>>

Guido Panzarasa evaluating the results with a colleague

to fluoresce in the lab. He carefully drips a solution with a pH level of 7.5 into a dish. Under a UV light, the change is plain to see. He adds another solution and the luminescence fades. A glance at the little bottle confirms it: the pH level of the second solution is lower.

Luminous molecules under UV

The Empa team designed a molecule composed of benzalkonium chloride and pyranine. While benzalkonium chloride is a substance also used for conventional medical soap to combat bacteria, fungi and other microorganisms, pyranine is a dye found in highlighters that glows under UV light. "This biomarker works really well," says Panzarasa; "especially at pH levels between 5.5 and 7.5. The colors can be visualized with simple UV lamps available in electronics stores." The Empa team recently published their results in the journal "Sensors and Actuators".

The designer molecule has another advantage: thanks to the benzalkonium chloride, it has an antimicrobial effect, as researchers from Empa's Laboratory for Biointerfaces confirmed for the bacteria strain *Staphylococcus aureus*. Unwelcome bacteria might potentially also be combatted by selecting the right bandage material in future. As further investigations, such as on the chemical's compatibility with cells and tissues, are currently lacking, however, the researchers do not yet know how their sensor works in a complex wound.

Keen interest from industry

In order to illustrate what a smart wound dressing might actually look like in future, Boesel places a prototype on the lab bench. "You don't have to cover the entire surface of wound dressings with sensors," he explains. "It's enough for a few small areas to be impregnated with the pyranine benzalkonium molecules and integrated into the base material. This means the industrial wound dressings won't be much pricier than they are now – only up to 20% more expensive." Empa scientists are currently working on this in the follow-up project FlusiTex-Gateway in cooperation with industrial partners Flawa, Schöller, Kenzen and Theranoptics.

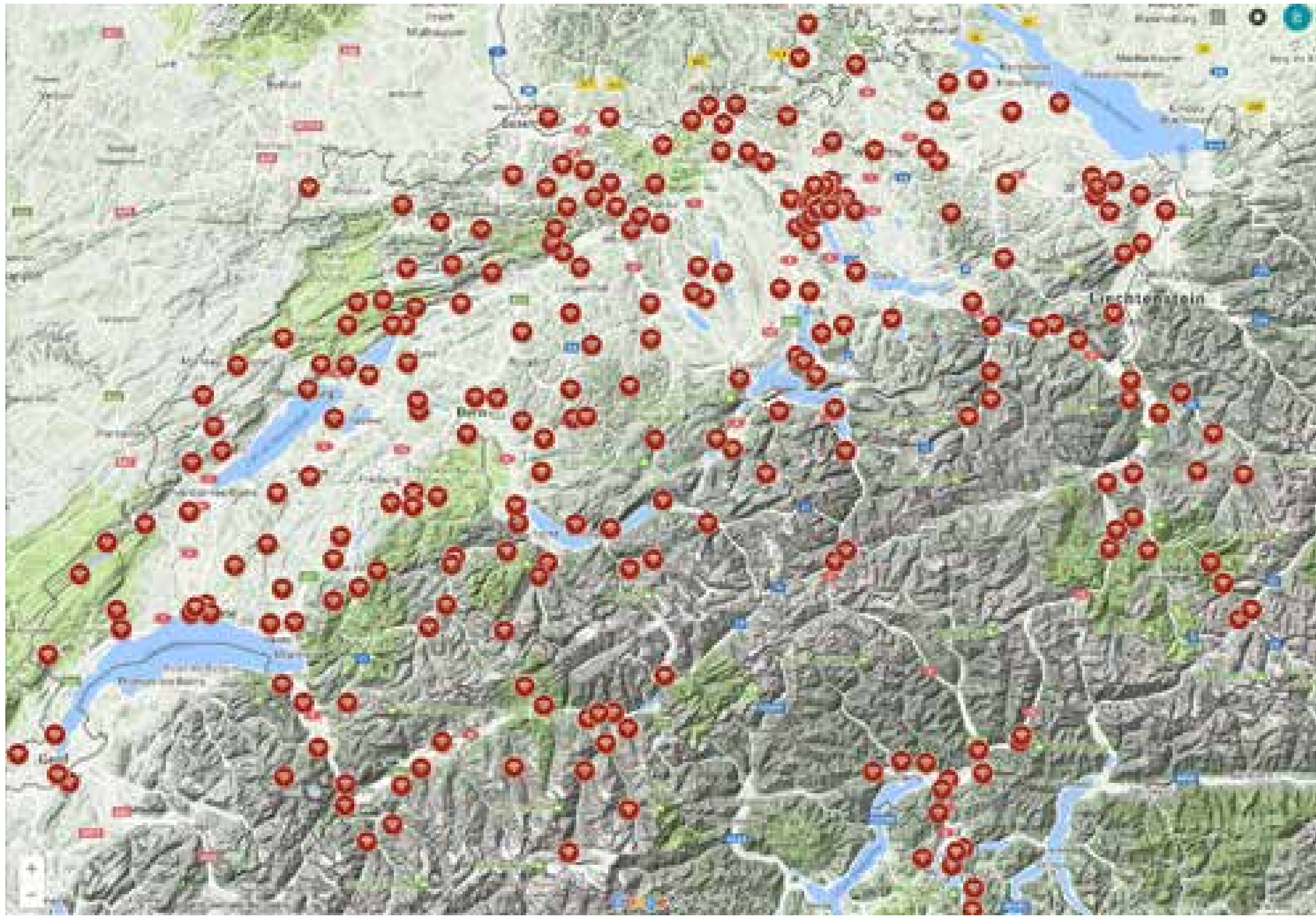
Panzarasa now drips various liquids with different pH levels onto all the little cylinders on the wound pad prototype. Sure enough, the lighter and darker dots are also clearly discernible as soon as the UV lamp is switched on. They are even visible to the naked eye and glow in bright yellow if liquids with a high pH come into contact with the sensor. The scientists are convinced: since the pH level is so easy to read and provides precise information about the acidic or alkaline state of the sample, this kind of wound dressing is just the ticket as a diagnostic tool. Using the fluorescence meter developed by CSEM, more accurate, quantitative measurements of the pH level can be accomplished for medical purposes.

