FITNESS
Flexible smart skins

Launch of EU-funded FITNESS project

Flexible smart skins

The FITNESS project will realize flexible smart skins able to provide a non-contact sense of "touch". The envisioned smart skins will operate at microwave frequencies, and the same device will also allow far-field communication. The key technology enabling these functionalities is that of metasurfaces, i.e. structured surfaces that have unusual properties at some frequencies. In this case, they convey and manipulate surface waves, which also can be turned into radiating leaky waves for far-field communications.

What is FITNESS about?

The FITNESS project encompasses the synthesis of new low-loss flexible microwave substrates, research on the embedded electronics, the analysis and design of metasurfaces on curved structures and data analysis. The first demonstrator will be realized in the field of robotics, while later applications are envisioned in the medical area. Therefore, FITNESS will integrate ultra-low power operation from the beginning. The devices will essentially work through the measurement of the transmittance between a limited number of ports (sparse electronics), through surface waves following the shape of the smart skin which is wrapped around the robot or the body. One of the main societal outputs will consist of a more harmonious cooperation between robots and humans through the constant probing of their respective near-field environments.

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State of the art

Metasurfaces (MTS) are structured, essentially two-dimensional, materials with unusual electromagnetic properties. They are composed of hundreds or thousands of subwavelength patches, with varying dimensions, printed on a dielectric substrate. The ambition of FITNESS is to exploit flexible MTSs for near field sensing, in the first instance in the area of collaborative robotics. The major concern here is the risk of collision with humans. Hence, tasks performed by robots are too slow and too simple, which is an important obstacle to robot use in healthcare, agile manufacturing and many other fields. By equipping robots with a flexible sensing skin, in addition to standard sensors (e.g., cameras, lidars and radars), the risks can be essentially eliminated. The FITNESS microwave technology will enable for the first time a smooth transition from the near-field "sensing aura", to far-field communication, using the same device, which is beyond the capabilities of present-day proximity sensors. FITNESS includes important innovations toward thin integrated electronics distributed along the MTS. Thinned CMOS chips bonded onto a compliant host substrate will enable mechanical flexibility and high-frequency operation. The Silicon-on-Insulator (SOI) technology is chosen, as it provides high linearity, excellent passivation, and low loss.

Advances regarding flexible microwave materials are lagging behind, curtailing the development in the field. The integration of mechanical properties (i.e., elastic deformation, self-healing) in low-loss materials is a challenge. In FITNESS, new multifunctional polymer substrates and compatible metallization techniques for MTSs and electronics will be developed to achieve low losses and advanced mechanical functions, e.g., structures that are flexible, stretchable, or even self-heal.

FITNESS proposes a near-field to far-field sensor, based on surface waves and their possible transformation into leaky waves, to be wrapped around robots or humans. The measurement of the correlation between transmitted and received signals at all pairs of ports will also be used to monitor the effects of folding the flexible skin. The control of surface waves clearly differentiates the proposed technology from near-field radar.

FITNESS's approach

FITNESS will use a holistic approach to develop thin (a few mm) integrated smart skins, through a tight exchange between diverse areas: RF front-end circuits, chemistry and polymer materials, flexible substrates, Silicon integration, phased array antennas, metamaterials, numerical modelling, heat management and communication systems.

The level of integration between materials and electronics will foster new and long-term scientific collaborations, which are reflected in the diversity of the consortium. The partners comprise leading European universities and research centres in antennas, RF, electronics, robotics and polymer material domains, but also EV-T, a recently founded SME in the high-tech field of electronic integration. The demonstration in the field of robotics and the longer-term healthcare prospects will attract very large EU industry players, and this will be already touched by the Industrial Advisory Board. FITNESS thus fits into a wider plan at European scientific and industry levels, for competition with the USA and China in the strategic area of new sensors and wearable electronics. Development of "in situ" demonstrators and filing of patents will be central drivers for technology transfer. FITNESS will contribute to bridging the antenna and robotics fields, and leveraging the development of new polymers for sensors

The Consortium

FITNESS unites a highly complementary consortium, unique expertise and state of the art facilities, bridging the gap between research and application. All 7 participants have participated in collaborative R&D projects at national and international levels. To reach the highly ambitious FITNESS objectives, a multidisciplinary and complementary team has been gathered with the key European experts, covering electromagnetics, electronics, materials and thermal aspects. The partners represent 3 universities (5 research teams), 2 private companies/SMEs & 2 research centres and cover 4 EU countries. Proper advice through the Advisory Board will be obtained to anticipate ethical issues regarding body-worn applications.

The partners (short names in brackets) are:

1. Université Catholique de Louvain (UCL), BE
2. Centre National de la Recherche Scientifique (CNRS), FR
3. Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e. V. (FhG), DE
4. eV-Technologies (EV-T), FR
5. Sveuciliste U Zagrebu Fakultet Elektrotehnike I Racunarstva (UNIZG), HR
6. Leibniz Institut für Polymerforschung Dresden (IPF), DE
7. L - UP SAS (LUP), FR

Key facts

FITNESS stands for "Flexible IntelligenT Near-field Sensing Skins" and is a visionary four-year research project funded by the European Commission under the Horizon Europe Programme (grant agreement number 101098996) with a total budget of 3.6

million Euros. Via this funding scheme, namely the Pathfinder programme, the European Innovation Council (EIC) supports the exploration of bold ideas for radically new technologies. It welcomes the high-risk / high gain and interdisciplinary cutting-edge science collaborations that underpin technological breakthroughs.

Official Project starting date: [01-04-2023], project kick-off meeting: [13 & 14-04-2023].

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