A tiny wire with a memory to diagnose cancer

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A nanowire can detect cancer. Credit: Thinkstock

EPFL researchers have used a nanowire to detect prostate cancer with greater accuracy than ever before. Their device is ten times more sensitive than any other biosensor available.

One indicator that a cancer has started to develop is the presence of biomarkers. These are molecules that are produced by the cancer and pass into the bloodstream.

Researchers at EPFL's Integrated Systems Laboratory (LSI/STI) have developed a new type of sensor that can detect tiny quantities of these markers and thus improve diagnostic accuracy. The sensor comes in the form of a tiny wire and is ten times more sensitive than any other biosensor ever realized. It is therefore capable of detecting cancer at a very early stage so that patients can receive better treatment. The researchers' work has been published in *Nano Letters*.

An electrical component with a memory

When doctors suspect that a patient has cancer, they look for biomarkers in their body. But it's not easy to detect these molecules in very small quantities – blood is a very dense fluid, full of molecules and cells that get in the way.

EPFL researchers have managed to get around this obstacle by inventing a new detection technique. The trick is to trap the molecules of interest by the blood sample and then detect them in a dry environment, where measurements won't be disturbed by all the molecules. To do this, the researchers used a Memristor – a new electrical component that can "remember" all the electrical currents that pass through it. The device has been successfully tested on the biomarker for prostate cancer, known as the Prostate Specific Antigen (PSA).

A nanowire, DNA fragments and an electric current

To begin with, fragments of modified DNA are grafted onto a silicon nanowire. The DNA is used to trap the molecules. It is modified so that it traps only the biomarkers for prostate cancer.

The wire is dipped into a cancer sample for close to an hour, giving the DNA time to get hold of the molecules. It is then dried and an electric

charge is first sent through it. If there are molecules on the wire, they create resistance, which alters the wire's conductivity in places. But this alone is not enough to accurately detect the biomarkers.

It is only when the same charge is sent through the wire a second time in the opposite direction that the molecules can be properly detected. "If the wire had no memory, the two currents' curves would be superimposed, which means there's no memory effect," said Sandro Carrara, from the Integrated Systems Lab.

If the right biomarkers are trapped at the wire surface, then at the exact spot where the current reverse during the phases of sending charges into the wire, there will be a difference in the curve known as a voltage gap. It is this phenomenon that makes it possible to detect the biomarkers with so high sensitivity together with the use of modified DNA to trap the biomarkers.

"It's the first time a Memristor has been used to make such type of biosensor," said Carrara.

For now, the technique has only been used to detect biomarkers for prostate cancer. But it could be used for all types of markers. "We are also working with the Ludwig Institute and the CHUV hospital, which are providing us with samples and tumor extracts. Our next step is to use the same technique to detect breast cancer."

More information: Ioulia Tzouvadaki et al. Label-Free Ultrasensitive Memristive Aptasensor, *Nano Letters* (2016). DOI: 10.1021/acs.nanolett.6b01648

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