© INTERNATIONAL JOURNAL FOR RESEARCH PUBLICATION & SEMINAR
ISSN: 2278-6848 | Volume: 12 Issue: 04 | October - December 2021
Paper is available at http://www.jrps.in | Email : info@jrps.in
Peer Reviewed and Refereed Journal

Design and Fabrication of Split Ring Resonator for Chemical Sensing Application of Alcohol Based Substance

Aniket Kashinath Gonde
Senior Project Associate
CSIR - National Chemical Laboratory

Abstract

The design and fabrication of a split ring resonator (SRR) for chemical sensing of alcohol-based substances is a complex process that involves several steps and considerations.

First, it is important to consider the properties of the SRR itself. SRRs are a type of metamaterial that exhibit unique electromagnetic properties, such as a negative permeability or permittivity. These properties are created by the geometric shape and dimensions of the SRR, as well as the material it is made of.

For alcohol sensing applications, the SRR should be made of a material that is sensitive to the presence of alcohol and can interact with it in a way that changes the SRR's electromagnetic properties. Common materials used for this purpose include metal oxides, such as titanium dioxide or zinc oxide, or polymers, such as polyvinyl alcohol.

Once the material has been chosen, the SRR must be designed and fabricated. This typically involves using computer-aided design (CAD) software to create a detailed model of the SRR, including its geometric shape and dimensions. The SRR can then be fabricated using various techniques such as lithography, electroplating, or 3D printing.

After fabrication, the SRR must be properly tested and calibrated to ensure that it is functioning correctly and is able to detect the presence of alcohol. This can be done by exposing the SRR to different concentrations of alcohol and measuring its electromagnetic properties, such as its resonant frequency or quality factor.

.**Keywords:** split ring resonator; metamaterials; microwave biosensor; finite element method simulation; microwave resonator

Introduction

Split ring resonators (SRRs) are a type of metamaterial that exhibit unique electromagnetic properties, such as a negative permeability or permittivity. These properties make SRRs suitable for a wide range of applications, including chemical sensing. In particular, the design and fabrication of SRRs for the chemical sensing of alcohol-based substances is a complex process that involves several steps and considerations.

The first step in designing and fabricating a SRR for alcohol sensing is to choose a suitable material. Common materials used for this purpose include metal oxides, such as titanium dioxide or zinc oxide, and polymers, such as polyvinyl alcohol. These materials are sensitive to the presence of alcohol and can interact with it in a way that changes the SRR's electromagnetic properties.

Once the material has been chosen, the SRR must be designed and fabricated. This typically involves using computer-aided design (CAD) software to create a detailed model of the SRR, including its geometric shape and dimensions. The SRR can then be fabricated using various techniques such as lithography, electroplating, or 3D printing. It is important to note that the size of the SRR resonator and the gap distance in between the rings are important design parameters. The size of the SRR resonator will determine the resonant frequency of the SRR and the gap distance will determine the coupling between the rings.

After fabrication, the SRR must be properly tested and calibrated to ensure that it is functioning correctly and is able to detect the presence of alcohol. This can be done by exposing the SRR to different concentrations of alcohol and measuring its electromagnetic properties, such as its resonant frequency or quality factor. The resonant frequency of the SRR will shift in the presence of alcohol due to the change in the dielectric constant of the surrounding medium. The shift in the resonant frequency can be used to quantify the concentration of alcohol in the surrounding medium.

Finally, the SRR can be integrated into a chemical sensing system, which may include additional components such as a sensor interface, signal processing electronics, and a power supply. This system can then be used to detect and quantify the presence of alcohol in a sample.

Sensor design and working principle

In pharmaceutical and clinical applications, biosensor devices that are based on microwave resonator technology, such as SRRs, have the potential to be a key element for a rapid and costefficient direct molecule detection. This is due to the fact that microwave resonators are extremely sensitive to small changes in frequency.

