UNC CHARLOTTE
The WILLIAM STATES LEE COLLEGE *of* ENGINEERING

Senior Design Project Description

Company Name	*University of North Carolina at Charlotte*	**Date Submitted**	*06/10/2020*
Project Title	*Additive Manufacturable Metasurface Antennas* **(UNCC_META)**	**Planned Starting Semester**	Fall 2020

Personnel

The table below provides an estimate of student's needs.

Discipline	Number	Discipline	Number
Mechanical		Electrical	3
Computer		Systems	
Other			

Company and Project Overview:

The project will be developed in the electromagnetic laboratory in the Electrical and Computer Engineering Department at the University of North Carolina at Charlotte under the supervision of the Principal Investigator (PI) Prof. Mario Junior Mencagli. The PI has an experience of about six years on several aspects of wave-matter interaction related to metamaterials and metasurfaces (MTSs). Among these aspects, emerging MTS antennas have represented one of the principal research interests of the PI. MTS antennas have witnessed remarkable development over the last few years. Key advantages they offer include their lightweight and ultra-thin form factor and ability to beam shape, provide multiple directive beams, and offer polarization control. To date, however, most of the research efforts on these antenna systems have been dedicated to MTS antennas manufacturable with the standard PCB technology. Moreover, currently proposed solutions do not offer any radiation pattern reconfigurability, which is a crucial capability for antennas compatible with future communication systems. In the proposed project, the students, under the supervision of the PI, will investigate novel MTS antennas that can be realized with emerging additive manufacturing techniques. Passive and reconfigurable solutions will be explored in the framework of the project.

Project Requirements:

The MTS antennas operating principle is based on the transformation of a cylindrical surface wave, excited by a central coplanar feed, into a radiative wave, called a leaky wave, through a spatially modulated surface impedance. To date, the surface impedance is implemented through MTSs consisting of a dense lattice of electrically small metallic elements (called pixels) distributed on a surface backed by a ground plane. The modulation is obtained by varying the size and/or shape of the elements maintaining the reticular pitch constant.

The objective of this project is to design, manufacture, and test an antenna based on the concept of the MTSs using additive manufacturing techniques. The basic idea is to replace two-dimensional pixels, constituted of printed metallic patches, with cylindrical pixels of arbitrary cross-section and

variable height. In principle, the height of the pixels mainly controls the level of the impedance, while the shape of the cross-section determines the degree of anisotropy and therefore controls the polarization. Both fully dielectric and fully metallic pixels will be explored. The final antenna design must be capable of being produced using a 3D printer and the standard materials associated with it, such as ABS (3D printer dielectric material) and metal-filled PLA (3D printer metallic material). Reconfigurable solutions will be investigated by means of conductive liquid materials, which enable to tune the electromagnetic parameters of the antenna.

Students will compare theoretical and experimental data related to the performance of the designed antenna (gain, directivity, and efficiency), by simulating the chosen design parameters, manufacturing, and testing the MTS antenna. A verification testing protocol will need to be developed and implemented to ensure the desired operation of the antenna.

Expected Deliverables/Results:

- Design methodology of MTS antennas using additive manufacturing techniques;
- Full wave simulations using commercial software (Ansys HFSS, Comsol) of the antenna system;
- Realization of the design MTS antenna with various 3D printing materials;
- Comparison of numerical and experimental results.

Disposition of Deliverables at the End of the Project:

- Present the findings at top-notch conferences on engineering (Eur. Conf. Antennas Propaga., Eur. Microw. Conf., IEEE Int. Microw. Symp., IEEE Int. Antennas Propaga.).
- The foreseen scientific results from this collaboration have the potential of leading to publication in Word-class high impact journals such as IEEE Trans. Antennas Propag., and IEEE Trans. Microw. Theory Tech.
- Deliver working modulated MTS antenna at Expo.

List here any specific skills, requirements, specific courses, knowledge needed or suggested:

- Interest in conducting research on electromagnetic MTSs related to radiative systems;
- Suggested Pre/Co-Requisites.: ECGR 3121 Intro to Electromagnetic Fields, ECGR 3122 Electromagnetic Waves, ECGR 4121 Antennas, and ECGR 4090 Metamaterials and Metasurfaces.