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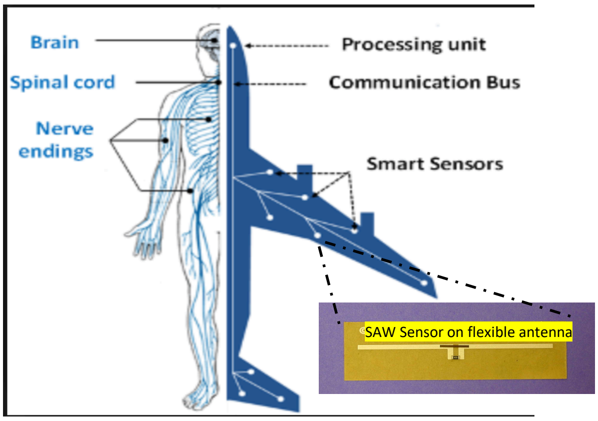
Profile: Engineering or Master degree with background in either RF/ antenna /telecommunications, micro-nanotechnology, electronics, wave physics. The applicant must be fluent in English or French.
Please e-mail resume and master/Eng. school grades

PhD position:
Low profile, lightweight, high gain stretchable antennas for highly constrained wireless sensing environments

Antennes étirables, légères, compactes et fort gain pour mesures sans fil en environnement contraint

In our modern society, the need for continuous reliable knowledge of measurandes of interest, preferably wirelessly, is driving the fast development of the Internet of Things (IoT). In this framework, due to their size, antennas are critical components of wireless communication and remote sensing systems. They are increasingly challenged components in current systems that are often space, weight and power constrained and/or lossy.
This PhD subject aims at addressing difficult fundamental antenna bottlenecks in two practical fields: on body applications and industrial applications, including Structural Health Monitoring.



i) On-body antennas

Monitoring the human body's parameters is a growing trend. From potentially life-saving healthcare applications to more casual wellness/sport use, connected objects that monitor body parameters are part of a multibillion dollars - and growing - market. Yet, the need for possibly uncomfortable wires, bracelets or sometimes belts prevents the end-users from long-term continuous use of such connected objects. Going wireless, on-skin and thus designing suitable efficient antennas is paramount.

Fig. 1 : Stretchable antenna on fabrics. *Hage-Ali &al.*

In the context of on-skin sensors, antennas have to be extremely thin, be able to be conformably mounted to any surface and formed to any shape, resist to strain and impacts.

A few groups are working on the topic: the liquid metal approach to stretchable antennas reported by different groups since 2009 [1,2,3] uses Galinstan (Ga-In-Sn) alloys embedded in elastomeric channels, and lead to high stretchability and dipoles antennas frequency tuning up to 120%[Erreur ! Signet non défini.]. However this approach uses expensive, non-biocompatible conductors with limited feature resolution (~10 micrometers), may be temperature limited depending on the alloy [Erreur ! Signet non défini.], and the integration in fully stretchable liquid alloy RF systems is challenging[4]. Stretchable antennas based on plain 50 nm-thick gold patterns are limited in stretchability (20%) and radiation efficiency due to resistive loss related to the skin depth effect[5]. Silver-nanowires based antennas exhibit low radiation efficiency and moderate stretchability[6] (15%).

Our view is that the best way to efficient on-skin antennas is the approach involving meandered patterns of high conductivity metals (copper, gold) like the one depicted Fig 1 and 2. We believe that this is the route to low-cost, light weight, electrically small, translucent, failure resilient, bio-implantation compatible, easily integrated stretchable antenna and the easiest to yield ultrathin "epidermal devices".

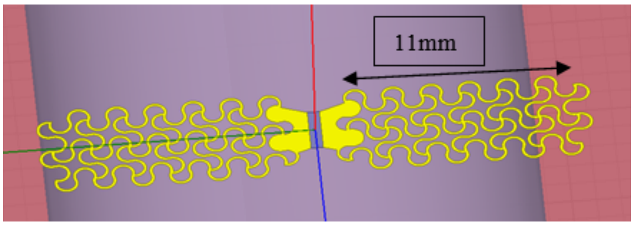


Fig. 2: Modelling of an "epidermal" dipole antenna printed on the skin at 2.3 GHz

Dipole antennas, like the one depicted Fig. 2, directly printed one the skin are stretchable, yet exhibit a somewhat low gain.

