Wireless and passive SAW devices, for Structural Health Monitoring applications.

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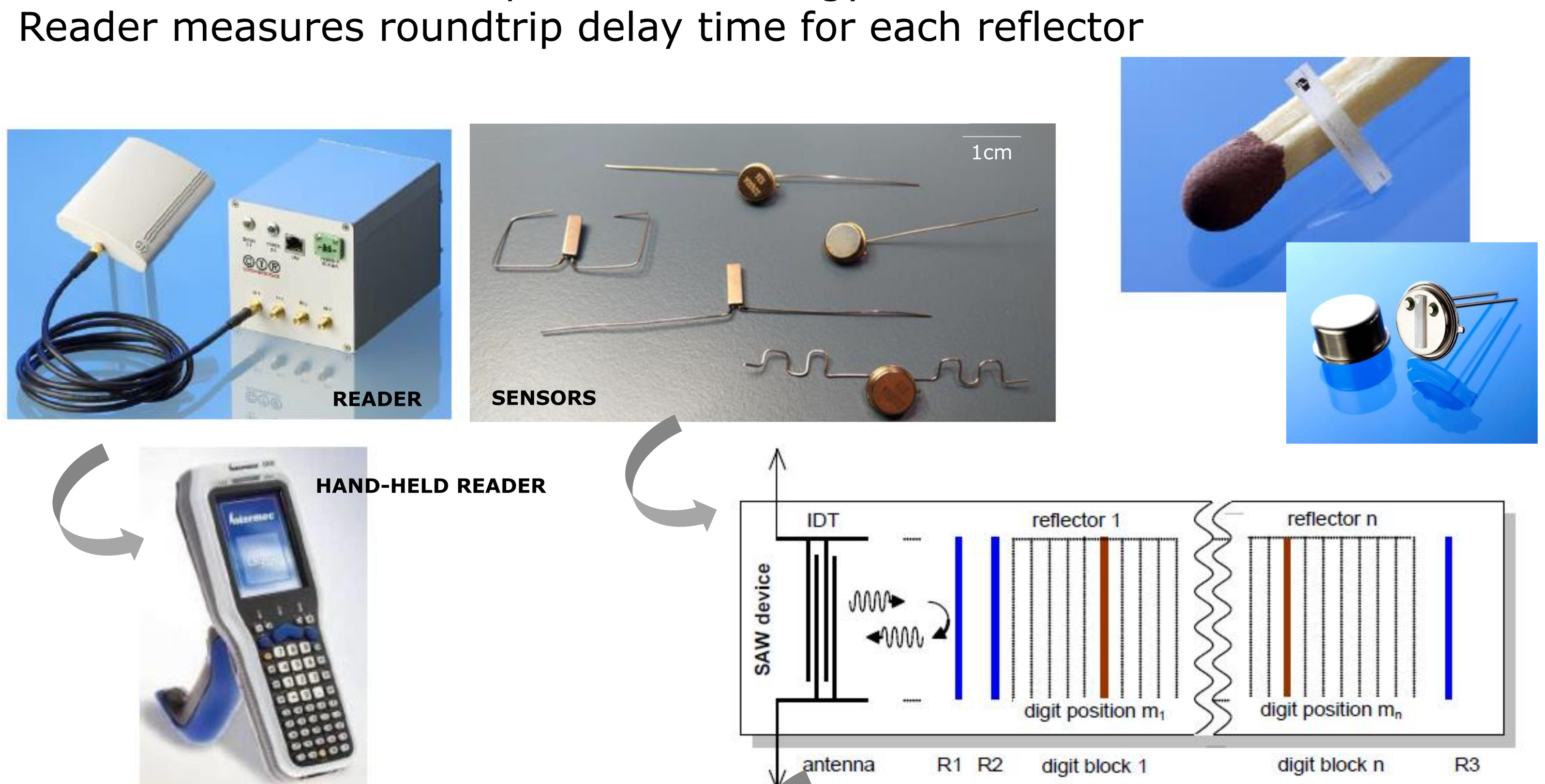
Abstract

Surface Acoustic Wave (SAW) passive and wireless sensors are a promising solution for condition and structural health monitoring (SHM) applications. They are robust devices, which can withstand extreme operating conditions (very high temperatures, high pressure etc.…). They do not require any embedded electronics and can be implanted in various kinds of (dielectric) structures. Moreover, SAW Sensors of the Reflective Delay Line (R-DL) type have built-in RFID capabilities, which can prove extremely useful for various industrial applications. Some selected applications are described in this poster. They are based on existing CTR 2.45GHz R-DL devices.

