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An imec.icon research project | project results

SMART HEALTH

I-CART

Protecting firefighters from burn injuries with smart protective clothing

Firefighters wear super-insulated clothing to protect them in high temperature situations. However, this protective clothing also numbs their senses to some extent, making it hard for them to tell when they risk burn injuries and should remove themselves from a dangerous situation. The imec.icon project I-CART was set up to reduce the number of burn injuries suffered by firemen by developing a sensor system that can be integrated into their protective clothing. In a way, the system reactivates their pain senses and natural instinct to avoid high temperatures by giving them an auditive warning signal when it is time to retreat.

The project was set up at the request of the Brigade of Firefighters of Paris (BSPP), the third biggest brigade worldwide. Firefighters frequently suffer second-degree burns, which comes at a high social and economic cost, e.g. long absences from work. Many of these injuries could have been avoided if the firefighters had known to retreat earlier.

Frederick Bossuyt, research lead of the I-CART project: "We faced two main challenges in this project. The first is that protective clothing needs to meet the European EN-norms, yet at the moment these have not yet been adapted to include technologically enhanced protective gear. Then, from a technological point of view, the main challenge was to make sure that our electronics were robust and safe enough to function in high temperatures."

THE OUTCOMES

1. Electronic system and software designed by Connect Group

Bart Allaert (Manager New Technologies Connect Group), Kurt Dewulf (Development Engineer Connect Group): "The aim of the project is to design an integrated detection system in order to prevent second and third degree burn wounds by measuring temperatures. Connect Group designed the complete electronic system: electronic blocks and all electronics components, together with the development of the software have been defined by Connect Group, fulfilling the requirements of the end customer. The complete lay-out and interconnections between the different sub-assemblies were integrated. Special attention was paid to components which must be of a high reliability level. Temperature sensors, together with an appropriate low power microprocessor and a full on-board-logging system are integrated in the system. Also challenging is the impact of human sweat. An appropriate coating solution was found to protect our electronic circuits against this contaminating environment. Batteries, mounted in special high temperature resistant material, are crucial: they supply power to the system in the harsh situation which is a combination of high temperature, mechanical shock and vibrations. An extra feature of the system is low power consumption. Software is designed to detect the first level temperature and drives the integrated auditive haptic feedback system, taking into account the status of emergency."

2. Functioning sensor system for textile integration

We developed a thin sensor system that is suitable for textile integration. To communicate from the sensors to the central circuit board, we used a specially developed ribbon including conductive thread integrated into the garment. The entire system is small, thin and does not affect the wearer's comfort.

Vera De Glas, project lead of the I-CART project: "There have already been a number of large research projects on this topic in the past, but none of these yielded any commercial results. The reason for this is that their scope was too wide: tracking not only temperature, but also geolocation, gas detection, etc. That's why we decided to focus on one dedicated case, i.e. preventing burn injuries by measuring temperature. This made it easier to test and fine-tune our prototypes in the field, an absolute requirement to develop this as a commercially available solution."

3. Co-designed and tested by firefighting experts

Our smart tech-enhanced protective clothing was tested elaborately through container tests in collaboration with BSPP in Paris.

"These tests were important to fine-tune the algorithms that generate the warning signal and to determine the optimal location of the sensors (e.g. inner or outer layer). We also managed to reduce the number of sensors to 8 in total, 4 on the jacket and 4 on a complementary polo shirt. Though our main focus was on reliability and accuracy, reducing the number of sensors improved the cost-efficiency of our solution," explains Frederick Bossuyt.

4. Safe and robust electronics

The project focused on protective clothing that meets the EN469 and EN ISO 11612 standard.

Vera De Glas: "So obviously, we have to be sure that adding technology does not impact the wearer's safety. Not all electronics can function in such harsh circumstances with high temperatures. From a technological point of view, this was definitely one of the biggest challenges. To put our solution to the test, we placed it on a thermo-man during a flashover test (8 seconds in 1200 degrees). The test indicated that the technology does not pose an extra risk to the firefighter."

NEXT STEPS

"We are currently investigating the road towards commercialization, but what is holding us back at the moment is the lack of official regulations regarding protective clothing with integrated electronics. The European Commission has recently issued a mandate (M/553) to develop standards for technology enabled garments that provide protection against heat and flame, but this is a time-consuming process and takes several years. In the meantime, we will further fine-tune the prototypes – e.g. improving the algorithms and ensuring all electronics become washable," says Vera De Glas.

"Though this project focused exclusively on firefighters, some of the lessons we've learned could also contribute to developing similar systems for different types of clothing or medical applications. It would be interesting to explore this further with other partners," adds Frederick Bossuyt.

I-CART project partners:

BRIGADE DE SAPEURS-POMPIERS DE PARIS

CONNECT GROUP
INTEGRATED SUBCONTRACTORS

GHENT UNIVERSITY

SIOEN

FACTS

NAME	**I-CART** (Individual Capturing of Thermal Risks)
OBJECTIVE	Reducing the number of burn injuries suffered by firefighters by developing a sensor system integrated into their protective clothing
TECHNOLOGIES USED	electronic circuit design and manufacturing; integrated temperature sensor system; dedicated battery mounting; auditive haptic feedback; textile integration; temperature estimation models
TYPE	imec.icon project
DURATION	01/10/2017 – 20/09/2019
PROJECT LEAD	Vera De Glas, Sioen
RESEARCH LEAD	Frederick Bossuyt, CMST, an imec research group at Ghent University
BUDGET	882,962 euro
PROJECT PARTNERS	Sioen, Connect Group, Brigade of firefighters of Paris (BSPP)
RESEARCH GROUPS	CMST and IDLab, imec research groups at Ghent University; imec EA

WHAT IS AN

IMEC.ICON PROJECT?

The imec.icon research program equals demand-driven, cooperative research. The driving force behind imec.icon projects are multidisciplinary teams of imec researchers, industry partners and/or social-profit organizations. Together, they lay the foundation of digital solutions which find their way into the product portfolios of the participating partners.

The I-CART project was co-funded by imec, with project support from Agentschap Innoveren & Ondernemen.

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Vlaanderen is ondernemen

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