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# Surface acoustic waves wireless sensor technology for extreme environments

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High temperature surface acoustic waves (SAW) sensors have attracted the attention in the last two decades because they are fully passive, batteryless and, when coupled to an antenna, wireless. They can be remotely interrogated using a backscattering-based interrogation and are thus particularly useful in harsh / rotating or translating environments, where other sensing techniques have limitations. Moreover, the reflective delay line (R-DL) configuration (Fig. 1) makes it possible to carry out sensors network, since one given sensor can be unambiguously identified through its coded time-resolved response. The R-DL technology requires short time pulses and thus a large enough bandwidth as those authorized in the 915 MHz or 2.45 GHz ISM bands.

In most cases, high-temperature SAW sensors are enclosed in, and connected to a ceramic package, which is then connected to the antenna. All the materials involved (SAW electrodes, piezoelectric substrate, package and antenna components, interconnexions), are seriously challenged at high temperatures.

Regarding the piezoelectric substrate, only ferroelectric lithium niobate $LiNbO_3$ combines great resistance to harsh conditions and outstanding electromechanical properties allowing operations in the targeted 915 MHz or 2.45 GHz ISM bands. Commercialized $LiNbO_3$-based R-DL SAW sensors can operate at 350°C for several days [1]. They are limited by two phenomena: possibly the segregation process encountered by the substrate and the oxidation of the aluminium-based interdigited transducers (IDTs) electrodes.

Operating temperatures higher than 350°C could be reached with this technology, giving access to much more applications in various domains (metallurgy, aeronautics, automotive, glass industry …), provided new high-temperature IDTs materials are developed. Such materials should combine a high melting temperature, a great resistance to oxidation, a low electrical conductivity, and finally a low density allowing the generation outside the IDTs of high-frequency surface waves. This last condition excludes the use of platinum as, with such a dense metal, the thickness of the IDTs should not exceed 50 nm so that 2.45 GHz SAW are not trapped inside the IDTs. So thin Pt IDTs undergo agglomeration phenomena at very limited temperatures close to 400°C.

Finally, only alloy thin films can gather all the above-mentioned properties regarding IDTs material. In particular, NiAl is a very interesting candidate. It has a high melting temperature of 1640°C, a low density of 5.9, a bulk electrical resistivity of 9 µΩ.cm and a very good resistance to oxidation in the bulk state. Recent results obtained with 150 nm-thick NiAl IDTs, showing a lifetime of more than 10 days at 500°C, widen new horizons for the high-frequency, high-temperature wireless SAW sensor technology with ID functionality [2].

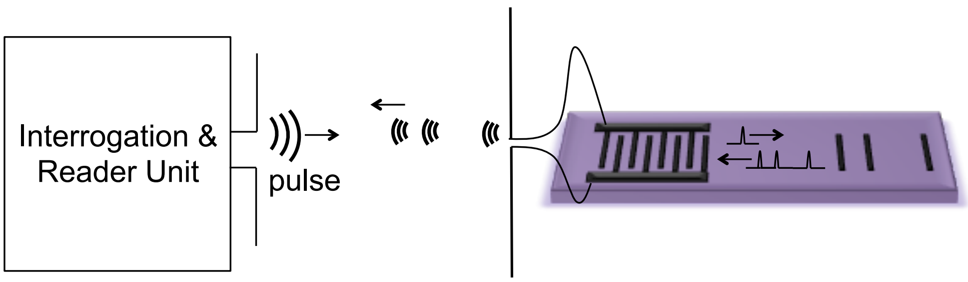


**Figure 1.** Schematics of the reflective delay line wireless SAW sensor technology

## References

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