The AMANDA project has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No. 825464

NEWSLETTER No.4

July 2021

AutonoMous self-powered miniAturized iNtelligent sensor for environmental sensing anD asset tracking in smArt IoT environments

IN THIS ISSUE

AMANDA

The world in your hands

WELCOME TO THE 4TH EDITION OF THE AMANDA NEWSLETTER!

Dear reader,

We are happy to introduce you the 4th edition of the AMANDA newsletter, which provides information on our latest achievements of ongoing research and upcoming activities. Behind us is a very special year, a year marked by an unprecedented coronavirus pandemic, and the whole world has been affected to a greater or lesser extent. Despite these adversities, it is also fascinating how much we have all managed to continue living and doing our work with resilience and inventiveness. We are in the middle of the third year of project implementation, and despite the difficult last year due to the COVID-19 crisis and the inability to access laboratories for component production and testing, we are really pleased to confirm that the project is continuously progressing.

Like previous editions, this newsletter is filled with highlights from recent activities of the AMANDA project, as well as information about the upcoming activities and external events that you can look forward to!

Finally, we would like to extend our warm invitation to connect with the AMANDA project via our website and social media channels and follow the news that we regularly publish, as well as webinars and workshops that we organise this year and next. If you are also interested in learning more about AMANDA use cases and scenarios, we especially recommend that you visit the official AMANDA YouTube channel and watch the videos released so far.

AMANDA partners

The AMANDA Consortium

AMANDA brings together three research (CERTH, ZHAW, IMEC) and five industry partners (MICRODUL, LIGHTRICITY, ILIKA, EPEAS, PENTA) from six European countries that jointly undertake the research and deliver the envisaged technological breakthroughs to strengthen European leaderships in ESS (Electronic Smart Systems).

CERTH CENTRE FOR RESEARCH & TECHNOLOGY HELLAS · MICRODUL Customized Swiss Microelectronics · e-peas semiconductors · zh aw · lightricity · imec · ilika · penta ID SYSTEMS

WHAT IS THE AMANDA PROJECT ABOUT?

The AMANDA consortium is introducing, designing and developing a maintenance-free, miniaturised and easily deployable Autonomous Smart Sensing Card - ASSC for environmental sensing, as well as for asset and people tracking/monitoring in smart living and working environments.

The unique ASSC will have a credit card's size, feel, and look, with a maximum thickness of 3mm. A self-powered thin card can monitor air quality, temperature, humidity, image, magnetic field, acceleration and long-range tracing. Therefore, the ASSC has the capability of four out of the five human senses: sight (image sensor), smell (CO_2 sensor), hearing (microphone) and touch (capacitive sensor).

The most significant advantages of the ASSC over other products on the market are its autonomy, a unique combination of sensors, and small dimensions. The end device will be a next-generation Autonomous Smart Sensing Card that will include multiple sensors, such as CO_2, imaging, capacitive and temperature sensors developed by AMANDA partners, in conjunction with off-the-shelf commercial sensors (low-power accelerometer, spintronics sensor/magnetometer, RH&T (Relative Humidity & Temperature), VOC (Volatile Organic Compound) sensor, light sensor, acoustic sensor).

In addition, to ascertain that the final design will be protected from external conditions, the ASSC will integrate encapsulation and custom packaging in such a way as to allow the sensors to gather data from the environment. Moreover, the card is designed with advanced security aspects to protect gathered and computed data from cyberattacks and common IoT vulnerability vectors.

ASSC's Competitive Advantages

- Multi-sensing capability (incl. environment)
- On-board processing
- Wireless connectivity (incl. long-range)
- Completely energy-autonomous (self-powered even in the low-light indoor environment)
- Wearability (small footprint, thickness, lightweight)
- Easily integrated into existing applications
- Low maintenance cost

Although the market today offers a wide range of autonomous devices, rarely devices are autonomous and multisensory. The ASSC has a comparative advantage over existing products on the market in its declared autonomy of 10 years of operation. Furthermore, a significant advantage of a multi-sensor card is the ability to measure multiple sensors simultaneously. Multi sensing, data fusion and edge intelligence should give the ASSC a considerable advantage over single-sensor systems on the market.

