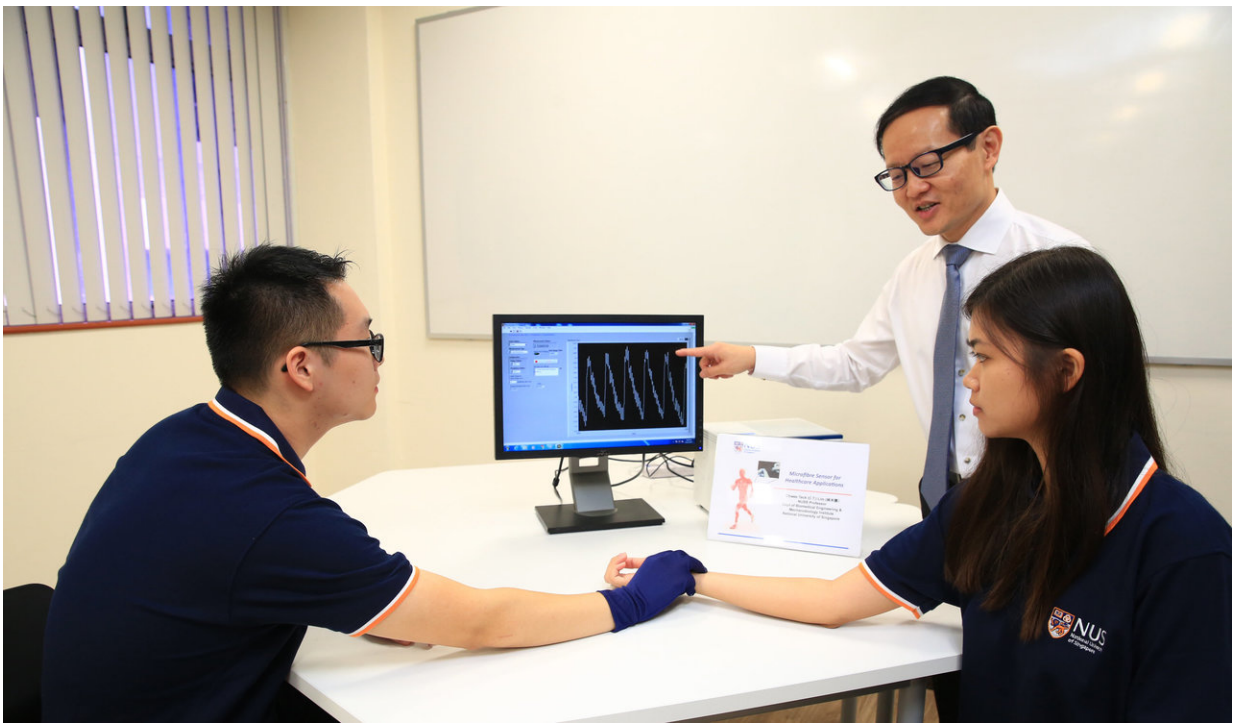
Researchers develop smart, ultra-thin microfibre sensor for real-time healthcare monitoring and diagnosis

November 16 2017



A research team led by Professor Lim Chwee Teck (standing) from the Department of Biomedical Engineering at NUS Faculty of Engineering has developed a soft, flexible and stretchable microfibre sensor for real-time healthcare monitoring and diagnosis. The sensor can measure pulse waveform in real-time, and the information can be used to determine one's heart rate, blood pressure and stiffness in blood vessels. Credit: National University of Singapore

A research team from National University of Singapore (NUS) has developed a soft, flexible and stretchable microfibre sensor for real-time healthcare monitoring and diagnosis. The novel sensor is highly sensitive and ultra-thin with a diameter of a strand of human hair. It is also simple and cost-effective to mass produce.

Wearable and flexible technology has gained significant interest in recent years, leading to tremendous progress in soft and wearable sensors. In tandem with this trend, microfluidic devices using conductive liquid metals have been increasingly employed as wearable pressure and strain sensors. However, current devices have various limitations - for instance, they may not fit well on the skin or are uncomfortable to wear.

