# Investigating The Impact Of Substrate Composition On 3D Printed MmWave CSRR Sensor

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## Abstract

Diabetes is a chronic noncommunicable disease which lays a heavy burden on many impoverished communities globally. The ability to monitor and manage the disease is one key component to lessening its impact. 3D printing (3DP) offers an economical manufacturing method to produce medical sensors for these communities. However, sensor design for 3DP is not simple. This work considers a modified millimeter wave (mmWave) sensor based on a complementary split ring resonator (CSRR) topology for non-invasive blood glucose monitoring. The modified CSRR sensor is designed to operate in the mmWave, 61 - 61.5GHz industrial, scientific and medical (ISM) band and has a center frequency of 61.2GHz and is designed to be constructed on a Nylon substrate using 3DP. Two established heterogenous mixture models, Landau & Lifshitz, Looyenga and Rayleigh, were chosen to evaluate the relative effective permittivity of the Nylon substrate for varying infill percentages.

The mixture models were calculated using MATLAB® simulation and produced different values for effective permittivity for a range of infill percentages. The CSRR sensor was investigated via a frequency domain study using the COMSOL Multiphysics®, RF Module in order to evaluate the impact of the effective permittivity variations. The COMSOL Multiphysics® software tools allowed for the rapid tuning of the original CSRR sensor geometry to achieve a sensor resonant frequency within the ISM band. The LiveLink™ feature of the COMSOL Multiphysics® software allowed for the integration of the calculated MATLAB® mixture model data in order to evaluate the impact of the variations of the sensor substrate's effective permittivity on the sensor performance.

Simulation results demonstrate variations in reflection coefficient (S11) of up to 1.5dB and resonant frequency of up to 1.25GHz. Therefore, the mixture model must match the 3DP process to avoid significant deviation between the simulated and actual sensor. These results have significant implications when designing a wide array of sensor structures for 3DP over a variety of operating frequency bands.

## Figures used in the abstract

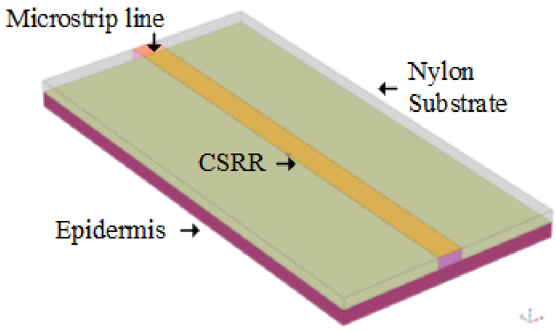


**Figure 1** : Fig.1 COMSOL Multiphysics® model used to optimise the CSRR sensor

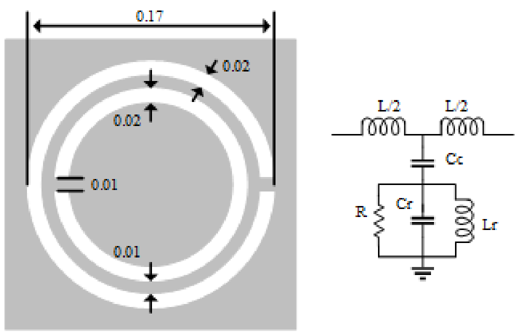


**Figure 2** : Fig. 2 Dimensions (mm) and equivalent circuit for the CSRR sensor