Title and Acronym	**A**utono**M**ous self powered mini**A**turised i**N**telligent sensor for environmental sensing an**D** asset tracking in sm**A**rt IoT environments
Call	H2020-ICT-2018-2
Type of Action	RIA
Grant Agreement No.	825464
Duration	42 months (Start Date: 1 January 2019)
Estimated Project Cost	3,999,625.00 EUR
Requested EU Contribution	3,999,625.00 EUR
Coordinator	Centre of Research and Technology Hellas / Information Technologies Institute
Keywords	autonomous, energy harvesting, multi-sensing, data fusion, artificial intelligence, edge intelligence, miniaturisation, cybersecurity, wireless connectivity

How has COVID-19 Affected AMANDA?

Because of the lockdowns linked with the COVID-19 pandemic, fieldworks had to be postponed, and laboratories were not accessible. Thus the AMANDA Consortium requested a six-month extension which was approved, all with the aim of successfully and qualitatively carrying out all project activities. On the other hand, the crisis was also a time that strengthened the internal communication so the project's objectives are being achieved and stakeholder engagement is being ensured.

Without a doubt, the COVID-19 pandemic significantly affected all project activities, but in particular, dissemination and communication of the project's progress and results.

More specifically, during the months from January 2020, almost all face-to-face activities and events were cancelled, postponed or held online. Thus, to tackle the long-term effects of the pandemic, the Consortium adopted a proactive approach and created new or additional communication mechanisms (virtual meetings, participation in online conferences, performing 1st AMANDA - ASSC webinar), and showed that AMANDA is resilient and despite the circumstances and restrictions, it can be very productive.

Overall, the difficulties encountered during the pandemic prompted AMANDA partners to strive for better and closer cooperation to overcome them.

Can you give us a brief overview of capacitive and temperature sensors that Microdul develops and the work you do in AMANDA?

MICRODUL
Customized Swiss Microelectronics

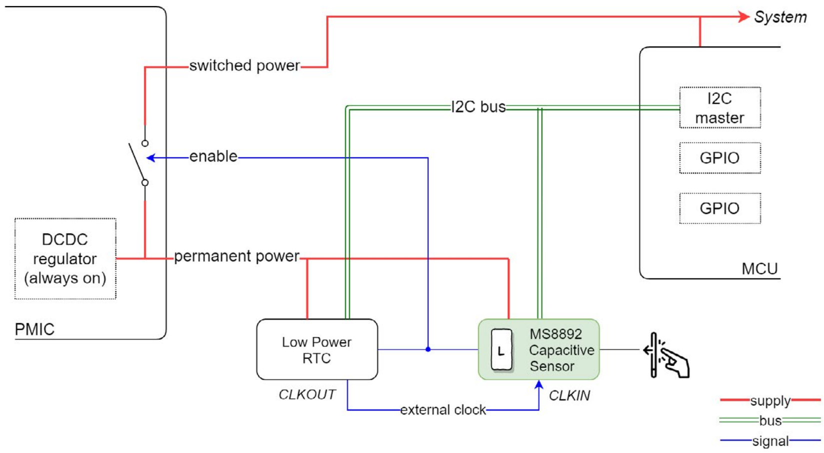
Lowest power wake-up and temperature sensing

The first "A" in the abbreviation "AMANDA" stands for "Autonomous". Switching off the system current when the card is not sensing is necessary to keep the energy use to a minimum. The lowest energy consumption is critical when the solar cell is in the dark to preserve the battery life. Using the lowest power sensors also supports preserving the battery life.

Waking the AMANDA card up

The system consists of a power management IC (PMIC), a system controller (MCU), and two wake-up sources; a capacitive touch sensor and the real-time clock (RTC). For simplicity, the diagram does not show the rest of the system, including the solar cell and battery connected to the PMIC, or the sensors, memories, RF modules etc., connected to the MCU. The MCU and the rest of the system are supplied by a switched power supply. Disabling the system power enables the lowest possible power consumption in power off mode, in which even the leakage current of the system is avoided.

