Micro-membrane diaphragm pump for delivering ambient air to gas sensors

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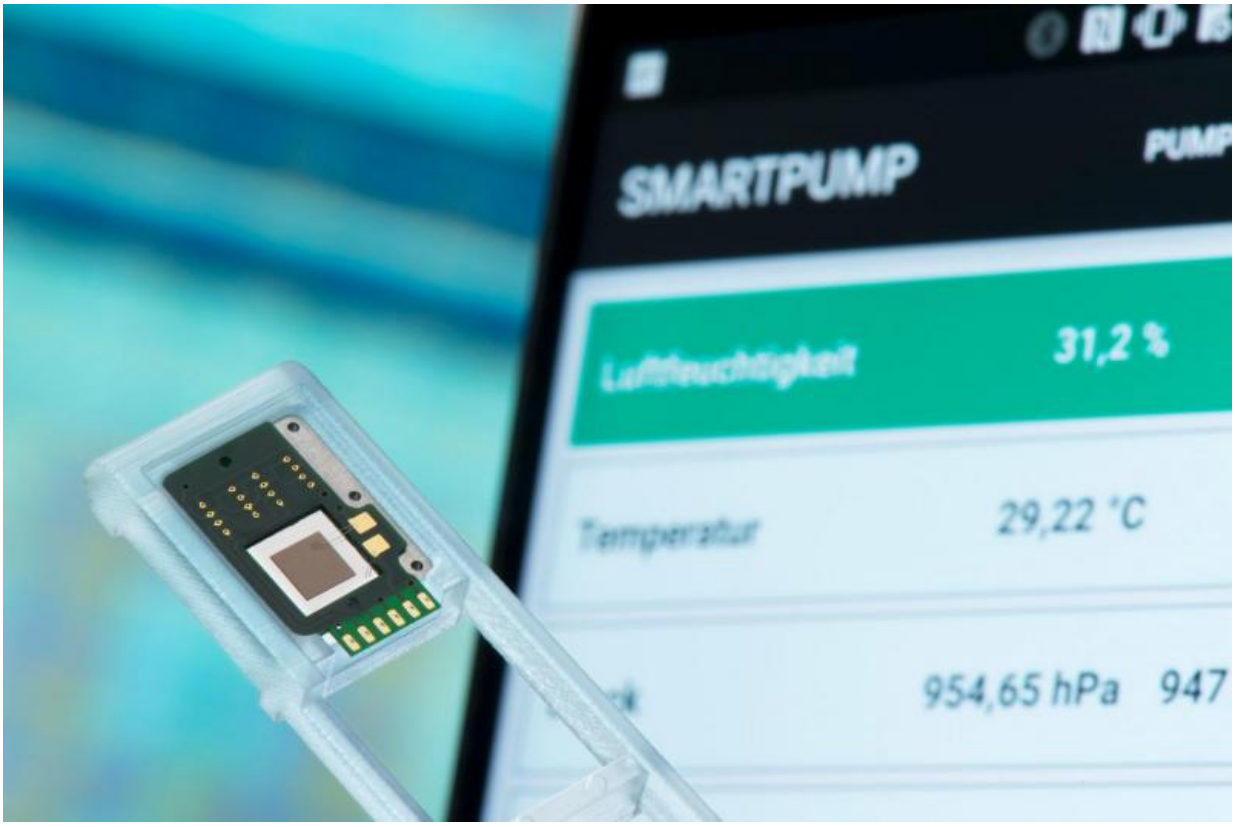

The world's smallest micromembrane pump measures just 25 square millimeters. Credit: Fraunhofer EMFT

Particulate matter harms the heart and lungs. In the future, a smartphone with an inbuilt gas sensor could be used to warn of heavy exposure. To

help the sensor respond quickly and provide accurate measurements, researchers at Fraunhofer have developed a powerful micro diaphragm pump for delivering ambient air to the sensor.

"Our smart pump measures only 25 square millimeters, making it the world's smallest pump. That said, it still has a high compression ratio," says Dr. Martin Richter, department head of micro dosing systems at the Fraunhofer Research Institution for Microsystems and Solid State Technologies EMFT in Munich.

Richter and his team use the piezoelectric effect, which converts an applied electrical field into mechanical strain, to generate pressure in the pump chamber. Alternating the voltage helps move the silicon membrane up or down, which in turn draws in ambient air through a valve and compresses it in the pump chamber before expelling it.

Using tricks to increase pressure

Conventional micro diaphragm pumps powered by piezoelectricity generate only relatively low pressure with air; the asymmetry of the piezo effect means a lot of room is required in the pump chamber to move the membrane. This inevitably results in a high dead volume, in other words a high volume of residual gas within the chamber. Richter and his team came up with a trick to reduce this dead volume and increase the pump's suction capacity. "We use the piezo effect to specifically preload the diaphragm when assembling the piezoceramic. The advantage of this is that we no longer need a deep pump chamber. This trick enables us not only to build micropumps with high compression ratios but also to make them smaller in size."

Not just the diaphragm but also the flap valves and the pump chamber are made of monocrystalline silicon, which offers numerous benefits over metals and plastics. For one, the metalloid – which is also used to

make solar cells and computer chips – is pliable and fatigue-free. For another, the individual pump components can be etched from the silicon layer with a high degree of precision and subsequently joined together.

However, its disadvantage is the relatively high cost of silicon, which is why it is crucial to make the pump as small as possible. "Our goal is to reduce the size of the pump to 10 square millimeters to make its mass production profitable. We are well on track to achieving this," Richter says.

Currently, what makes it even more difficult to integrate gas sensors into smartphones is the fact that reaction times for these sensors are far too long. The smart pump would be able to deliver air specifically to the gas sensors, which would reduce the reaction time from several minutes to just two seconds. They could measure not only the concentration of particulate matter but also, for instance, whether the air in a room is stale and a window should be opened for ventilation. In principle, it could also analyze breath, for instance to measure its alcohol content. "However, this requires a high degree of measurement accuracy, which has not yet been achieved. Otherwise someone might decide to get behind the wheel of a car believing they measure just 0.3 per mille, when in fact they measure 0.9 per mille," Richter warns.

Multiple applications

The micropump could also be used in medicine, for instance as a medical patch to continuously deliver tiny amounts of hormone or pain killer. Or as an implant to help regulate pressure within the eye in treating glaucoma. The pump could also supply machines with precise doses of lubricant. "This is an application that we are currently developing with a partner from industry."

As part of Fraunhofer's Discover funding program, which supports

unconventional and original ideas, Richter and his team is also looking into an additional application: adding scent information to audio and video files. "A headset fitted with our smart pump could deliver precise doses of different scents close to the nose. The gaming industry has already expressed an interest in this." Richter adds that the smart pump should be an interesting prospect for anyone looking to deliver precise, tiny doses of liquids or gases.

The smart pump project is being funded by the Fraunhofer Future Foundation, which aims to strengthen innovation and employment in Germany by licensing research results to companies.

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