According to Boesel, it might one day even be possible to read the signals with the aid of a smartphone camera. Combined with a simple app, nursing staff and doctors would have a tool that enables them to easily and conveniently read the wound status "from outside", even without a UV lamp. And patients would then also have the possibility of detecting the early onset of a chronic wound at home. //

CO_2 under surveillance

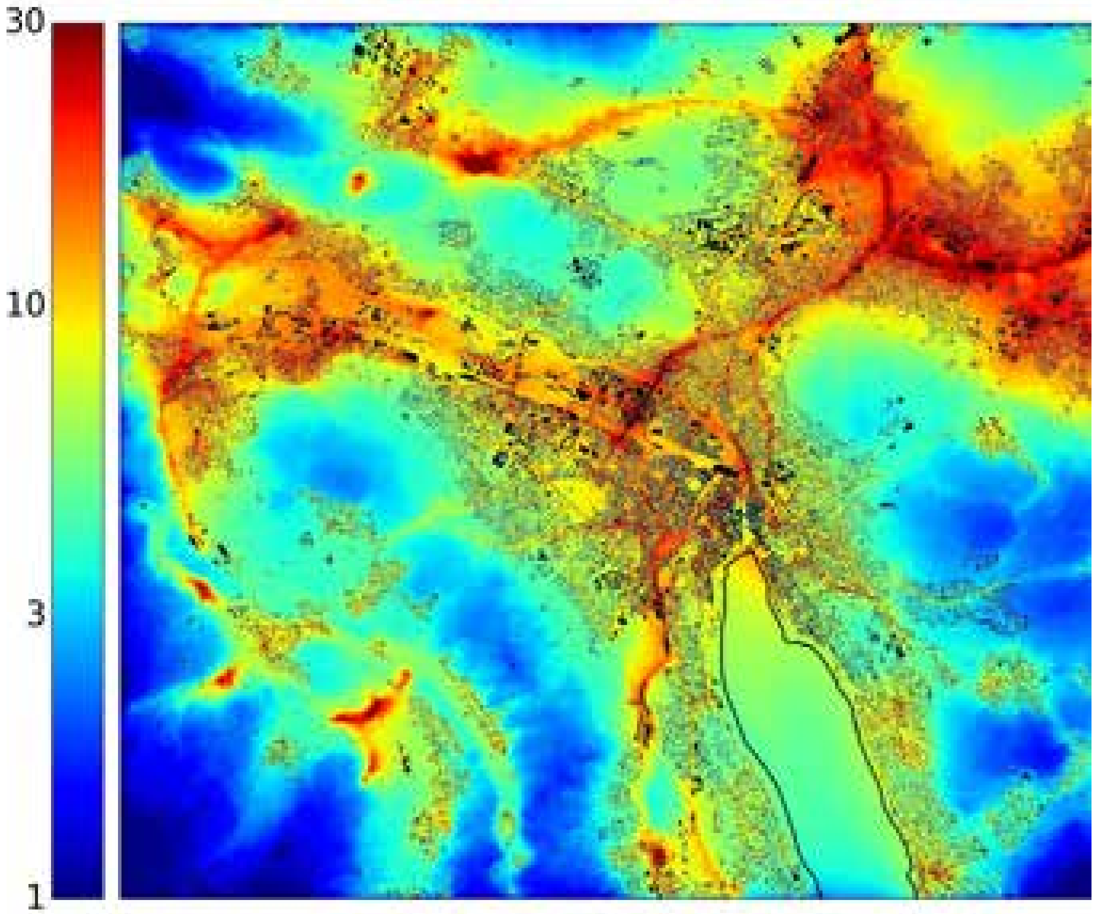
Switzerland is to gain a dense, globally unique CO2 measuring network: 300 sensors permanently collect up-to-date readings, which form the basis for atmospheric dispersion models that are being developed at Empa.