Wake up sources from this power-off mode are the capacitive touch sensor MS8892 and the RTC. A touch event or an RTC alarm enables the system power by controlling a switch in the PMIC. The outputs of the MS8892 and the RTC are both active-low, open-drain types that are connected (signal *enable*).



A high level on signal *enable* is achieved by a pull-up resistor. To reduce external components, the MS8892 contains an internal pull-up resistor. If the signal *enable* is driven to a logic low level by the MS8892, the internal pull-up resistor is disconnected to avoid the static current flow. This is a further method to reduce power consumption in ultra-low-power systems.

The system power state is kept in the internal latch 'L' in the MS8892. The latch 'L' will be set (thus switching on the switched power via enable) by a touch event or when the RTC pulls the signal *enable* low due to an alarm. After power-up, the MCU is in control and can read out the wake-up source from the MS8892. It can re-configure the parameters of the MS8892 and the alarm settings of the RTC. The system will return to the power-off mode by clearing the latch in the MS8892, which disables the switched power supply. The latch can be cleared by an I2C command or an optional hardware signal from a GPIO of the MCU to the INIT pin of the MS8892. In this application example, further power is saved by clocking the MS8892 from a permanent clock signal from the RTC (external clock). This allows the internal oscillator of the MS8892 to be disabled. When the system is powered down, the current drain of the PMIC, RTC and capacitive touch switch is about 300nA but is ready and waiting for a wake-up event! More information on MS8892 can be found here.

Measuring temperature with “zero” standby current?

One of the major challenges for any autonomous application is to keep the standby power low enough for the battery to last when power is not generated (for example, when the solar cells are in the dark). The MS1089 temperature sensor uses no active current between measurements, which means that only standby current flows. Typically, the standby current for the MS1089 is less than 5nA, making it ideal for autonomous applications. Another challenge is to have a low minimum voltage. The MS1089 is designed with an operating voltage from 1.8V to 3.6V. This range covers the most prevalent supply voltage settings encountered in current battery-powered or autonomous applications.

The peak current during temperature measurement is 70µA, which is very suitable for batteries used in autonomous applications. The average current is 28nA with one measurement per minute, making the MS1089 “best in class” concerning current consumption. Typical accuracy is ±0.3°C from 0°C to 60°C, which fits well for environmental monitoring.

Three different temperature measurement resolutions are available; 0.1C°, 0.05°C and 0.025°C. The average current consumption depends on the resolution, but even at the highest resolution (0.025°C), the average current is only 110nA for one measurement per minute. The MS1089 has a “Fast-mode Plus” (1MHz) I2C interface, and up to four sensors can be addressed on the same bus (4 sub-addresses). Measurements can be started, and the temperature can be read digitally via the I2C bus. Alternatively, measurement can be started by driving a trigger pin TM low for a short time. In both cases, the MS1089 will indicate when the measurement is finished by driving the TM pin low again. This can be used as a wake-up interrupt to the MCU when the measurement is finished.

The development was started in 2019, and the first silicon has been extensively evaluated using prototype packaging. Chip-Scale-Package (CSP) samples (1.22mm X 1.145mm) are being manufactured now and will be available later in 2021. This small CSP package can be soldered using a normal reflow process.

What are the market applications for capacitive and temperature sensors?

Capacitive sensors are often attractive because there are no mechanical parts to wear out and they are competitively priced.

Silicon temperature sensors are small, accurate and competitively priced. They are suitable for temperatures from -40°C to 120°C.