This part of the PhD work aims at tackling this issue:

The idea here is to decouple the EM waves from the human body. Different approaches will be investigated, involving patch antennas, travelling wave antennas and system integrated waveguides.

These concepts will be translated in ultrathin "stretchable" format and developed numerically and experimentally and tested in combination with passive wireless SAW sensors developed in our MicroNanoSystems group.

ii) Antennas for structural health monitoring

Industrial environments can be difficult place for wireless sensors that have to monitor their proper operation: Heat, dust, grease, metallic part, heavy space constraints, corrosion, rotating parts can be part of the equation.

Our research group is well positioned on this research topic : our wireless, battery less and packageless (3less) technology based SAW sensor developed in our group is of great interest for Structural Health Monitoring (SHM) applications where grid of sensors are used to detect damage on engineering structures. For this purpose, the high-integration, identification (ID) and sensing capabilities of SAW devices might be very useful. Because no embedded energy is required, the sensor lifetime is thus

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[1] J.-H. So, J. Thelen, A. Qusba, G. J. Hayes, G. Lazzi and M. D. Dickey, "Reversibly Deformable and Mechanically Tunable Fluidic Antennas," *Adv. Funct. Mater.*, vol. 19, no. 22, pp.3632-3637, 2009

[2] S. Cheng, A. Rydberg, K. Hjort and Z. Wu, "Liquid metal stretchable unbalanced loop antenna," *Appl. Phys. Lett.*, vol. 94, no. 14, pp.144103-3, 2009

[3] M. Kubo, X. Li, C. Kim, M. Hashimoto, B. J. Wiley, D. Ham and G. M. Whitesides, "Stretchable Microfluidic Radiofrequency Antennas," *Adv. Mater.*, vol. 22, no. 25, pp.2749-2752, 2010

[4] S. H. Jeong, A. Hagman, K. Hjort, M. Jobs, J. Sundqvist and Z. Wu, "Liquid alloy printing of microfluidic stretchable electronics," *Lab Chip*, vol. 12, no. 22, pp.4657-4664, 2012

[5] Q. Liu, A. Robinson, K. Ford, R. Langley and S. Lacour, "Elastic dipole antenna prepared with thin metal films on elastomeric substrate," *Electronics Letters*, vol. 48, no. 2, pp.65-66, 2012

[6] L. Song, A. C. Myers, J. J. Adams and Y. Zhu, "Stretchable and Reversibly Deformable Radio Frequency Antennas Based on Silver Nanowires," *ACS Appl. Mater. Interfaces*, vol. 6, no. 6, pp.4248-4253, 2014

[6] Hussain, A. M., Ghaffar, F. A., Park, S. I., Rogers, J. A., Shamim, A., & Hussain, M. M. (2015). Metal/Polymer Based Stretchable Antenna for Constant Frequency Far-Field Communication in Wearable Electronics. *Advanced Functional Materials*, *25*(42), 6565-6575;

unlimited. An embedded 3less sensor shall be able to follow a tagged product and thus ensure its quality over its entire life cycle, delivering on-demand, real-time Radio Frequency ID (RFID) and sensing information. The change of smart material properties will induces a permanent shift of resonance frequency of the device that can be easily detected wirelessly by a standard reader unit[7,8].

The antenna must be designed to present the necessary performance including gain and directivity to allow remote communication while adapting to the support of the structure to monitor and its electrical and mechanical properties. Original and specific designs will be developed and tested, with a focus on "placement-insensitive" antennas design like the one in patent [9]

Work environment

This PhD topic has both theoretical and experimental components, ranging from modelling to design the most efficient antennas for certain constraints, to fabrication and RF characterizations.

The applicant will benefit from a comprehensive state of the art research environment: 3D FEM software for simulations, cleanroom for antenna prototyping, impedance and radiation measurements facilities.

Applicant profile:
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Supervisors:

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[7] L. Reindl, G. Scholl, T. Ostertag, A. Pohl, and R. Weigel, "Wireless remote identification and sensing with SAW devices," Proc. of IEEE International workshop on commercial radio sensor and communication techniques, pp. 83-96, 1998.
[8] Method for interrogation of surface acoustic wave type passive sensor in e.g. application field,
G. Prieur, O. Elmazria, H. M'Jahed, Patent N°: WO2013057298-A1; US2014253094-A1; EP2769237-A1
[9] Placement insensitive antenna for RFID, sensing, and/or communication systems,Jennifer T Bernhard, Jessica E Ruyle, US Patent8746577