APPLICATION OF WIDE-BAND HYPERBOLICALLY FREQUENCY-MODULATED TECHNOLOGIES IN SURFACE ACOUSTIC WAVE SENSORS

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Developing the technology had been prompted by the fact that hyperbolically frequency-modulated signals are used in nature, e. g., by some of the species of dolphins and bats who use such a modulation for echo-location. Application of the technology in surface acoustic wave (SAW) sensors allows achieving their operation in a wide range of temperatures, which would be difficult to achieve by using other wide-band frequency modulations, e. g., linear [1]. To demonstrate that, a surface acoustic wave temperature sensor with the SAW reflecting gratings designed for operation with HFM signals was fabricated. The operating principle of the sensor is illustrated in Fig. 1.

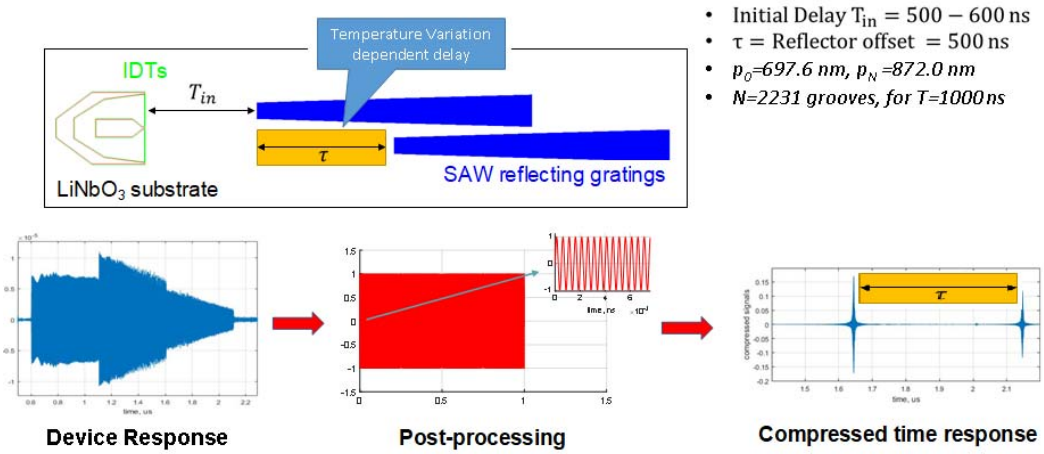

Fig. 1. Operating principle of the SAW sensor. IDTs – interdigital SAW transducers

The temperature response is obtained from the times of the SAW propagation in the sensors. The device was fabricated by forming two pairs of identical aluminum interdigital transducers and etched-groove reflectors in parallel acoustic channels on a YZ-cut lithium niobate ($LiNbO_3$) substrate. The sensors were remotely (via antennas) interrogated by a reader ("Hybrid SAW Reader" by RSSI GmbH) in the frequency range of (2 – 2.5) GHz. Echo-responses were post-processed using a numerical matched-to-signal filter to obtain the compressed time responses. The difference τ between the peaks of the time response was proportional to the deviation of the sensor temperature; the proportionality was determined by thermal properties of $LiNbO_3$.

The results obtained imply that the sensor properly operated remotely in the temperature range from -150 °C to +140 °C, allowing determining the temperature with the uncertainty of 50 mK (0.05 °C) [2].

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[1] V. Plessky, M. Lamothe, Hyperbolically frequency modulated transducer in SAW sensors and tags, Electronics Letters **49** (24), 1503-1504 (2013).
[2] S. Yandrapalli, R. Miskinis, D. Smirnov, V. Plessky, A. Shimko, Ultra-Wide-Band SAW Sensor with HFM Etched Reflectors, 2018 IEEE International Ultrasonics Symposium, DOI: 10.1109/ULTSYM.2018.8580225.