CAPACITIVE SENSORS
Automotive: Control e.g. entertainment, mirrors, keypads
LCD-screens: On/off touch control
Lighting: e.g. LED control
Medical: Body detection for wearables
Door locks: Touch & proximity detection
Smart home: Control
White goods: Detection, keypads
Safety: Tools, grip detection
Audio: Body detection
Pipes: Water leak detection
Sports shoes: Body detection

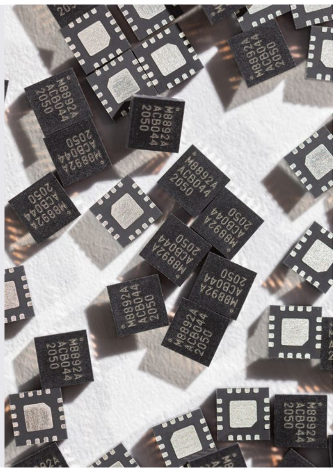
TEMPERATURE SENSORS
Wireless sensor tags
Human body temperature measurement
Wearables
Power-supply monitoring
Environmental monitoring and HVAC
Vaccine storage temperature monitoring
Computer peripheral thermal protection
Battery management
Notebook computers
Cell phones
Thermostat controls

SUCCESSFUL COMPLETION OF THE SENSOR DEVELOPMENT

What are the advantages of MS8892 and MS1089 over similar sensors available on the market today?

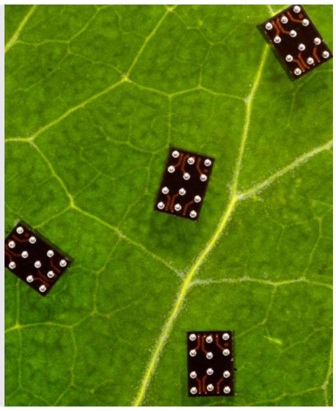
CAPACITIVE SENSOR

- The MS8892 can operate with an external clock, so if you already have a real time clock (RTC), then you can use its clock for the MS8892. This gives the lowest power wake-up with touch and time alarm
- The power-up state from either the RTC (based on alarm) or the MS8892 (based on touch) is stored in the MS8892, so it can directly control a power switch, an LDO, or a PMIC
- The source of the wake-up event (RTC alarm or touch) is registered in the MS8892 and can be read by the controller
- The MS8892 is available in a QFN16 3x3mm standard package or a chip scale package measuring just 1.03 x 1.52 x 0.65mm
- Manufacturing tolerances can be accounted for by setting a relative step for detection of an event



TEMPERATURE SENSOR

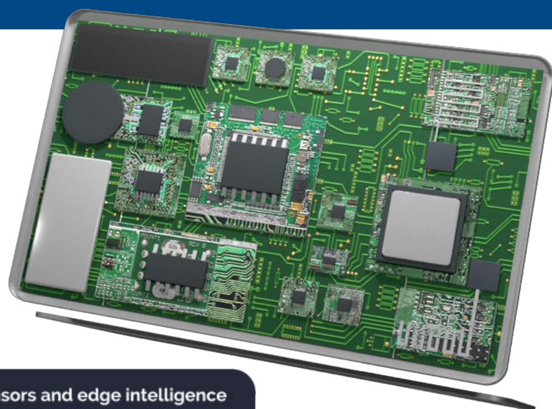
- Typically "zero" (<5nA) standby current
- Lowest power, "best in class" power (typically 28nA) for IoT and autonomous applications when measuring once per minute or less
- Low peak current 70μA
- Accurate, typically ±0.3°C from 0°C to 60°C
- Attractive supply range 1.8V to 3.6V suitable for most applications
- Handshake mechanism to allow cutting system power during measurements
- Small chip-scale package 1.22 x 1.145mm

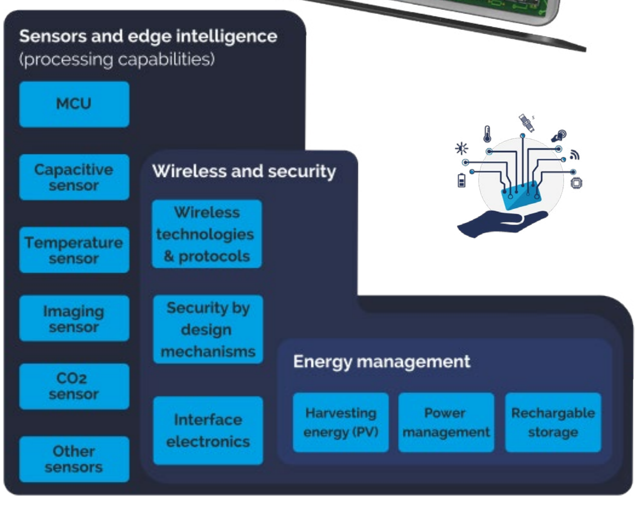


Conceptual Architecture of the AMANDA ASSC

In order to ensure the ASSC's viability as an IoT solution, its conceptual architecture consists of 3 major building blocks as shown below:

- **The Sensor and Edge Intelligence block**, which incorporates the sensing and processing capabilities of the ASSC.
- **The Wireless and Security block** with the aim to setup the appropriate communication tools and infrastructure to match the ASSC's operational needs and intrinsic limitations of each version. Moreover, the software and hardware security mechanisms that will eradicate any possible vulnerability of the ASSC are designed and implemented as part of this architectural stage.
- **The Energy Management block**, which comprises the Energy Harvesting, Power Management and Rechargeable Storage Modules, providing complete autonomy.





INSIGHTS FROM THE 5TH PLENARY MEETING

AMANDA reached its 5th plenary meeting, which took place online due to the restrictive measures brought about by the COVID-19 pandemic. Twenty-six representatives from the eight partners participated in the event that was held on the 9 March 2021, which involved engaging presentations and critical discussions focusing on the project's progress. During the one-day meeting, AMANDA partners exchanged views on the latest project developments and planned the project's exciting work in the third year. In particular, the project partners were working towards the successful completion of the sensor development.

The project partners also focus their outreach efforts towards progress in most work packages, namely energy autonomy booster, cybersecure mesh communication and processing, smart interconnect PCB development and system integration. The second version of the Unconstrained Prototype was presented, and testing should be done soon. Such work certainly leads to achieving the project's main goal – introducing, designing, and developing a maintenance-free, miniaturised and easily deployable Autonomous Smart Sensing Card (ASSC) for environmental sensing and people tracking/monitoring in smart living and working environments.

AMANDA Joins the PRAXI Network

After the initial meeting successfully held in April 2021, AMANDA is joining the PRAXI Network, a unit of the Foundation for Research & Technology - Hellas (FORTH).

praxi
help-forward network

PRAXI Network's mission is to make enterprises and research organisations more competitive via the linkage between research and industry, the promotion of innovation and entrepreneurship as well as transnational cooperation. Its services are extended from information to mediation and advisory support covering the whole spectrum of activities related to innovation, technology transfer, research collaboration and commercial exploitation of research results. The AMANDA Consortium is looking for companies and R&D institutions interested in using the card or tailoring the design to fit their needs. The Consortium is interested in services, license and joint venture agreements as well as technical and research cooperation. We are convinced that the collaboration with Praxi Network in the coming period will bring the necessary support to the AMANDA project and encourage us to become more competitive.

WEBINAR ON THE AMANDA AUTONOMOUS SMART SENSING CARD

On 17 May 2021, a successful webinar on the AMANDA Autonomous Smart Sensing Card was held. The AMANDA webinar aimed to present a general overview of the project, emphasising the possibility and benefits of using the unique ASSC to help mitigate the effects of current and future pandemics.

The webinar provided participants with a better understanding of the significant advantages of the AMANDA card over the products on the market and presented where the card can be applicable (smart cities, smart homes, intelligent working environments).

The AMANDA webinar included three presentations and an exciting and dynamic Q&A session. In the first presentation, Dr Charis Kouzinopoulos (CERTH) presented the AMANDA concept, main hardware and software components, and wireless communication capabilities of the ASSC.

In the presentation that followed, Dr Denis Pasero (ILIKA) explained the three use cases identified in the AMANDA project and six scenarios that make optimal use of all the functionalities from the AMANDA card in its three versions – indoor, outdoor and wearable. Finally, in the third presentation, Prof. Dr. Marcel Meli (ZHAW) focused on use cases related to air quality and COVID-19 and led an informative discussion on the AMANDA card – a powerful portable system as a monitoring companion.