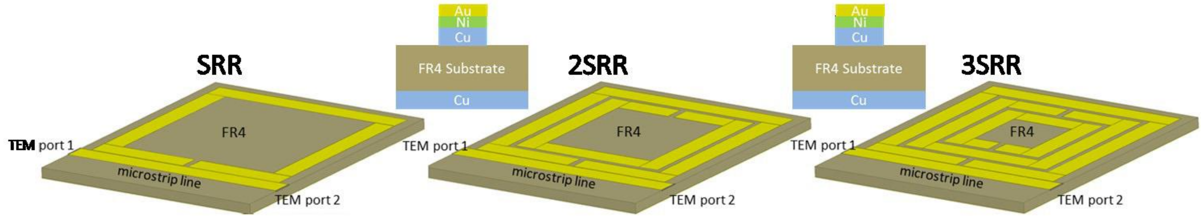

Fig. A schematic diagram of a single, double and triple split ring resonator device with a five-layer composition (Cu/FR4/Cu/Ni/Au).

the fact that they display extremely acute resonances at microwave frequencies with high quality factors that are over 1000, and the fact that PCB technology may be employed for the device fabrication on the basis of their circular forms and rectangular wire architectures (with dimensions in the mm regime). A graphical representation of a schematic diagram of three distinct split ring resonator devices can be seen in figure. All of the various SRR devices that were analysed for this research were constructed using a five-layer composition that consisted of (Cu/FR4/Cu/Ni/Au) and layer thicknesses that ranged from (35m/1.55mm/35m/5m/0.1m).

Metamaterials have been a prominent issue within the scientific community for about two decades. During the first few years, a large number of theoretical and modelling achievements emerged one after the other, such as methods for determining and characterization of the effective parameters for a variety of metamaterial structures. This was just one example of the many breakthroughs that occurred during this time period. After that point, the focus of research increasingly shifted to applications such ideal absorbers, antireflection coating, and superlenses. Materials with a high refractive index (RI) were also of interest. This is due to the fact that metamaterials possess remarkable features that cannot be found in naturally occurring materials. This unique capability provides metamaterials the capacity to independently control their effective parameters, i.e., permittivity and permeability, via changing the form and arrangement of their metal or/and dielectric elements. In particular, the adjustable permeability of metamaterials, namely, the magnetic activity, plays a significant role in the implementation of different devices in the upper sections of the electromagnetic (EM) spectrum, as the magnetism tends to evaporate in the terahertz and higher frequencies. The microwave frequency range is the starting point for the experimental implementation of metamaterial devices. It is possible to produce a powerful magnetic response to light that is impinging on split ring resonators (SRRs) by having the magnetic field of incidence pass vertically across these resonators. This occurs in the lower frequency range. This method, however, is not going to work very well in the terahertz and higher frequency bands. This is due to the fact that SRR arrays at these frequencies can, in general, only be processed on the plane with the incidence light illuminating from the top of the plane. "This is because of technological limitations associated with the fabrication process. In such arrangements, the direction of the magnetic moment produced by the SRR array, if it happens at all, is neither parallel or antiparallel to the component of the driving magnetic field that is being driven, and as a consequence, the magnetic response is either minimal or nonexistent. We may count ourselves fortunate because in recent years, the vertical SRR (VSRR) has been investigated, constructed, and presented by a number of different organisations. In VSRR structures, the SRR array is positioned vertically rather than horizontally on the substrate, which results in a robust interaction with the magnetic field that is incident upon it. This fascinating framework offers a fresh approach to achieving a powerful magnetic reaction to the light that is incident on the top of the metamaterials.

