Chemical Sensor using RF Circular Waveguide

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Chemical sensors have been used for several decades to identify and detect concentration levels of various liquids to facilitate the deployment of those liquids across a wide range of industrial applications. These liquids must be stored and categorized according to the Globally Harmonized System (GHS). RF (radio frequency) sensors are very attractive choices for many of electronic, biomedical and industrial applications. They offer many advantages including high sensitivity, robustness and low fabrication and measurement costs. High sensitivity and accurate identification of chemical and biological liquid samples using microwave dielectric and cylindrical resonators have been studied and demonstrated.

A very high quality-factor (QF) circular substrate-integrated-waveguide (SIW) resonator is proposed as a chemical sensor here. Typically, high QF is one of the important requirements of an RF sensor giving it an advantage of having higher selectivity. The proposed circular SIW resonator is inspired by a traditional rectangular SIW cavity, which has a circular electric field concentrated towards its center. By considering the behavior of circular electric field, a circular shaped SIW resonator is designed achieving a QF of as high as 1080.

Figure 1 (a) below shows the designed circular SIW resonator excited by a microstrip line, analyzed for 5.5 GHz frequency. Substrate used is RT/Duroid 5880 with a thickness of 1.575mm. a 4mm diameter whole is drilled in the center to accommodate a vertical capillary. Before drilling, the bare resonator gives a frequency response of 5.25 GHz. After drilling, either the vertical capillary is empty or filled with chemical. When it is filled with ethanol, the 5.18 GHz frequency is sensed, when nothing is inside, it gives a frequency of 5.35 GHz. Figure 1 (b) shows the photograph of fabricated prototype, a PFA tube of 4mm outer diameter and 3.5mm inner diameter is used as a vertical capillary. Vias of SIW are drilled and soldered from top and bottom making a circular metallic wall around top PCB etched pattern. Figure 1 (c) shows simulation and measurement results. Simulation was done on ANSYS Electronic Desktop 2016 and the frequency responses are recorded using an HP 8510C VNA (Vector Network Analyzer) (Hewlett Packard (HP), Palo Alto, CA, USA).

Simulation and measurement results show a very good agreement with each other. The proposed high QF sensor is a non-contact, reliable, cost-effective and easy to fabricate. It can be used in numerous sensing applications.

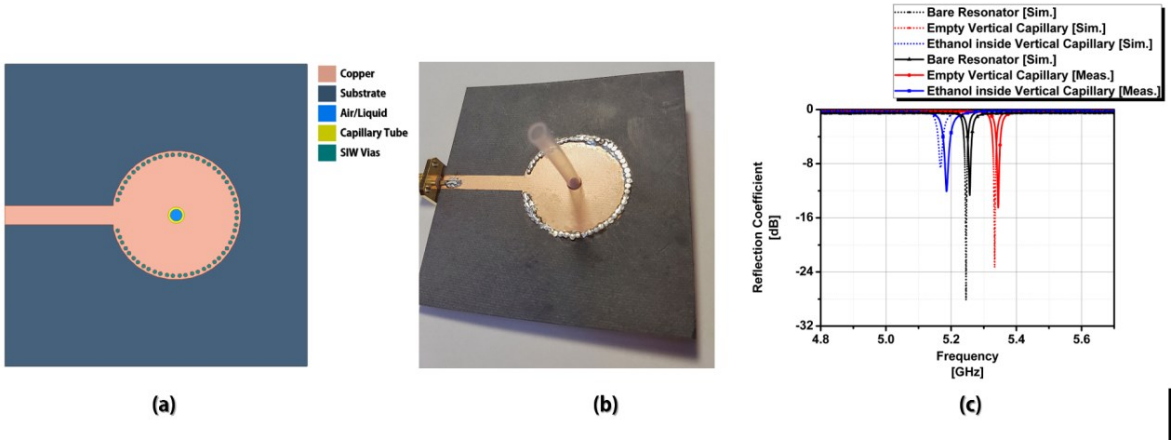

Figure 1 (a). The proposed sensor design, 1 (b). Photograph of fabricated prototype, and 1 (c). Results