# From a lab-on-a-chip to an ink-jet printer

Acoustic waves promise to speed up blood tests, get ink to "jet" without a nozzle and deliver asthma drugs more effectively

Duncan Graham-Rowe

BY USING sound to manipulate biological samples on a "lab-on-a-chip", the dream of rapid – even on-the-spot – chemical analysis and diagnosis of disease has moved closer to reality.

The trick is to induce powerful acoustic waves in a droplet of your target sample on a chip by using something called surface acoustic waves or SAWs. These high-energy sound waves can be used to cause ripples in a piezoelectric material, which can transform voltage into mechanical movement or vice versa. In this case SAWs stimulate movements in fluids, which can be harnessed in various ways (see "Sound streams and good vibrations" and diagram below).

SAWs have already been deployed in other technologies, such as in the touchscreens of smartphones. They sense your finger by detecting disturbances in the SAWS, for example. However, recent research has pushed the field forward so acoustic waves are being used in a range of analytical tools.

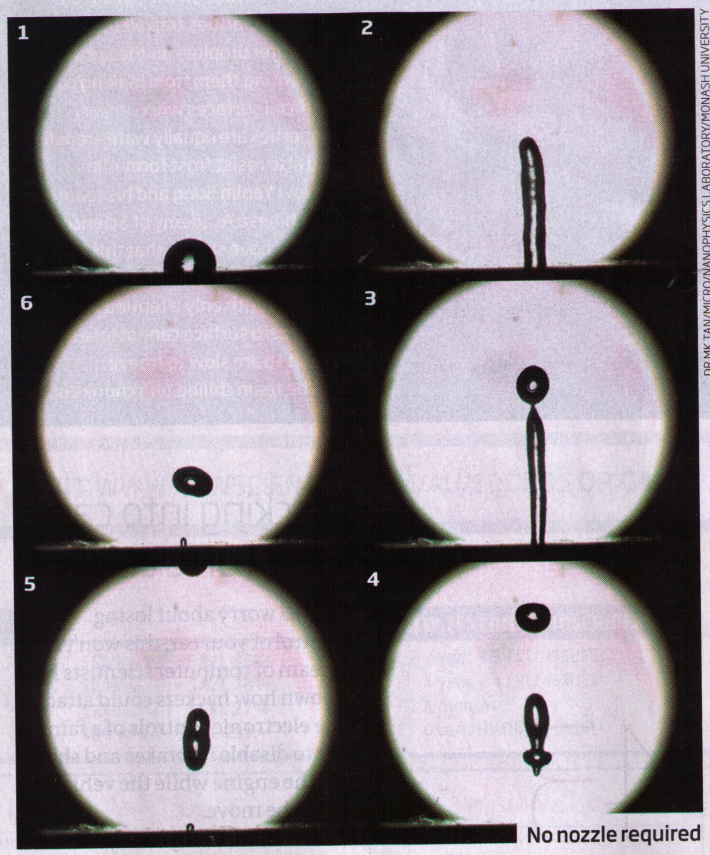
One of the first people to see the potential of SAWs in chemical analysis was Achim Wixforth of the University of Augsburg in Germany. When a low-intensity sound enters a fluid, it generates a compression wave, causing the substance's molecules to wobble backwards and forwards before settling back into their original position. At higher intensities, acoustic waves can cause the molecules in a fluid to move in a stream in the direction of the wave – a phenomenon called acoustic streaming. Wixforth demonstrated that acoustic streaming could be used to mix tiny quantities of biological fluids and went on to found a spin-off company called Advalytix.

Traditionally, to chemically test such samples, you would have to pump them into rows of wells containing reagents. Mixing sample and reagent is tricky when the quantities are minute, and diffusion is often your only option. Using SAWs to do the mixing can speed up the process as the fluids can be manipulated at will.

The polymerase chain reaction – the standard technique for amplifying genetic material for DNA sequencing and scanning – normally requires a process of repeated reaction cycles of gentle heating and cooling. Wixforth has shown that this effect can be achieved by repeatedly moving a sample droplet between heating elements on a chip, and using SAWs to speed up the reactions through mixing (*Lab on a Chip*, vol 5, p 308).

Mixing is just the start. By carefully controlling acoustic streaming within a droplet, it is also possible to move and filter droplets entirely on the same chip. Bombard drops with SAWs from multiple angles (see picture) and they can even be made to "jet", like the ink in an ink-jet printer but without the nozzles, says Leslie Yeo, a nanophysicist at Monash University in Clayton, Victoria, Australia.

Traditional microfluidic chips can also do these things, but only when hooked up to external pumps. Generating SAWS takes much less power. What's more the newer technique also has some extra tricks. If you focus the acoustic stream on the sides of a droplet you can also get it to rotate. Spin it hard enough and the droplet behaves like a centrifuge. This is extremely useful if you want to use your




DR MK TAN/MICRO/NANOPHYSICS LABORATORY/MONASH UNIVERSITY

No nozzle required

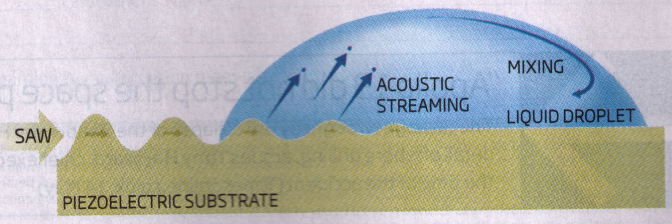
## All shook up

How surface acoustic waves (SAWs) could help speed up chemical analysis

Energy from the SAWs ripples across the substrate into the fluid

As the wave enters the droplet, it is deflected, causing molecules to stream forward

This acoustic streaming effect causes mixing



chip for blood tests, where the cells need to be separated from the plasma. "It's like a tornado," says Yeo. "Normally centrifuges take about 10 minutes, but this takes less than a second."

