Interview on Waveguide measurements of biochar derived from sewage sludge

1) Please tell me a little bit about your field of research

I am an associate professor in electromagnetics. I have been working on dielectric radomes, frequency-selective surfaces, waveguide discontinuities and microwave filters, high-altitude platform (HAP) propagation channels, Global Navigation Satellite System Reflectometry (GNSS-R) for soil moisture retrieval. More recently, I have been focusing on the analysis and characterization of novel materials (polymers and cements with carbon nanotubes, graphene or biochar as fillers) at microwave frequency for applications like shielding and sensing. I have been working with strong multidisciplinary teams of chemists, architects and biologists from both academia and industry.

2) Can you describe the background to the work that is presented in your Electronics Letters submission?

I have worked for many years on the determination of soil moisture with GNSS-Reflectometry techniques and on the characterization and shielding properties of composites based on epoxy resin and carbon nanotubes. In recent collaboration with Bioforcetech Corporation, which works on the conversion of sewage sludge into biochar, came up the idea of investigating the shielding properties of composites made with sludge biochar as filler. Waste management is a critical issue due to the rapid increase in human population. Until now, biochar derived from sewage has been used in agricultural applications as amender. Ever-increasing amount of sewage sludge is generated therefore there is a need to seek novel applications.

3) What is the main advance you have reported in your Letter and what is the significance of this advance?

Biochar derived from sewage sludge is used for the first time as filler in composites for shielding applications. Sludge biochar seems to be a very good contender among other carbon-based materials for use in shielding applications. The use of sewage sludge in shielding applications is one step towards the solution of the aggravating problem of waste disposal. The process of conversion of sewage sludge into biochar adopted by Bioforcetech Corporation does not create greenhouse gases nor does it consume energy. This makes the whole process carbon negative. In terms of microwave properties of shields produced by sewage sludge biochar, in this work we found that due to the high filler content, the dissipative losses are significant with respect to the reflective losses, both contributing to the total shielding effectiveness.

4) What challenges did you have to overcome during the research for your Letter?

For the measurements of the shielding effectiveness in a waveguide, samples of specific dimensions are required. For this purpose, we had to realize a 3D printed master mould from which silicone moulds were made. Both the master mould and silicone moulds are reusable which ensures the eco friendliness of the whole process. To reach comparable values of shielding effectiveness obtained with other carbon fillers, we had to use high filler percentage. The fabrication of composites with a high filler percentage becomes challenging when the homogeneity of the sample is essential.

5) How much has your research field changed since you began working in it, and how do you think it will develop over the next 10 years?

A number of novel carbon materials have been discovered and used in applications that were never thought of such as carbon nanotubes, graphene and biochar. Since these materials are novel, therefore there is the need of a number of different characterizations: morphological, mechanical, thermal and electrical. Multidisciplinary research can help in understanding the hidden features of these materials.

The knowledge of the properties of these materials are essential for finding adequate applications. For accurate characterization in the microwave frequency band, a number of techniques are required to cover the entire frequency band. This work covers only a part of the radiofrequency band.

With ever increasing number of devices operating in microwave and millimetre waves, the problem of shielding is becoming more relevant. With 5G and IoT the number of devices are foreseen to increase even further. The use of cheap and eco-friendly materials will be of uttermost importance.