CARBON-FIBER COMPOSITES IN ANTENNA APPLICATIONS

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The influence of carbon-fiber composite (CFC) as ground plane material on antenna performance is investigated. Radio frequency properties of CFC's are measured with the Nicholson-Ross-Weir method [1].

Introduction

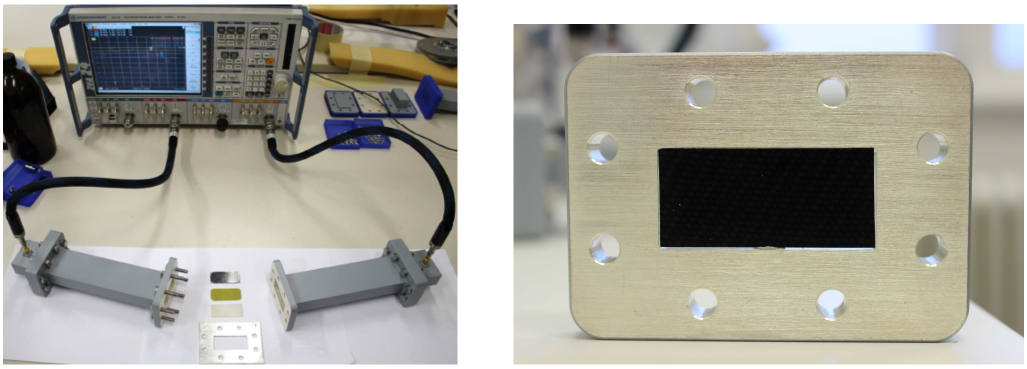
Cars of the future will employ complex communication systems to enable car-to-car communication, cooperative driving, higher data rates for passengers and embed traffic into the internet of things. More complex and reliable antenna systems will be included into cars to meet this increasing demand for telecommunication.

In the automotive industry carbon-fiber composites (CFC's) are increasingly utilized in the construction of cars. The construction flexibility that CFC's offer can be utilized in the integration of larger communication systems into vehicles. But in order to design the next generation of vehicular antenna systems, the electrical properties of these CFC's need to be characterized at radio frequencies. I will present the electrical properties of two CFC's derived from waveguide measurements.

Additionally, I present the influence of CFC's as ground plane material on the performance of monopole antennas. Antenna key parameters like gain, radiation efficiency, radiation patterns and return loss are measured in an anechoic chamber.

Characterization of Carbon-Fiber Composites

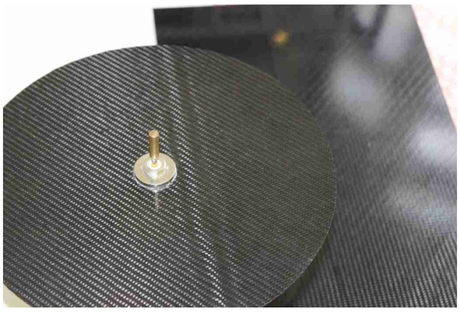
The electrical properties of CFC's are anisotropic in general, as conductivity is high in fiber direction and lower perpendicular to the fibers. To characterize the anisotropy of the material, rectangular samples with different alignment are cut from the investigated material. One sample at a time is then placed in a fixture in the middle of a rectangular wave guide. The CFC sample disturbs the electromagnetic waves inside the waveguide, part of the incoming wave gets reflected and part of it is transmitted to the other end of the waveguide. From the measured scattering-parameters the electric permittivity and magnetic permeability can then be calculated with the Nicholson-Ross-Weir method [1]. Measurements are preformed from 4 - $6\,$GHz and include the frequencies for the IEEE 802.11p standard for intelligent transportation systems.



(a) Scattering-parameter measurement of CFC samples in a rectangular waveguide.

(b) CFC sample inside waveguide.

Fig. 1. Measurement of the anisotropic electrical properties of CFC with the NRW-method.



(a) Monopole antenna on a circular CFC ground plane.

2.45 GHz	Al	CFC1	CFC2	CFC3
10dB bandwidth [GHz]	0.29	0.32	0.31	0.32
relative 10dB BW [%]	11.8	13.1	12.7	13.1
maximum gain [dBi]	2.1	2.0	1.4	1.6
relative efficiency [%]	100.0	102.3	91.0	94.4
5.9 GHz				
10dB bandwidth [GHz]	1.30	1.42	1.43	1.48
relative 10dB BW [%]	22.0	24.1	24.2	25.1
maximum gain [dBi]	4.2	3.2	3.0	3.5
relative efficiency [%]	100.0	82.2	76.9	87.3

(b) Measured 2.45 GHz and 5.9 GHz monopole antenna properties for three different CFC and aluminum ground planes.

Fig. 2. Influence of CFC as ground plane material for monopole antennas, as presented in [2].

Influence of CFC on Antenna Performance

In addition to the characterization of the electrical properties of CFC, the influence of CFC as ground plane material for antennas is investigated. Circular ground planes cut from three different CFC's are compared with an aluminum ground plane, based on measurements inside our anechoic chamber [2]. The results show that for the investigated CFC's the radiation patterns do not change significantly but the radiation efficiency is reduced by up to 23%.

REFERENCES

[1] Vicente, A.N.; Dip, G.M. and Junqueira, C., *The step by step development of NRW method*, Microwave & Optoelectronics Conference (IMOC), 2011.

[2] Artner, G.; Langwieser, R.; Lasser, G. and Mecklenbräuker, C.F., *Effect of carbon-fiber composites as ground plane material on antenna performance*, IEEE-APS Topical Conference on Antennas and Propagation in Wireless Communications (APWC), 2014