"Our novel microfibre sensor can hardly be felt on the skin and conforms extremely well to skin curvatures. Despite being soft and tiny, the sensor is highly sensitive and it also has excellent electrical conductivity and mechanical deformability. We have applied the sensor for real-time monitoring of pulse waveform and bandage pressure. The results are very promising," said Professor Lim Chwee Teck from the Department of Biomedical Engineering at NUS Faculty of Engineering, who is the leader of the research team.

Real-time monitoring of pulse waveform

The smart microfibre sensor developed by the NUS Engineering team comprises a liquid metallic alloy, which serves as the sensing element, encapsulated within a soft silicone microtube. The sensor measures an individual's pulse waveform in real-time, and the information can be used to determine one's heart rate, blood pressure and stiffness in blood vessels.

"Currently, doctors will monitor vital signs like heart rate and blood pressure when patients visit clinics. This requires multiple equipment

such as heart rate and blood pressure monitors, which are often bulky and may not provide instantaneous feedback. As our sensor functions like a conductive thread, it can be easily woven into a glove which can be worn by doctors to track vital signs of patients in real-time. This approach offers convenience and saves time for healthcare workers, while patients can enjoy greater comfort," added Prof Lim.

The microfibre sensor could also be beneficial for patients suffering from atherosclerosis, which is the thickening and stiffening of the arteries caused by the accumulation of fatty streaks. Over time, these streaks accumulate into plaques which may completely block off blood flow or break apart, resulting in organ failure or may trigger a heart attack or stroke.

Existing methods of detecting plaque in blood vessels - such as computerised tomography scans and magnetic resonance imaging - would require expensive and bulky equipment. Such tests need to be done in hospitals by trained medical professionals.

As plaque will change the stiffness of the blood vessel and hence the pulse waveform, the novel sensor developed by the NUS Engineering team could be easily used to detect plaque before it accumulates to a size big enough to block or rupture the blood vessel.

Earlier this year, the NUS team published the development of the microfibre sensor and its application for pulse monitoring in scientific journals *Proceedings of the National Academy of Sciences* (PNAS) and Advanced Materials Technologies, respectively.

Bandage pressure monitoring

Another clinical application of the smart microfibre sensor is for the management of venous ulcers, which are caused by poor blood

circulation. They occur when the veins in the legs could not push blood back to the heart as well as they should. As blood pools in the veins, there is increased pressure in the veins, causing progressive skin damage over time.

Compression therapy is a common treatment for venous ulcer. Depending on the severity of the ulcers, bandages with varying amount of pressure have to be applied on the legs of patients for months to even a year. If the bandage is too tight, it could result in tissue damage, but if the bandage is too loose, the healing could be ineffective. Currently, healthcare workers tend to estimate the pressure in the bandage at the point of application, based on training and experience.

As the pressure provided by the bandage could change over time due to movements by the patient, accurate and continuous measurement of the bandage pressure in real-time is therefore important to ensure that healing takes place effectively.

Being ultra-thin and highly flexible, the NUS Engineering team's microfibre sensor can be easily woven into bandages to monitor the pressure that is being delivered and maintained. This could potentially improve the effectiveness of the treatment and reduce the time required for healing. In future, patients could also track the bandage pressure using an app, and the information could be shared with doctors who could remotely monitor the progress of the treatment.

The team is currently collaborating with the Singapore General Hospital to test the application of the microfibre sensor for bandage pressure monitoring.

Commercialisation and further research

"Our microfibre sensor is highly versatile, and could potentially be used

for a wide range of applications, including healthcare monitoring, smart medical prosthetic devices and artificial skins. Uniquely designed to be durable and washable, our novel invention is highly attractive for promising applications in the emerging field of wearable electronics," said Prof Lim.

The team has filed a patent for its smart microfibre sensor. Researchers are currently refining the sensor design and reducing the size of its accessories to improve the user-friendliness of the device. The NUS team had recently won the Most Innovative Award at the Engineering Medical Innovation Global Competition held in Taipei in September 2017.

While the NUS researchers continue to explore new applications of the microfibre sensor, they are also keen to work with commercial partners to bring their novel sensor to market.

More information: Wang Xi et al, Soft tubular microfluidics for 2D and 3D applications, *Proceedings of the National Academy of Sciences* (2017). DOI: 10.1073/pnas.1712195114

Provided by National University of Singapore