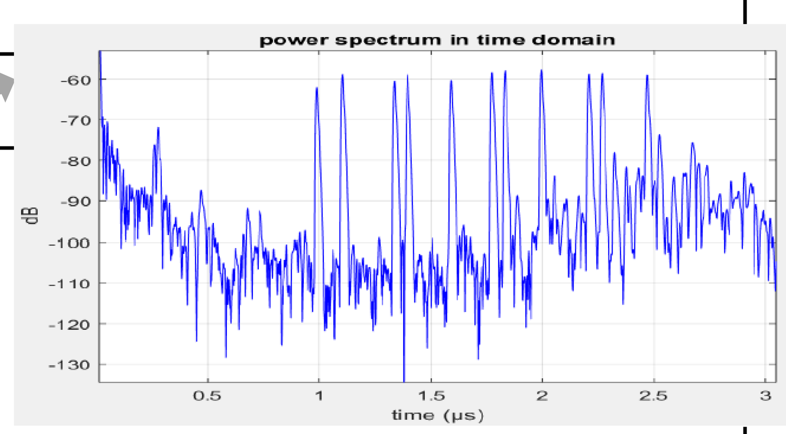
As SAW sensors often fail in operation, due especially to housing failure at high temperature, promising ‘package-less’ solutions are also presented. Here, guided modes that propagate in protective multilayer structures are used, instead of surface waves. Several multilayer configurations have been suggested, simulated and/or tested in the past years. However, thermo-mechanical effects are expected to impact the behavior of the devices. Besides, a solution to embed the antenna in the layer stack is yet to be developed. The realization of innovative ‘package-less’ (implantable) SAW devices for SHM applications will require these two issues to be solved, first.

“Standard” SAW R-DL Sensors

- RF Power emitted from Reader Unit
- IDT on piezoelectric substrate converts EM waves to SAW
- Waves propagate along surface (Quartz, Langasite, LiNbO3)
- Each reflector reflects a part of the energy
- Reader measures roundtrip delay time for each reflector



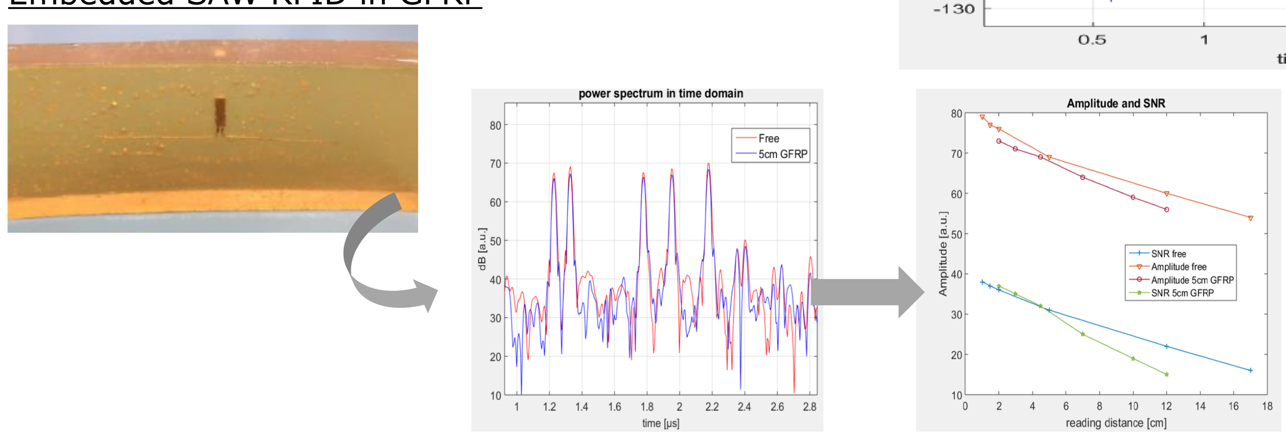
See [1,2] for more information on SAW RFID Sensors



