Disposable 'lab-on-a-chip' may save costs and lives

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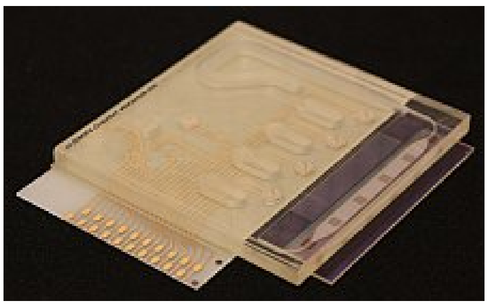

SEMOFS cartridge with sensor. Picture: SEMOFS Consortium

(PhysOrg.com) -- Low-cost, disposable cartridges that would let doctors perform diagnostic tests at the point-of-care could speed up diagnosis and treatment while lowering costs. European researchers are rapidly closing in on that goal.

Researchers in the European SEMOFS (Surface Enhanced Micro Optical Fluidic Systems) team knew that, to reach their goal of disposable cartridges capable of performing complex medical diagnostic tests quickly and at low cost, they would have to push existing technology to the limit.

“We are targeting state-of-the-art sensitivities or better,” says Jerôme Gavillet, the dissemination coordinator of SEMOFS, “in a system that could be available anywhere for less than €50.”

The team's goal is a polymer-based device the size of a credit card that would incorporate sophisticated technologies to control the movement of biological fluids, detect the presence of specific proteins, for example early signs of cancer, and analyse the results.

"For each patient, a physician would open the package, put some blood or serum on the card, let it work, and then connect it to a card reader," says Gavillet.

The relatively inexpensive card reader would display and record what the card had measured.

Advances in microfluidics and plasmonics

The EU-funded SEMOFS team says that it has made the greatest progress in two areas – microfluidics and plasmonics.

Microfluidics involves materials and techniques for controlling the movement of minute quantities of fluids. The SEMOFS card moves blood, serum and other fluids through channels slightly wider than a human hair.

In order to control the movement of biological fluids through such tiny channels imprinted into the polymer card, the researchers developed ways to make the surfaces of the channels 'super-hydrophyllic' or 'super-hyrdrophobic'.

Hydrophilic surfaces wet easily. Glass is hydrophilic, which is why a thin glass tube will draw water into itself via capillary action.

In contrast, hydrophobic surfaces like Teflon® repel water.

The SEMOFS researchers used nanotechnology to structure the interior surfaces of the device's channels to make them far more hydrophilic than glass or far more hydrophobic than Teflon®, as needed.

The super-hydrophilic channels guide the fluids to their destinations without the need for any kind of pump.

In contrast, small areas with super-hydrophobic surfaces act as valves, temporarily stopping the flow of a fluid until sufficient pressure is applied to force it through.

That added pressure comes from puffs of a hydrogen-oxygen gas mixture generated by an electric voltage directed to tiny chambers filled with a water-saturated polymer gel.

"When you have a meeting point of two, three, or many channels, you may want to have sequential managing of different liquids," says Gavillet. "It's like a railway – you make one train wait until another one has gone by."

Pushing plasmonic detection

Once the biological sample and the fluids necessary to process it have interacted in the proper sequence, the device uses plasmonics to determine if proteins from the sample have bonded to the detecting surfaces inside the card.

Plasmonics utilises the properties of the 'gas' or plasma of free electrons moving inside or along the surface of a conductor.

The electron gas inside the SEMOFS detector resonates at particular frequencies when it is stimulated by light. When proteins bond to antigens on the detector surface, their presence forces a slight change in that resonant frequency.

The researchers found that, by carefully engineering a stack of conductive and dielectric layers, topped by the layer primed to bond with the target protein, they could push the device's sensitivity beyond current limits.

"The final objective is to reach one picogram per square millimetre," says Gavillet, "i.e. to reach state-of-the-art sensitivity even on a low-cost disposable chip."

A picogram is one trillionth of a gram.

The final challenge the SEMOFS team faces is integrating the technologies they have honed into a single, easily reproduced card or cartridge.

They plan to pack everything – light sources and dectector, waveguides, and the microfluidic system – into one polymer-based card.

The electronics that will read the cards and display the results will be a separate unit.

They are working to finalise the card in the eight months before the project, funded by the European Commission's Sixth Framework Programme for research, comes to an end.

The researchers expect that the technologies they have refined and integrated will prove useful not just in clinics and doctors' offices, but in other areas where inexpensive but extremely sensitive detectors are needed.

"There's a market anywhere you want to probe a liquid or a gas," says Gavillet.

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