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Sofia Toto[1], Martin Wuest[4], Pascal Nicolay[2], Gian Luca Morini[3], Juergen J. Brandner[1]

[1]Karlsruhe Institute of Technology, Institute of Microstructure Technology IMT, Hermann von Helmholtz Platz 1, 76344 Eggenstein Leopoldshafen, Germany; sofia.toto@kit.edu, juergen.brandner@kit.edu

[2]Carinthian Tech Research, Europastrasse 12, 9524 Villach, Austria
, pascal.nicolay@ctr.at

[3]DIN, Alma Mater Studiorum Universita di Bologna, Viale del Risorgimento 2, 40136 Bologna Italy

gianluca.morini3@unibo.it

[4]Inficon Ltd. Alte Landstrasse 6 FL-9496 Balzers

Design and manufacturing of a wireless SAW-Pirani sensor with extended range

Pressure is a key parameter for a large number of industrial processes. Amongst others, vacuum industry relies on accurate pressure measurement and control. Designing a single device being able to sense from very high vacuum to atmospheric pressure is a challenge to an interdisciplinary research community, leading to the development of a variety of pressure sensors using different operating principles and still handling diverging pressure ranges.

In this publication an attempt to design a compact wireless sensor handling pressures between 10^{-4} Pa and 10^{5} Pa is presented. This sensor may be competitive to sensors available in the market suitable for micro and macro applications. Operating the sensor wireless helps to prevent leakage and maintain vacuum.

The sensor is combining the well-known Pirani effect with Surface Acoustic Waves, which allows to extend the sensing range. Surface Acoustic Waves propagate on the surface of piezoelectric substrates. Their phase and resonance frequency are sensitive to properties of the surrounding environment such as temperature and pressure.

SAW-Pirani sensors use the same operating principle as a conventional Pirani sensor since the heat losses of the substrate are proportional to the gas pressure in contact with the surface. However, the variation of the surface temperature is transduced in this case into a frequency shift that can be measured via a wireless interrogation signal.

The core of the presented sensor device consists of a 1 cm^3 polymer cube crossed in its center by a microchannel. The sensing chip is located inside the crossing channel.

The chip is heated via a wireless power charge receiving coil. It is interrogated via a microantenna printed on the bulk of the cube. A thermal analysis and simulation allowed to set the dimensions of the device.

The manufacturing of the prototype started with the sensing chip. It consists of a Lithium Niobate substrate with an Interdigital Transducer (IDT) surrounded by a Joule heating resistance at its surface. The IDT is etched using electron-beam lithography.

The chip will then be integrated to the core of the sensor using bumps allowing minimum physical contact with the polymer.

The interrogation antenna is designed to fit with the needs of the sensor in terms of dimensions, reflection coefficient, power transmission distance and impedance matching. The sensor shall be interrogated from a distance of about 3 cm.

Preliminary results of the prototype testing and their comparison with the expectations of the design and the simulation will be presented.