Abstract

The interaction between an impinging electromagnetic wave and a target results in a scattered wave, which depends upon the frequency, the size, shape and electromagnetic properties of the target. The measurement of a scattered signal can be used to detect or characterize a target, and the applications range from radar systems at large scale to optical tomography at the microscale. When the targets have very large or very small dimensions, the microwave analogy appears as a useful approach to experimentally investigate a scattering problem. The experiment is therefore scaled to the microwave range and the target is mimicked by a centimeter-sized analog, while maintaining the same initial wavelength over target dimension ratio and conserving the same initial permittivity. The microwave scattering experiments are realized in the anechoic chamber of the Centre Commun de Ressources en Microondes at the frequencies between 2 GHz and 18 GHz.

The objective of this thesis is to widen the application of the microwave analogy by adopting the appropriate techniques to create objects of controlled shapes and electromagnetic properties using special manufacturing technologies, as well as by developing a versatile setup providing accurate measurements. A special interest is given on low scattering targets, i.e. with low permittivity contrasts and/or small dimensions compared to the wavelength. An extensive study on the random noise characterization of the measurement setup was made and the undesired reflections within the anechoic chamber were investigated. As a result, a novel optimization technique was proposed which allow having a flexible control of the setup parameters according to the investigated target. It consists on angular zones decompositions of the bistatic region with different power profiles. In addition, A Hardgating system utilizing two RF switches was installed to the measurement setup, allowing to make pulsed signals measurements and to filter out the stray signals.

Thanks the new setup optimization, it became possible to accurately measure low scattering levels down to -60 dBm^2. Moreover, additive manufacturing technologies were involved in the fabrication of analogs and a novel technique was proposed to obtain targets with “on-demand” value complex permittivity and shape. It became possible manufacture low scattering analogs of the real part of permittivity for any value between 1 and 3 by creating well controlled porous structures.

Three main targets are studied within the scoop of this thesis: low permittivity spheroids, analogs of photosynthetic microalgae, soot aggregates analogs with complex shape, and scaled forest scene models composed of tree analogs with some metal vehicle analogs.