TEXT: Martina Peter, Michael Lieberherr / PICTURES: Empa / Google Maps



In future, the CO_2 sensor network will collect data at 300 locations throughout Switzerland.

>>



The distribution of the CO_2 concentration in the City of Zurich averaged over 2013 and 2014. Thanks to the readings from the sensor network, this kind of model calculation will be more precise in future.

With the Paris Agreement in 2015, the international community made a commitment to reduce global greenhouse gas emissions. Meanwhile (and despite the recent US pull-out by "El Donaldo"), over 190 nations have ratified the agreement. Individual cities have set themselves even more ambitious targets. What is currently lacking, though, are the right tools to measure progress – such as one that enables up-to-the-minute measurements of CO_2 levels.

The Carbosense project is creating new possibilities in this respect. Soon, 300 CO_2 sensors scattered all over Switzerland will be in use to convey their data in real time via the Internet of Things. So far, there were only a handful of places throughout the country for measuring CO_2 . This new dense, globally unique sensor network records spatial and temporal changes in CO_2 levels in the atmosphere. As project leader Lukas Emmenegger, head of Empa's Laboratory for Air Pollution/Environmental Technology, explains: "The CO_2 sensor network will be a valuable springboard that will allow us to better understand the natural and manmade sources and drains of CO_2 in Switzerland."

The x-ray machine for CO_2

For the City of Zurich, where the sensor network will be particularly close-knit, Empa developed a computer model that simulates the CO_2 concentration from ten different sources (see diagram). These emission sources include various kinds of traffic, industry or heating systems in residential buildings, for instance. By combining these simulations with the sensor data, Empa will be able to display the city's current CO_2 emissions practically in real time. "This will give us readings with a sufficient density to follow Zurich's CO_2 emissions virtually live," says Emmenegger. "What's more, the measurements will provide valuable information on the spread of other air pollutants."

The scientific and technical applications based on this sensor data recorded all over Switzerland, on the other hand, will give valuable hints for traffic planning, healthcare measures, developments linked to "smart cities", and even for a better understanding of the exchange of CO_2 between the atmosphere and the vegetation.

Swisscom is installing the CO_2 sensors at antenna sites. The 300 battery-powered sensors transmit their readings to the computing centers at the ETH Domain's Swiss Data Science Center (SDSC) via Swisscom's Low Power Network, which offers a narrow bandwidth but has a long range, transmits in an energy-saving manner and reduces network costs. This makes it just the ticket for linking up environmental sensors, parking spaces, containers or any other communal infrastructure.

Not only does science stand to benefit from the sensor network, but also the Low Power Network itself: the sensors scattered across the country are a good way to continuously assess network quality. Carbosense, a collaboration between Empa, SDSC, the Empa spin-off Decentlab and Swisscom, was initiated by Empa and Swisscom and is cofunded by nano-tera.ch. //

The Empa spin-off Decentlab

300 measuring devices scattered across Switzerland form the backbone of a CO_2 sensor network. Empa spin-off Decentlab integrated CO_2, temperature and moisture sensors along with a communication module for LoRaWAN (Long Range Wide Area Network) in a device and caters for the wireless, low-energy mediation of the data to the next gateway. These gateways are connected via the internet to Decentlab's cloud and visualization infrastructure. Empa scientists can access the data directly and are currently evaluating the data: depending on the time of day, the CO_2 values measured can be distorted by temperature and moisture. Thanks to new mathematical sensor models, however, these deviations can be corrected and losses of individual data packets can be "bridged".

Video (German language)
«CO_2-Messnetz in SRF-Tagesschau, February 6th, 2017
https://goo.gl/o2QyFJ

This new dense, globally unique sensor network records spatial and temporal changes in CO_2 levels in the atmosphere as well as moisture and tempeature. All data are accessible from a web platform.