Appleton Laboratory (RAL-England), RWTH (Germany), TU/e(The Netherlands), University of Bern (Switzerland) and European space Agency (ESA) will be presented. Measurements of dielectric constant and loss tangent for high dielectric materials in the millimetre and sub-millimetre wave range have been performed in close collaboration with RWTH and ESA.

The design of the first mixer based on EBG technology initially developed under the framework of the Startiger project (funded by ESA) and improved and finished by Public University of Navarra in close collaboration with RAL will be shown. Some first step towards the generation of high efficient transmission lines in EBG technology will also be shown.

[1] J.D. Joannopoulos, R.D. Meade,and J,N. Winn, “Photonic Crystals; Molding the Flow of Light”, Princeton, NJ, Princeton Univ. Press, 1995.
[2] “Special issue on quasi-optical techniques”, IEEE Trans. Microwave Theory Tech., **41**, Oct. 1993.

[3] P. de Maagt, R. Gonzalo, Y.C. Vardaxoglou, and J.-M. Baracco, "Electromagnetic Bandgap Antennas and Components for Microwave and (Sub)Millimeter Wave Applications", IEEE Trans. On Antennas and Propagation, **51**, No. 10, pp. 2667-2677, Oct. 2003.

[4] R. Gonzalo, I. Ederra, C.M. Mann, and P. de Maagt, "Radiation properties of terahertz dipole antenna mounted on photonic crystal", *Electronics Letters*, **37**, pp. 613 –614, 10 May 2001.