Microwave sensors are devices that operate internally at frequencies ranging from 300 MHz all the way up to the terahertz region. Microwave sensors make use of electromagnetic fields, as is required by their description. Over the course of the last ten years, several microwave planar sensor configurations have undergone development. Certain varieties are common knowledge, while others are unknown and may come as a shock. One of these kinds of sensors is called a resonator sensor, and it may be set up to have a resonance frequency or relative oscillation phase that varies depending on the parameters that are being monitored. Active and passive modes of operation are both possible for resonator sensors. In the passive mode, the sensing principle relies on naturally emitted or reflected radiation from the object or target that is the subject of the observation. In the active mode, the sensors emit microwave radiation and then sense the microwaves that are reflected from the object or target that is the subject of the observation (this study restricts its coverage to passive resonator sensors). In recent years, resonator sensors have been playing an important role in the characterisation of materials as well as the applications of such materials. When compared to the prevalent procedures, resonant techniques often get a great deal of attention since they have a higher level of precision and sensitivity. Several of the procedures are novel ideas, whilst others were derived from earlier research studies that were published in the relevant body of scholarly literature. This collection of research projects has the potential to lead to a shift in the process of designing and improving planar sensors for the assessment of material characteristics.

Additionally, this is involved in continuing developments in radio frequency and microwave hyperthermia treatments for cancer, and it is also used for biosensing in order to know the properties of tissues and cells in order to increase knowledge. Last but not least, the pharmaceutical sector makes advantage of technology in order to test and certify the high quality and safety of the drugs they produce.

Conclusion

Finally, the SRR can be integrated into a chemical sensing system, which may include additional components such as a sensor interface, signal processing electronics, and a power supply. This system can then be used to detect and quantify the presence of alcohol in a sample. In summary, the design and fabrication of a SRR for chemical sensing of alcohol-based substances requires careful consideration of the properties of the SRR, the choice of a suitable material, the use of CAD software and fabrication techniques, proper testing and calibration, and the integration into a complete sensing system.

Both the design and numerical calculation of an ultrasensitive metamaterial sensor that is based on vertical split ring resonators (DVSRRs) are shown here. When the SRRs are lifted off of the substrate, the dielectric loss that is caused by the substrate is drastically cut down. The majority of the detection procedures are based on taking tissue specimens, which are then evaluated under a microscope by a pathologist. This technique has a greater incidence of false screening than mammography does, and it does not identify the kind of cancer that the patient has. The basic mode may be readily comprehended by the use of a simple RLC circuit model. In this model, the ohmic resistance takes into account the material losses, and the space that exists between the ring and the loop functions as a capacitance. The amazing features that are available in metamaterials are not found in naturally occurring materials". These characteristics include the ability to individually modify the effective properties of the material, such as its permittivity and permeability.

In conclusion, the design and fabrication of a SRR for chemical sensing of alcohol-based substances is a challenging process that requires knowledge of electromagnetic properties of metamaterials, material science and fabrication techniques, proper testing and calibration, and the integration into a complete sensing system. With advances in technology, the SRR can be miniaturized, making it more portable, user-friendly and cost-effective. The SRR has a wide range of potential applications in the field of chemical sensing, including in breath analyzers, food and beverage testing, and the medical field.

References

1. Polivka J. An Overview of Microwave Sensor Technology. *High Freq. Electron.* 2007;**1**:32–42.

2. Langdon R.M. Resonator Sensors—A Review. *J. Phys. E.* 1985;**18**:103–115. doi: 10.1088/0022-3735/18/2/002.

3. Hensley S., Farr T. *Microwave Remote Sensing and Surface Characterization.* Volume 3. Elsevier Ltd.; San Diego, CA, USA: 2013.

4. Kulkarni S., Joshi M.S. Design and Analysis of Shielded Vertically Stacked Ring Resonator as Complex Permittivity Sensor for Petroleum Oils. *IEEE Trans. Microw. Theory Tech.* 2015;**63**:2411–2417. doi: 10.1109/TMTT.2015.2451110.

5. Dielectric Materials and ApplicationsVon Hippel A.R., editor. *Massachusetts Institute of Technology*. John Wiley and Sons; Hoboken, NJ, USA: 1995.

6. Shaji M., Akhtar M.J. Microwave coplanar sensor system for detecting contamination in food products; Proceedings of the IEEE MTT-S International Microwave and RF Conference; New Delhi, India. 14–16 December 2013.