4th URSI AT-RASC, Gran Canaria, 19-24 May 2024

Harmonic Humidity Sensing based on Green Materials

Valentina Palazzi[(1)], Federico Alimenti[(1)], Paolo Mezzanotte[(1)], and Luca Roselli[(2)]
(1) University of Perugia, Perugia, Italy; email: valentina.palazzi@unipg.it, luca.roselli@unipg.it

Wireless humidity sensors are becoming of interest in a growing number of applications, ranging from condition monitoring, to smart agriculture, to workplace safety [1]. They are used to check eventual liquid loss, to estimate the moisture content in the terrain, and in many other applications. However, when designing wireless sensors, issues such their power supply and their environmental impact must be carefully considered, due to the difficulty in keeping track of a growing amount of electronics in the environment [2].
This contribution describes a possible approach to perform wireless humidity sensing using harmonic transponders. The considered approach leads to fully passive transponders which can be read also in non-stationary environments, and leverages green materials.
The proposed transducer consists of a Micro-Electro-Mechanical Systems (MEMS) transducer based on a paper-aluminum (paper-Al) bimorph cantilever formed by an Al foil glued on top of a paper layer [3]. As humidity increases paper relaxes its fibers, thereby causing the cantilever deflection. Since the cantilever forms a parallel-plate-capacitor with the PCB to which it is anchored, the cantilever deflection causes a variation in the capacitance value. This is leveraged to tune the resonant frequency of a notch filter. Therefore, relative humidity can be encoded in the resonant frequency of the resonator.
In the present contribution the proposed transducer is used in a harmonic transponder, to generate a passive wireless humidity sensor. The transducer is placed at the input of the frequency doubler. The role of the frequency doubler is to separate the uplink from the downlink, thereby making the sensor almost insensitive to the clutter. Details on the design and fabrication process will be provided. A proof-of-concept prototype will be developed and experimental results will be reported.

Figure 1. Humidity transducer based on a bimorph paper-aluminum cantilever [3].

[1] M. A. Jamshed, K. Ali, Q. H. Abbasi, M. A. Imran and M. Ur-Rehman, "Challenges, Applications, and Future of Wireless Sensors in Internet of Things: A Review," in *IEEE Sensors Journal*, vol. 22, no. 6, pp. 5482-5494, 15 March15, 2022, doi: 10.1109/JSEN.2022.3148128.
[2] J. Zikulnig, S. Lengger, L. Rauter, L. Neumaier, S. Carrara and J. Kosel, "Sustainable Printed Chitosan-Based Humidity Sensor on Flexible Biocompatible Polymer Substrate," in *IEEE Sensors Letters*, vol. 6, no. 12, pp. 1-4, Dec. 2022, Art no. 1500804, doi: 10.1109/LSENS.2022.3224768.
[3] F. Alimenti et al., "A Wireless MEMS Humidity Sensor Based on a Paper-Aluminium Bimorph Cantilever," 2021 IEEE MTT-S International Microwave Symposium (IMS), Atlanta, GA, USA, 2021, pp. 823-826, doi: 10.1109/IMS19712.2021.9574869.