SELECTED APPLICATIONS

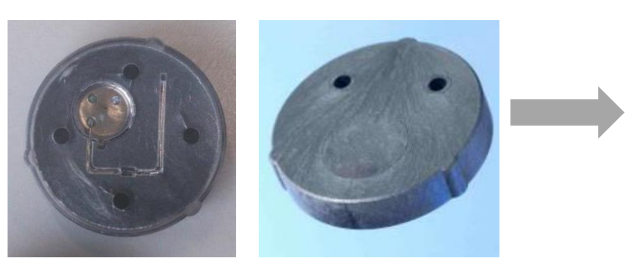
⇒ SHM

Embedded SAW RFID in GFRP



Damping and SNR versus Distance

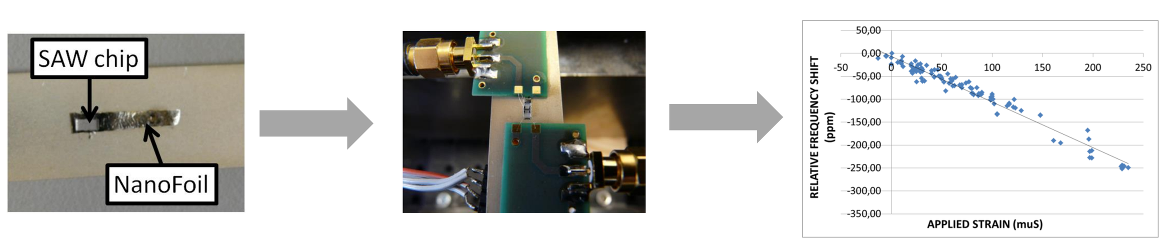
Embedded SAW by Injection Molding in Liquid Crystal Polymer



Identification of drill pipes on the rig & during transport
- 250 °C
- 1300 bar
- Abrasive liquids

⇒ chemically resistant and temperature stable

Glue-less mounting of a SAW strain sensor on a metal blade [3]



Other applications
- SAW Sensor interrogation through thick (>2cm) fiberglass panels ⇒ OK!
- SAW Sensor interrogation through carbon-fiber reinforced material ⇒ NOT OK! (conductive…)

References

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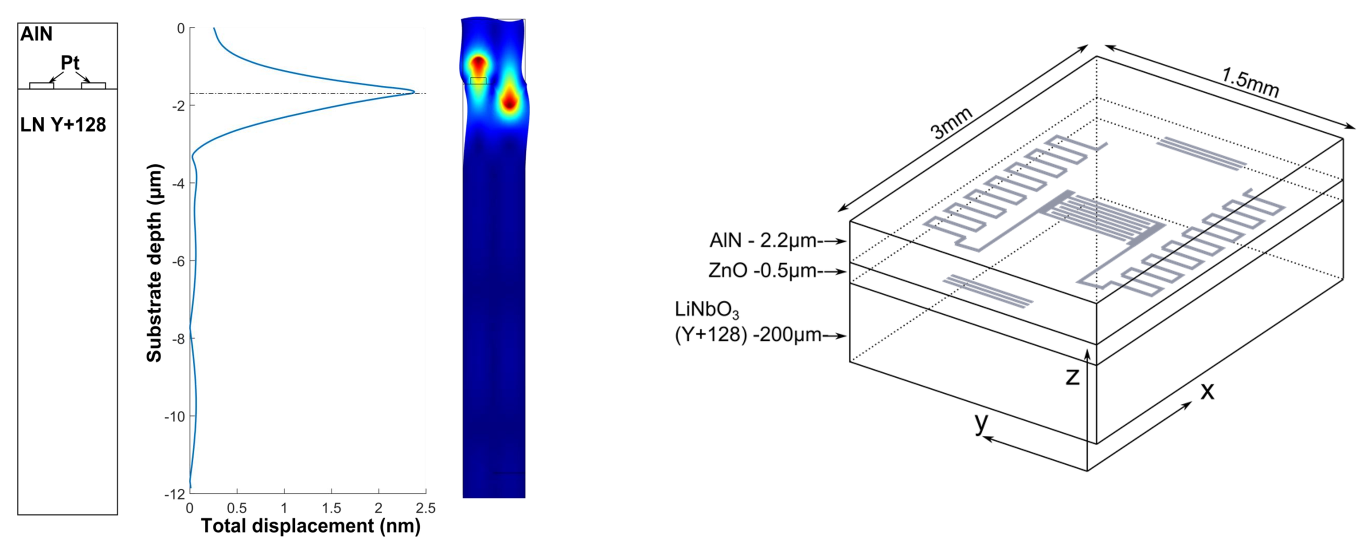
A new concept

