



Fraunhofer Institute for Ceramic Technologies and Systems IKTS

**Patients with severe respiratory or lung diseases require intensive treatment and their lung function needs to be monitored on a continuous basis. As part of the Pneumo.Vest project, Fraunhofer researchers have developed a technology whereby noises in the lungs are recorded using a textile vest with integrated acoustic sensors. The signals are then converted and displayed visually using software. In this way, patients outside of intensive care units can still be monitored continuously. The technology increases the options for diagnosis and improves the patient's quality of life.**

For over 200 years, the stethoscope has been a standard tool for doctors and, as such, is a symbol of the medical profession. In television hospital dramas, doctors are seen rushing through the halls with a stethoscope around their neck. Experienced doctors do indeed use them to listen very accurately to heartbeats and the lungs and, as a result, to diagnose illnesses.

Now, the stethoscope is getting some help. As part of the Pneumo.Vest project, researchers of the Fraunhofer Institute for Ceramic Technologies and Systems IKTS at the Berlin office have developed a textile vest with integrated acoustic sensors, presenting a high-performance addition to the traditional stethoscope.

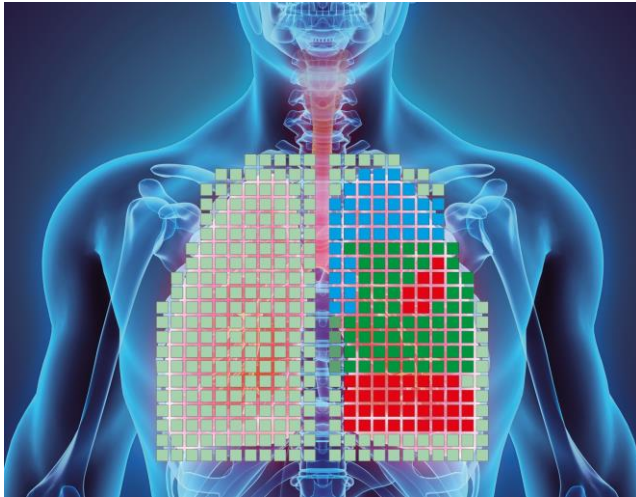


Acoustic sensors are integrated into the front and back of the textile vest to listen to the thorax.

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Piezoceramic acoustic sensors have been incorporated into the front and back of the vest to register any noise produced by the lungs in the thorax, no matter how small. A software program records the signals and electronically amplifies them, while the lungs are depicted visually on a display. As the software knows the position of each individual sensor, it can attribute the data to its precise location. This produces a detailed

acoustic and optical picture of the ventilation situation of all parts of the lungs. Here is what makes it so special: As the system collects and stores the data permanently, examinations can take place at any given time and in the absence of hospital staff. Pneumo.Vest also indicates the status of the lungs over a period of time, for example over the previous 24 hours. Needless to say, traditional auscultation can also be carried out directly on the patients. However, instead of carrying out auscultation manually at different points with a stethoscope, a number of sensors are used simultaneously.



The visual representation shows the different lung areas and their ventilation situation. Parts marked in red have poor ventilation.

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“Pneumo.Vest is not looking to make the stethoscope redundant and does not replace the skills of experienced pneumologists. However, auscultation or even CT scans of the lungs only ever present a snapshot at the time of the examination. Our technology provides added value because it allows for the lungs to be monitored continuously in the same way as a long-term ECG, even if the patient is not attached to machines in the ICU but has instead been admitted to the general ward,” explains Ralf Schallert, project manager at Fraunhofer IKTS.

### Machine learning algorithms aid with diagnosis

Alongside the acoustic sensors, the software is at the core of the vest. It is responsible for storing, depicting and analyzing the data. It can be used by the doctor to view the acoustic events in specific individual areas of the lungs on the display. The use of algorithms in digital signal processing enables a targeted evaluation of acoustic signals. This means it is possible, for example, to filter out heartbeats or to amplify characteristic frequency ranges, making lung sounds, such as rustling or wheezing, much easier to hear.

On top of this, the researchers at Fraunhofer IKTS are developing machine learning algorithms. In the future, these will be able to structure and classify complex ambient noises in the thorax. Then, the pneumologist will carry out the final assessment and diagnosis.

### Discharge from the ICU

Patients can also benefit from the digital sensor alternative. When wearing the vest, they can recover without requiring constant observation from medical staff. They can transfer to the general ward and possibly even be sent home and move about more or less freely. Despite this, the lungs are monitored continuously, and any sudden deterioration can be reported to medical personnel straight away.



The first tests with staff at the University Clinic for Anesthesiology and Intensive Therapy at the University of Magdeburg have shown that the concept is successful in practice. “The feedback from doctors was over-

whelmingly positive. The combination of acoustic sensors, visualization and machine learning algorithms will be able to reliably distinguish a range of different lung sounds,” explains Schallert. Dr. Alexander Uhrig from Charité – Universitätsmedizin Berlin is also pleased with the technology. The specialist in infectiology and pneumology at the renowned Charité hospital was one of those who initiated the idea: “Pneumo.Vest addresses exactly what we need. It serves as an instrument that expands our diagnostic options, relieves the burden on our hospital staff and makes hospital stays more pleasant for patients.”

The technology was initially designed for respiratory patients, but it also works well for people in care facilities and for use in sleep laboratories. It can also be used to train young doctors in auscultation.



### **Increased need for clinical-grade wearables**

With Pneumo.Vest, the researchers at Fraunhofer IKTS have developed a product that is cut out for the increasingly strained situation at hospitals. In Germany, 385,000 patients with respiratory or lung diseases require inpatient treatment every year. Over 60 percent are connected to a ventilator for more than 24 hours. This figure does not account for the current increase in respiratory patients due to the COVID-19 pandemic. As a result of increasing life expectancy, the medical industry also expects the number of older patients with breathing problems to increase. With the help of technology from Fraunhofer IKTS, the burden on hospitals and, in particular, costly ICUs can be relieved as their beds will no longer be occupied for quite as long.

It should be added that the market for such clinical-grade wearables is growing rapidly. These are compact medical devices that can be worn directly on the body to measure vital signs such as heartbeat, blood oxygen saturation, respiratory rate or skin temperature. As a medical device that can be used flexibly, Pneumo.Vest fits in perfectly with this development. But do not worry: Doctors will still be using the beloved stethoscope in the future.

### **Fraunhofer “M<sup>3</sup> Infekt” cluster project**

Pneumo.Vest is just one part of the extensive M<sup>3</sup> Infekt cluster project. Its objective is to develop monitoring systems for the decentralized monitoring of patients. The current basis of the project is the treatment of COVID-19 patients. With the SARS-CoV2 virus, it is common for even mild cases to suddenly deteriorate significantly. By continuously monitoring vital signs, any deterioration in condition can be quickly identified and prompt measures for treatment can be taken. M<sup>3</sup> Infekt can also be used for a number of other symptoms and scenarios. The systems have been designed to be modular and multimodal so that biosignals such as heart rate, ECG, oxygen saturation, or respiratory rate and volume can be measured, depending on the patient and illness.

A total of ten Fraunhofer institutes are working on the cluster project under the leadership of the Fraunhofer Institute for Integrated Circuits IIS in Dresden. Klinikum Magdeburg, Charité – Universitätsmedizin Berlin and the University Hospitals of Erlangen and Dresden are involved as clinical partners..

*Source: Fraunhofer Institute for Ceramic Technology and Systems IKTS*