Resonator based microwave dehydration sensor

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Abstract

A resonator based microwave sensor for dehydration sensing was designed, modeled and a prototype was manufactured. The sensor was tested using tailor made skin phantoms which resembled dehydrated, normal and hydrated skin. Hydration state was determined from resonance frequency and sensor showed linear behavior.

Water is an important thing to all living creatures, including human beings. Over half of the body mass is consisting from water. However, the body mass can only change few percent when signs of dehydration begin. Dehydration causes symptoms from tiredness to headache and in extreme cases even unconsciousness and death. In healthy human thirst is activated by a build in mechanism. However, when thirst is felt, mild dehydration is already on. Moreover, elderly and small children are more prone to dehydration due small water mass and reduced sense of thirst. Other major high-risk groups are workers in warm and humid environment and people doing heavy sport exercises [1].

Liquid water has unique dielectric properties due the irregular shape of the water molecule, which makes it polar substance. This causes high relative permittivity and due the movement of water molecules in external electric field the friction between molecules are turned in to heat, which causes dielectric losses. Due these properties, water-based materials including all living things, are well suited for microwave measurements.

In this work, a complementary split ring resonator (CSRR) [2] is used as sensing element a status is measured directly from skin. The sensor was modelled using CST Microwave studio using skins dielectric data [3]. The dielectric values were altered according to changes in hydrated and dehydrated properties. The resonance frequency shift was monitored, and the hydration state was determined. Prototype of the device was manufactured directly on normal SMA-connector using a copper layer with laser patterned CSRR resonator. Then tailored skin phantoms, inspired by [4], based on urethane composite with carbon and ceramic fillers. Carbon materials were used to tune conductivity/loss and ceramic to boost relative permittivity. Sensor was characterized by these skin phantoms and clear frequency shift was observed between samples as the modelling suggested. Results are published in [5]. Manufacturing, measurement setup, simulated and measured results are presented in the conference.

Acknowledgements

This work was supported by Proof of concept (POC) funding, University of Oulu. The Center of Microscopy and Nanotechnology at the University of Oulu is acknowledged for technical support. Authors wish to thank Fab Lab Oulu for access to the CNC router. J. K. would like to acknowledge support of the Tauno Tönning Foundation.

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