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Dielectric Spectroscopy of Polymers and Colloidal Systems

POST-CONFERENCE REPORT

KAMILA SAMOLEJ, MAKSYMILIAN BARTOSIK, MACIEJ ŚLOT

University of Lodz, Faculty of Physics and Applied Informatics, Department of Solid State Physics, Pomorska 149/153, 90–236, Lodz, Poland
E-mail: maksymilian.bartosik@edu.uni.lodz.pl

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Spectroscopy represents an invaluable tool that facilitates the study of matter through its interaction with electromagnetic radiation. Within the rapidly evolving domain of 3D printing technologies, especially in bioprinting, the application of dielectric spectroscopy becomes particularly compelling. This technique is based on assessing the ability of materials to store and disperse electrical energy. Besides providing crucial information about the dielectric properties of materials, microwave spectroscopy also enables effective detection of material defects in the additive printing process, as evidenced by our use of a custom-built sensor operating within the microwave range (Fig. 1), which is currently under patent application [P.445179].

The research detailed in this abstract was conducted by our group at the department of Solid State Physics at University of Lodz (Ślot *et al*., 2023) and focuses on the dielectric characterization of polymers and colloidal systems using the reflection mode spectroscopy method. Polymers, owing to their low dielectric losses, find application in various fields – from complex electronic components to biomedical uses in 3D printing. Meanwhile, colloidal systems can mimic biofilaments used in laboratory tests of printing with biological substances, such as tissues or entire organs. The results demonstrate the feasibility of employing

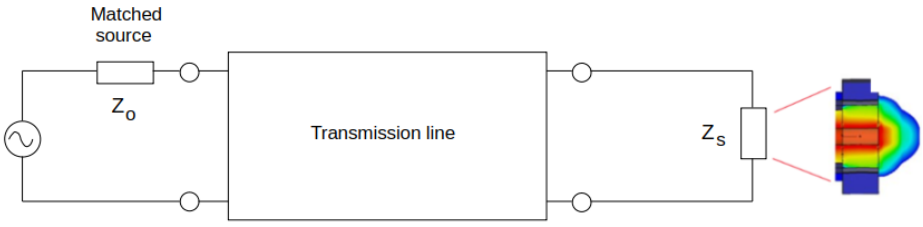

Figure 1. Representation of the sensing system as a circuit based on transmission line theory, along with the electric field distribution of the probe simulated using CST Studio. The sensor operates on the open-ended coaxial probe method, offering non-invasive yet direct contact with the sample under examination. Z_0 is an impedance of Vector Network Analyzer and Z_s is an impedance of the probe.

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the described microwave sensor to measure low-loss substances (with a dielectric constant <15) using the same measurement parameters applicable to standard 3D printing polymers. Additionally, variations in the noise level of the measured signal amplitude were observed in materials with a high dielectric constant.

The conducted studies confirm that the presented sensor for dielectric spectroscopy can be effectively used not only for traditional measurements of polymer materials but also for biological substances, gels, and food products. As anticipated, it was also noted that colloidal systems exhibit higher dielectric losses, thereby increasing their interactions with microwave radiation. This property broadens the scope of applications for our microwave sensor in studying these materials, potentially enhancing their suitability for quality control in bioprinting.

Reference

Ślot, M., Drabik, P., Bartosik, M., Samolej, K., Zasada, I. 2023. Non-Contact Microwave Sensor for 3d Printing Quality Control. Available at SSRN: https://ssrn.com/abstract=4655382 or http://dx.doi.org/10.2139/ssrn.4655382