- Multi-layered structure ⇒ Guided Bulk Acoustic Waves (G-BAW)
  ⇒ **surface-state insensitive**
- Two main guiding mechanisms ([4],[5]):
  - One Low acoustic-impedance layer sandwiched between two high-impedance layers (e.g. AlN/ZnO/LN)
  - AlN/{Pt-IDT}/LNY+128. Here, the heavy Pt grating and the special symmetry properties of the LNY+128 orientation make it possible for one „loss-less“ Rayleigh-like mode to propagate at the AlN/LN interface.

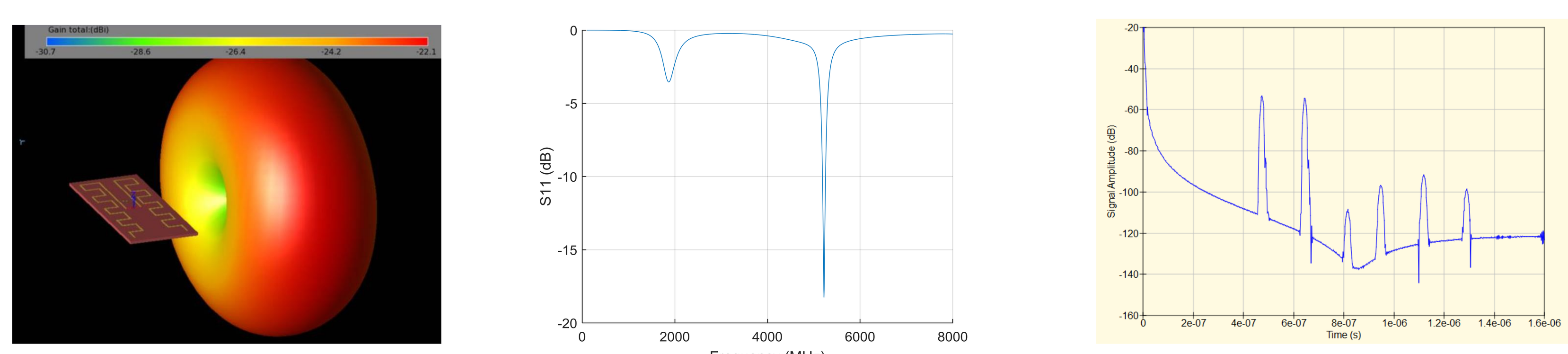


(a) (b)

Figure 1: (a) Guided Bulk Wave in AlN/Pt/LN, computed at 100°C. (b) Schematic description of an innovative AlN/ZnO/IDT/LN package-less SAW sensor, with embedded antenna.

- Expected issues, due to „Bimorph effect“ (⇒ growing stress & strain fields)
  - Delamination issues at high temperature…
  - Possible destruction of the guiding properties at lower temperature

AN EMBEDDED ANTENNA [6]?



(a) (b) (c)

Figure 2: (a) Embedded antenna: simulation model and radiation pattern, at 1.97GHz. (b) S11 parameters of the antenna only. (c) Computed time response of a typical reflective Delay-Line in AlN/ZnO/LN, similar to the one presented in figure 1.b. Note the expected level of the two main peaks, close to -55dB.

The antenna gain is poor, which is probably due to the presence of the highly dielectric LN substrate, in contact with the antenna. On the contrary, the thin ZnO and AlN layers do not seem to strongly impact the performances of the antenna. It is necessary to strongly improve the gain, for practical applications (future work).

References

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