Thirty-three participants joined the webinar, showing the business and scientific community's great interest in EU research and innovation. We are excited to announce that the recording is available for all those who did not have the opportunity to attend the AMANDA webinar. Presentations are also available on the AMANDA website under the Dissemination materials.

Upcoming Events in 2021

MD&M West 2021, 10-12 Aug (Annaheim, CA)	SIDO 2021, 22-23 Sep (Lyon, France)
Sindex, 31 Aug – 02 Sept (Bern, Switzerland)	ISWC 2021, 24-28 Oct (Barcelona, Spain)
Swiss Medtech Day, 09 Sept (Bern, Switzerland)	SIDO 2021, 09-10 Nov (Paris, France)
Swiss Medtech Expo, 14-15 Sept (Luzern, Switzerland)	SCEWC 2021, 16-18 Nov (Barcelona, Spain)
Sensor Converge, 21-23 Sept (San Jose, CA)	2nd AMANDA webinar, Nov 2021 (Online)

AN ENERGY-EFFICIENT, SMART SENSOR CARD
AMANDA in Polyscope Magazine

"An Energy-Efficient, Smart Sensor Card", an article about the AMANDA project is published in Polyscope - the practice-oriented Swiss trade magazine for industrial electronics and automation.

Prof. Dr. Marcel Meli, Lecturer and Head of the Wireless System Group at ZHAW - University of Applied Sciences, Institute of Embedded Systems (InES), emphasised the primary goal of the AMANDA project, that is to design and develop a maintenance-free, miniaturised and adaptable Autonomous Smart Sensing Card. All components are to be orchestrated into a functioning system, so the thickness of the ASSC do not exceed 3 millimetres. With a vision of such a compact and thin system, the AMANDA consortium is setting new standards.

Eine energieautarke, smarte Sensorkarte

Sensoren im Kreditkartenformat: Auf engstem Raum verbinden ZHAW-Forschende dafür Software- und Hardware-Komponenten miteinander. Das kompakte Messgerät ist das ambitionierte Ziel eines europäischen Forschungsprojektes.

Smart Sensing

ZHAW-Forscher Prof. Dr. Marcel Meli sieht vielerlei Szenarien für den Einsatz der autonomen

Längst sind wir mitten drin im Internet of Things: Viele Dinge sind bereits vernetzt, bei vielen weiteren ist das Potenzial dazu da. Um die Möglichkeiten optimal zu nutzen, sind einfache und kompakte Lösungen gefragt. Eine solche ist auch das Ziel des europäischen Forschungsprojekts AMANDA. Zusammen mit sieben weiteren Institutionen aus sechs verschiedenen Ländern entwickelt die ZHAW School of Engineering eine autonome Smart Sensing Card (ASSC). Im Format einer Kreditkarte wird sie eine ganze Palette an Sensoren beinhalten, um ihre unmittelbare Umgebung zu messen: Ob Lichtverhältnisse, Lärm und CO²-Gehalt, oder Temperatur, Luftdruck und -feuchtigkeit – die Karte weiss Bescheid. Die Messwerte werden automatisch an die gewünschten Empfänger übertragen. Ein Mikroprozessor steuert das Messen und Senden der Daten. Die dazu nötige elektrische Energie gewinnt die Karte mittels Energy Harvesting aus der Umgebungsbeleuchtung und speichert sie in einer Batterie.

Viele Szenarien möglich

Die konkreten Anwendungsbereiche sind vielfältig: Angenommen, man nutzt die ASSC in einem smarten Gebäude, kann sie beispielsweise die Raumtemperatur und die Lichtverhältnisse kontrollieren. So würde sich automatisch die Heizung oder das Licht einschalten, wenn es zu kalt oder zu dunkel wird. Der CO2-Sensor kann die Luftqualität überwachen oder als Rauchmelder bei einem Brand Alarm schlagen. Des Weiteren ist es möglich, die Karte als Tracker zu nutzen, um Dinge und Personen in Echtzeit zu lokalisieren. «Es gibt viele denkbare Szenarien und Einsatzmöglichkeiten, privat wie geschäftlich», sagt Marcel Meli, der das Projekt seitens ZHAW leitet.

