MICROWAVE CHARACTERIZATION OF A CNT BUCKY PAPER TRANSMISSION LINE

S. Capdevila, J. Pérez, M. Jofre, N. Ferrer-Anglada, A. Aguasca, S. Blanch, J. Romeu, L. Jofre
Universitat Politècnica de Catalunya, Jordi Girona 1-3, Barcelona, Spain
scapdevila@tsc.upc.edu

The technological advances in integrated circuit and nano manufacturing are leading to the inception of a new range of electronic devices that operate in the GHz frequency range. It is the aim of this paper to study the electromagnetic properties that a carbon nanotubes bucky paper sheet may present in the GHz range, and how this could be used in the construction of miniaturized antenna systems.

The miniaturization of antenna devices in general, and of resonant antennas in particular, becomes harder as the targeted size becomes much smaller than the wavelength, as they usually require a dimension on the order of the wavelength. Several techniques exist that allow miniaturising antenna systems, but they also present some side effect on the performance of the antenna. One of this technique relies on the use of dielectrics with high permitivitties in order to reduce the effective wavelength and so the dimensions of the antenna, but these materials may present some limitation when the size of the device becomes too small (like for example a extreme reduction of its bandwidth), therefore it becomes necessary the study of new materials that could present some advantage in terms of resonant size that would fit the requirements of constructing miniaturised antennas.

Possible structures that could be used in the development of such systems are nanotubes. Carbon nanotubes could be defined as a cylinder made from a graphene sheet, presenting metallic or semiconductor behaviour, [1], depending on the direction of folding the graphene sheet, and may present a slow wave velocity, allowing significant reduction of the wavelength and hence resonant antenna dimensions, [2]. The theoretical behaviour has been studied in several papers, [2], [3], as well as some studies towards its applications, [4]. But in these studies the nanotubes where considered isolated.

In this work the approach will not consider an isolated carbon nanotube, but we will characterize the *macroscopic* properties of a material formed by single-walled carbon nanotubes, what it is known as 'bucky paper'. There has been some similar study on the behaviour of carbon nanotube composite, [5], but they did not focus on its usage as a conductive sheet. The study will be done by measuring the S-Parameters of a transmission line in a broad range of frequencies up to 50GHz using the setup of Figure 1. Once the measurements are done, it is possible to extract some electrical parameters of the bucky paper strip that may be of interest, as it may be the case of the conductivity that presents the strip.

Figure 2 shows the preliminary results for the conductivity measured from the attenuation of the S-parameters of the microstrip line made with bucky paper. It can be observed that the conductivity of a sheet of bucky paper may be in the order of 10^4 and 10^5 S/m, although further measurements will be made in order to assess the dependence of the strip conductivity with respect to the excitation power or the existence of a polarization voltage.

References:

[1]. R. Saito, G. Dresselhaus, and M. Dresselhaus, **Physical properties of Carbon Nanotubes**, 1st ed. Imperial College Press, 1998.

[2]. G. Hanson, "Current on an infinitely-long carbon nanotube antenna excited by a gap generator," **Antennas and Propagation, IEEE Transactions on**, vol. 54, no. 1, pp. 76–81, Jan. 2006.

[3]. J. Hao and G. W. Hanson, "Infrared and optical properties of carbon nanotube dipole antennas**," Nanotechnology, IEEE Transactions on**, vol. 5, no. 6, pp. 766–775, Nov. 2006.

[4]. V. Sazonova, Y. Yaish, H. Ustunel, D. Roundy, T. A. Arias, and P. L. McEuen, "A tunable carbon nanotube electromechanical oscillator," **Nature**, vol. 431, no. 7006, pp. 284–287, Sep. 2004. [Online]. Available: http://dx.doi.org/10.1038/nature02905

[5]. J. Li and J. Lumpp, "Electrical and mechanical characterization of carbon nanotube filled conductive adhesive**," 2006 IEEE Aerospace Conference**,4-11 March 2006, p. 6pp.

Figures:

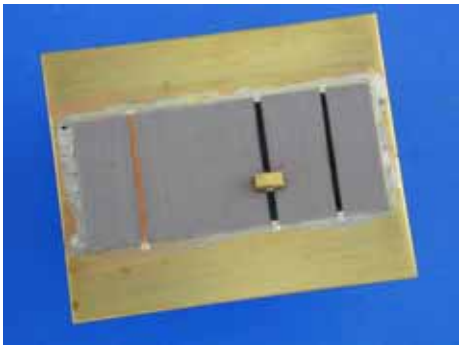

Figure 1. Measurement setup, to the left a metallic (copper) microstrip line that is taken as a reference in the measurements, to the right two different microstrip lines: the first one present a shortcircuit in the middle, in order to get a reflection coefficient with different lengths, and most to the right a pass-through line, for measuring in a transmission fashion.

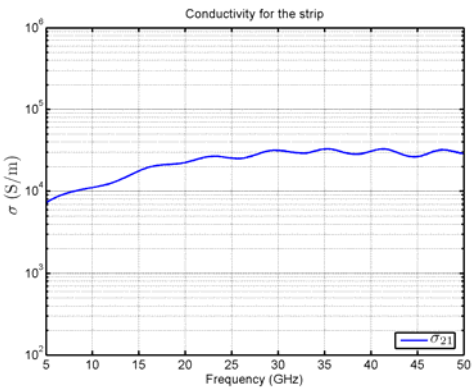

Figure 2. Preliminary results on the conductivity of a CNT bucky paper strip measured in a microstrip transmission line. It can be observed how the value of the conductivity is in the order of 10^4 S/m