Towards New Low Loss Microwave Chiral Media Based on Dielectric Inclusions

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IN the last years, the Research Groups on Computational Electromagnetics (GrECo), from the University of Valladolid, and on Applied Electromagnetics, from the University of Murcia, have been working together in the design, fabrication, modelling and measuring new chiral media to be used in the microwave frequency range. This has been done in the frame of Research Projects funded by Spanish Government and, as a result, chiral media based in metallic inclusions in a host dielectric have been performed. The latest realizations, until now, use metallic "crank-like" inclusions assembled in various geometries to avoid undesired effects such as anisotropy, non-reciprocity and polarization filter effects.

All of those structures have been analyzed with a powerful numerical tool based on the Transmission Line Matrix (TLM) method, which is a time-domain technique allowing for wideband results, and measured with both free-wave and guided-wave (using circular waveguide) techniques.

The main idea underlying on the design is to reproduce what happens in chiral media at optic frequencies: to have inclusions exhibiting chiral symmetry whose size is comparable to the wavelength. So, we designed media for microwave frequencies embedding metallic helices into a resin host, then the helices were simplified to simple metallic cranks, that also present chiral symmetry. The next step was to use as host a Printed Circuit Board (PCB). In this way, a much simpler and unexpensive process is attained, allowing, in addition, a great flexibility on the design. As we believed that, in the end, the chiral effect is the result of scattering processes in the (chiral-symmetric) inclusions, we used metallic inclusions to enhance it. Nevertheless, the drawback is that the losses are also strong.

So, why don't we try dielectric inclusions? Natural chiral media for optic frequencies do! Then, we have performed some numerical simulations with our TLM technique and obtained a few encouraging results. As shown in Fig. 1, a dielectric crank arrangement (alumina, $\varepsilon_r \approx 9.5$) in a dielectric host ($\varepsilon_r = 3.8$) shows polarization rotation of $\approx 12°$ at a frequency close to 46.5 GHz. If the structure is "mirrored", the rotation changes its sign. (The results above 60 GHz are out of the resolution capabilities of the technique for the mesh size choice). The cranks are 3x3x3 (mm) with a square cross section of 0.5x0.5 (mm). The layer is illuminated with a gaussian beam.

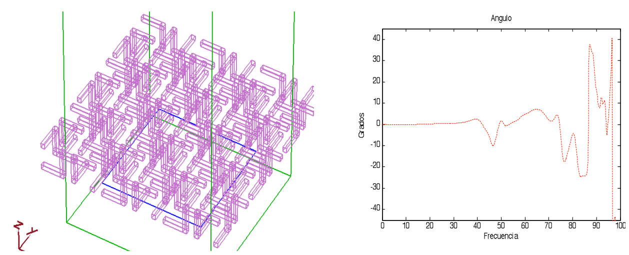

Fig. 1. Modeled chiral sample and polarization rotation vs frequency.

Many other results have been obtained numerically. Among them, let us remark that the transmited field is almost 40% of the incident field. We hope to get experimental results in a close future and to present them in the occasion of the "3º Congresso do Comité Português da URSI". In the meantime, new samples have been just prepared (Fig. 2).

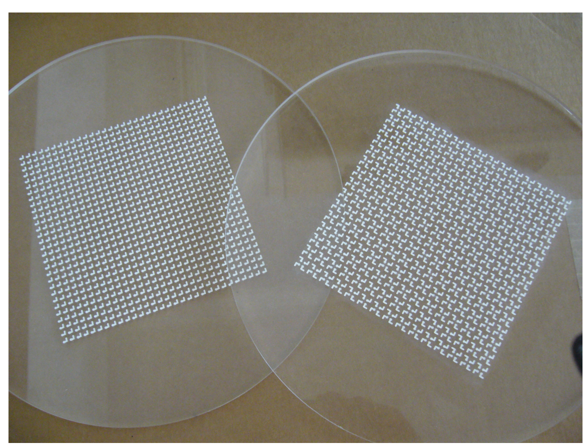

Fig. 2. New chiral dielectric samples for free-wave measurement.