Know-how in Low Power Embedded Systems

Alle Komponenten sollen auf engstem Raum in der höchstens drei Millimeter dicken ASSC zu einem funktionierenden System orchestriert werden. Am ZHAW-Institute of Embedded Systems entwickelt Marcel Meli mit seinem Team die dazu nötige Low Power-Architektur: «Unsere Aufgabe ist es, Software und Hardware in einem hocheffizienten Power-Management zu verbinden», so Meli. Ein weiterer Schwerpunkt liegt auf den drahtlosen Systemen und der Low Power-Positionierung. «Ortungstechniken wie GPS benötigen viel Energie, deshalb setzen wir in dieser Anwendung auf LoRaWAN und Blue-

AUF EINEN BLICK

Beteiligte Institute und Zentren der ZHAW:
- Institute of Embedded Systems (InES)

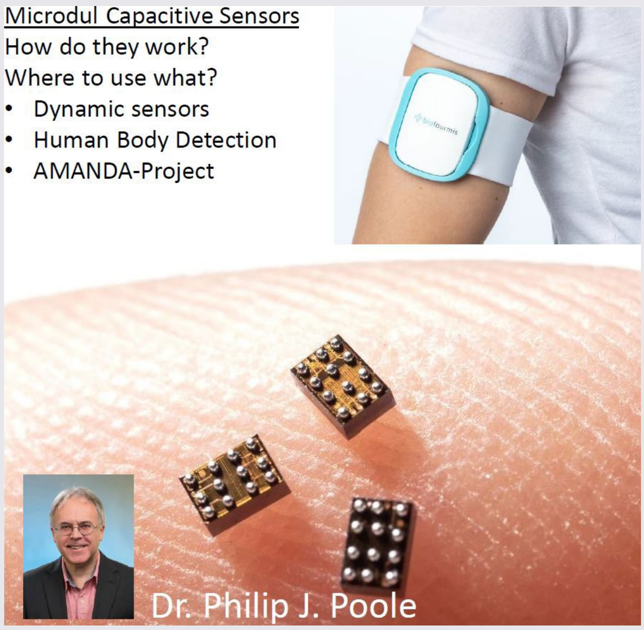
Projektpartner:
- CERTH, Griechenland (Koordination)
- Penta, Kroatien
- E-peas, Belgien
- IMEC, Niederlande
- Lightricity, England
- Ilika, England
- Microdul, Schweiz

Finanzierung: Europäische Union
Projektdauer: 2019 bis 2021

Prof. Dr. Marcel Meli summarises for the Polyscope and adds that in the format of a credit card, the ASSC will contain a whole range of sensors to measure its immediate surroundings: whether a light conditions, noise and CO_2 content, or temperature, air pressure and humidity. The measured values are automatically transferred to the desired recipient. A microprocessor controls the measurement and transmission of the data. The card gains the energy required for this from the ambient lighting using energy harvesting and stores it in a battery. Polyscope magazine is also available in an e-edition and can be found here (see pages 42-43).

WEBINAR: Save System Power with Ultra-Low Power Capacitive Sensors

Microdul looks back on a successful webinar on ultra-low-power capacitive sensors that was held online on 23 March 2021. A portfolio of Microdul's solutions with an emphasis on how capacitive sensors work and where they can be applicable was presented by Dr Philip J. Poole, director Semiconductors at Microdul AG. The MS889X-series are capacitive sensors and switches that have been specifically developed for use in "Wearables". The MS889X-series have an ultra-low current consumption and are ideal for battery-operated systems. There are numerous programming options to aid simple integration into an electronic system. Part of the webinar was also dedicated to the AMANDA project.



Datasheet, application note and summary sheet of capacitive sensors are available on the official website of Microdul.

The AMANDA project has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No. 825464

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