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Multiband and Ultrawideband properties of 2-D

Electrochemically-Deposited Random Fractal Monopole Antennas

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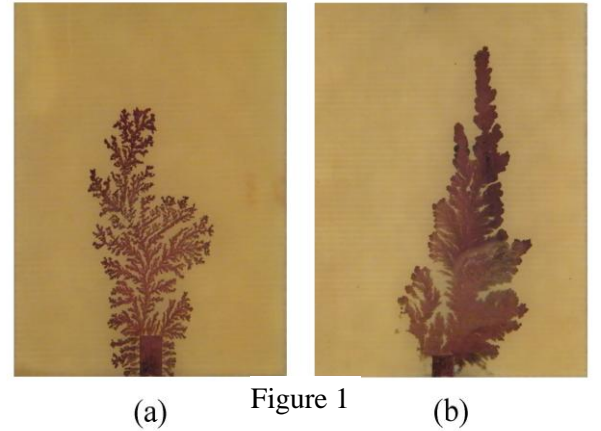
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In this study, two 2-D natural fractal monopoles generated by electrodeposition are characterized in term of fractal dimension, measured return loss and efficiencies.

The experimental set-up adapted from [1] consists of an electro-chemical reduction of aqueous metal ions and leads to natural solid metallic thin layer with fractal shapes supported by an insulating substrate. The electrolyte solution is made of copper sulphate prepared with ultra pure water. The current density being the principal drive to obtain fractal morphology, instead of constant voltage used in a first report on this topic [2], a constant DC current is applied between electrodes. An aggregation process by both diffusion and migration of the copper ions allows the growth of thin copper structures after one to five hours.

Due to the random process used, the structures obtained are all different in size and shape but possess common fractal geometry and characteristics. Therefore, depending on the constant DC current used, two main kinds of morphologies can be pointed out: lower currents lead to branched tree-like structures whereas higher currents makes the growth of planar structures with fractal contours possible. Two approximately similar in size samples with both morphologies have been chosen for investigation and will be presented. A 35-mm high branched tree-like structure shown in Fig. 1(a) and a 43-mm high planar structure with fractal contour shown in Fig. 1(b). The fractal dimension of the image of both

samples have been computed by the box method and will be reported and discussed.



In order to obtain monopole antenna configurations, structures of Fig. 1 have been mounted vertically above a perpendicular ground plane and connected to a 3.5 mm SMA connector. The input reflection coefficients S_{11} related to 50Ω have been measured for both antenna up to 12 GHz and will be presented and discussed.

The branched tree-like structure is very interesting from a miniaturization point of view. In term of return loss, this sample presents a multiband behavior, already pointed out by a previous study [2], with nine apparent matching frequencies ($VSWR \leq 2$) within the measured frequency range. By contrast, the planar structure with fractal contour fills more completely the 2-D surface but presents a lower shortening factor. Additionally, its return loss exhibits original and novel UWB capabilities never reported before for natural 2-D fractal antennas. In fact, it appears as a dual band operating system with a second wide band which almost reaches the (3.1-10.6 GHz) band designated by the Federal Communication Commission (FCC) for UWB applications. These broadband characteristics can be linked to higher fractal dimension and attributed to the shape of the opening slot between ground plane and antenna.

Finally, sufficient efficiencies of more than 85 % have been measured by the wheeler cap method for both antennas, confirming their possible use as radiating element.

The main advance is to demonstrate the interest of random natural fractal shape with high fractal dimension in actual extensive researches on UWB antennas. In this way, further investigations on samples and image of samples should be done, in particular additional configurations such as feeder of planar slot or as planar monopole could be tested

1. Fleury V., W. A. Watters, L. Allam, and T. Devers, "Rapid galvanic electroplating of insulators," *Nature*, Vol. 416, 716-719, 2002.
2. Puente C., J. Claret, F. Sagués, J. Romeu, M. Q. Lopez-Salvans, and R. Pous, "Multiband properties of a fractal tree antenna generated by electrochemical deposition," *IEE Electron. Lett.*, Vol. 32, No.25, 2298-2299, 1996.