Investigating Electromagnetic Properties of Yttria-Stabilized Zirconia (YSZ) for Wireless Sensor Applications

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Wireless sensors are in great demand, be it an implantable biosensor, high temperature sensors in turbines, or an exhaust gas sensor as detection is often envisioned away from the point of impact. Though wireless sensing techniques exist, majority of the existing devices are wired and locally or require some form of integration with a wireless/front-end module that commonly leads to non-portable, increased-cost sensor systems with limited deployment. Wireless sensor configuration can be implemented in two ways: a wireless enabled sensor and a wireless transducer [1]. The difference between a wireless-enabled sensor and a wireless transducer of a physical parameter is that the former needs a separate RF module with a communication antenna, whereas the latter just utilizes the change of one or more microwave/electrical parameters, such as frequency shift, to directly indicate the change of one physical parameter of the environment such as pressure, temperature or gas concentration. Earlier report [2] suggest Yttria-Stabilized Zirconia (YSZ) to be a candidate material for implementing wireless sensor operation. In this context, this investigation intends to study the temperature dependent electromagnetic properties of YSZ for implementing on-chip antennas and wireless transducers. The YSZ samples were prepared by tape-casting technique [3] and sintered at 1200^0 C.

Measurement: The dielectric properties (relative permittivity (ε_r) and loss tangent ($tan\delta$)) of samples were measured between 500 MHz and 20 GHz for 1500 frequency points. An E8362B PNA network analyzer and Agilent's 85070E dielectric probe kit were used for the dielectric measurements. The slim form probe with a diameter of 2.4 mm had been used during measurements due to its high accuracy. In order to ensure data reliability, each sample was measured three times, and the averages and standard deviations were calculated for the frequency band of interest. Note that the probe position was changed at each of these measurements. A green-body YSZ sample and a sintered YSZ sample were used to obtain preliminary data.

Figure 1 and Figure 2 show the relative permittivity (ε_r) and loss tangent ($tan\delta = {\epsilon''}/{\epsilon'}$) of one of the ceramic samples from 500 MHz to 20 GHz, respectively. As seen from the figures, both the relative permittivity ($\varepsilon_r \cong 6.5$) and loss tangent ($tan\delta \cong 0.05$) are almost constant through the entire band. Low loss tangent also allows for efficient design of various microwave systems and antennas.

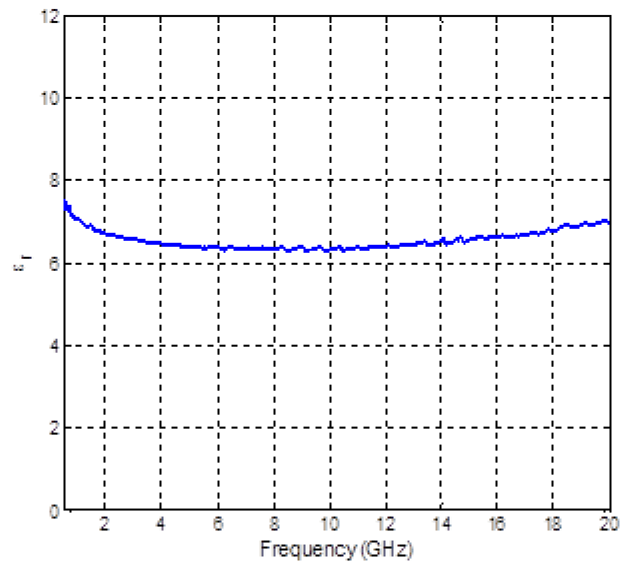

Figure 1. Dielectric Permittivity of Sintered YSZ as a Function of Frequency.

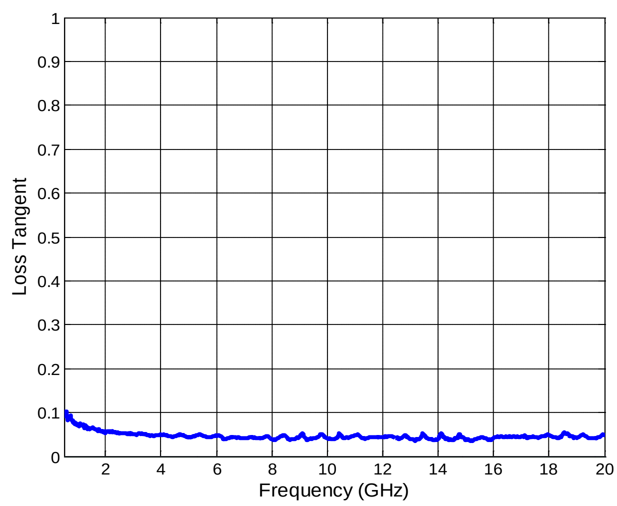

Figure 2. Loss Tangent of Sintered YSZ as a Function of Frequency

References

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