Besides blood tests Yeo is now carrying out research for Australia's Office of National Security as part of its counter-terrorism programme. The plan is to see if SAWs centrifuges and other approaches can safely be used to isolate and detect traces of pathogens, such as anthrax.

**"Spin the drop hard enough and it becomes a centrifuge, great for separating cells from plasma in blood tests"**

Meanwhile, Jon Cooper, a bioengineer at the University of Glasgow, UK, has been using SAWs to vaporise droplets. This is a key step in the preparation of samples for mass spectrometry. And it means that you don't need to add stabilising components to prevent a biological sample from being destroyed during the spectrometry process. With SAWS it is also easier to pinpoint trace elements because there are no stabilisers that might contaminate the sample.

Yeo is also studying the use of SAWs to convert liquids into fine sprays – nebulisation – for use in drug delivery. Asthma inhalers produce a range of different droplet sizes depending on how hard the user breathes in. Larger drops won't make it into deep lung tissue, while smaller ones may be exhaled, so only about 30 per cent of the drug reaches its target, says Yeo.

He has developed a prototype SAW nebulising chip, which he envisages could be incorporated into an inhaler that would allow a person to deliver the drug efficiently at the push of a button. A nebulising chip would boost the effective dosage to 80 per cent by adjusting SAWs to produce droplets approximately 3 micrometres in diameter. Yeo says this is the ideal droplet size for delivering the drugs into the lungs (*Lab on a Chip*, vol 9, p 2184).

While SAWs have so far only been used in a handful of chemical analysis technologies, the advances made by Yeo and other researchers suggest that more complex devices are on their way. Lab technicians won't need to hang up their white coats quite yet, but they are likely to find that their job entails less time indoors. ■

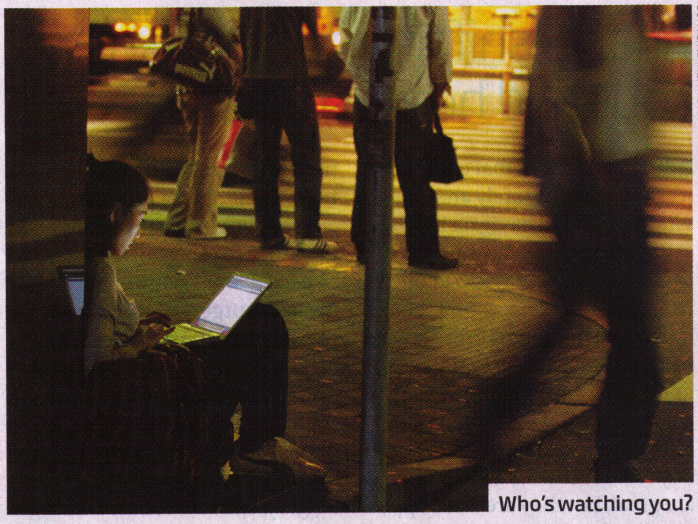
## Sound streams and good vibrations

Piezoelectric materials such as lithium niobate transform electrical energy into mechanical energy, vibrating when an alternating voltage is applied to them. When a pair of comb-shaped electrodes are placed on this material, interleaved so that they don't touch, they create a shallow electric field, localising the vibrations to a small patch of the surface of the material.

This causes an intense acoustic ripple to propagate across the plane of the surface. When this comes into contact with a droplet sitting on the surface of the material the energy is absorbed by the fluid. Because sound travels faster through solids than liquids, the wave is deflected into the droplet.

Although this energy dissipates quickly, at frequencies of around 10 megahertz it causes an effect called acoustic streaming. Instead of just creating compressive waves, it forces molecules forward to form a stream within the droplet.

Depending on the position, size and direction of these flows, they can create pressure variations sufficient to move, mix or spin the droplet. And if the intensity is increased further the droplet can be made to "jet", squirting off the surface like a nozzle-less ink-jet printer, or even vaporised.



MARK HENLEY/PANOS

Who's watching you?

# Your identity revealed by the social networks you sign up to

WHEN you sign up to a membership group on a social networking site you may be revealing more than you bargained for. An experimental website has managed to identify the names of people who visit it, by harvesting information about the groups they belong to. It's a trick marketing teams and scammers would love to copy.

The snooping site exploits the fact that your web browser keeps track of which web addresses you have visited. Website owners can glean this information by hiding a list of web addresses in the code for their web page. When someone accesses this page, their browser will tell the website owner which of the hidden addresses they have already visited.

Membership groups within social networks have distinct web addresses: the *New Scientist* group on Facebook, for example, is accessed via www.facebook.com/newscientist. What's more, the names of group members are publicly available. Gilbert Wondracek at the Vienna University of Technology in Austria, and his colleagues, collected data on 6500 groups, containing 1.8 million users, on Xing, a business-oriented social network based in Hamburg, Germany. After analysing the overlap between membership lists they estimated that 42 per cent of users could be uniquely identified by the groups they visit.

The researchers then built a website that read visitors' history of browsing Xing addresses. When they asked 26 friends and colleagues who use Xing to try it, they were able to identify 15 of them. Wondracek's paper showing how this was done was presented at the IEEE Symposium on Security and Privacy in Oakland, California, this week.

Since Wondracek's experiment, Xing has started adding random numbers to the addresses used to access its membership groups. The Xing server ignores the extra numbers, but they confuse attacks by a site like Wondracek's.

Arvind Narayanan, a computer scientist at Stanford University in California, fears that this may not be enough to fend off similar attacks, especially if they use multiple social networks and other websites that host membership groups. It is unlikely that all such sites will use random characters to mask addresses, he points out. Jim Giles ■

**"Your browser will tell the website owner's server which addresses it has accessed in the past"**