Short Research Visit
Cardiff University
16th to 19th September 2019
By Sadaf Marami

Title: Experimental study of interaction between SAW, fluid and particles in a microchannel flow

Aim: The ultimate aim of this short research visit was to investigate how the surface acoustic waves affect the fluid and particles in a continuous flow in a microchannel under normal and pulsed surface acoustic wave (SAW) generation.

Introduction: Introducing SAWs in microfluidic set ups can change the behaviour of the fluid flowing in the microchannel and microparticles suspended in it. The two main effects of a SAW field on fluid-microparticle mixture are acoustic streaming which affects both fluid and microparticles and acoustic radiation which only affect microparticles. The dominant force for each microparticle depends on density and size of each micro-particle. Using the interaction between SAWs, fluid flow microparticles' movement can provide a tool to manipulate and control the fluid and micro-particles.

Short Research Visit: In the beginning we used a microchannel mask polydimethylsiloxane (PDMS) microchannels. Figure 1 shows the microchannel mask and uncut PDMS microchannels. Then we cut the microchannel and punched holes in the places of the inlet and outlet.

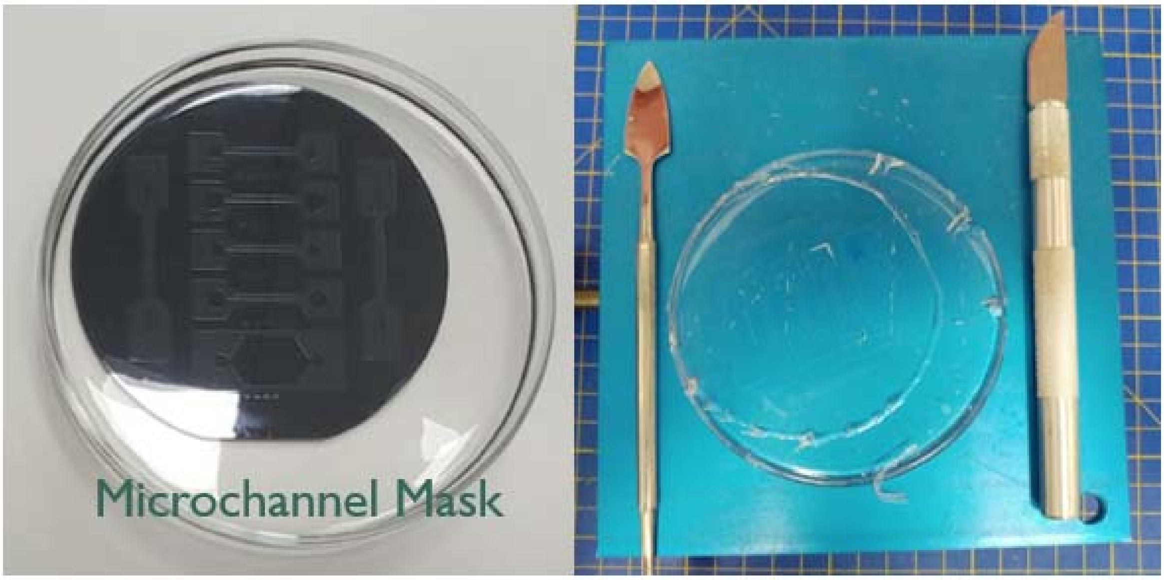

Figure 1 Microchannel mask and uncut PDMS microchannels.

Then we designed and 3D printed a jig to fit our SAW sample and the connector for the signal generator cables. After that we designed and 3D printed the parts needed to fix and press the PDMS microchannel on the SAW device. The SAW device for this experiment was comprised of the following:

1. A Zinc Oxide (ZnO) on Aluminium (AL) surface acoustic wave sample with two working nearly identical interdigital transducers (IDTs).
2. A polydimethylsiloxane (PDMS) microchannel with one inlet ant one outlet.
3. Connector and tubing for the inlet and outlet to be connected to the syringe pump.
4. A heat sink used as a base.
5. A 3D printed jig, three 3D printed parts and one clear plastic part to keep the microchannel in place and bound it to the SAW sample using pressure.

Figure 2 shows the SAW device and its components.

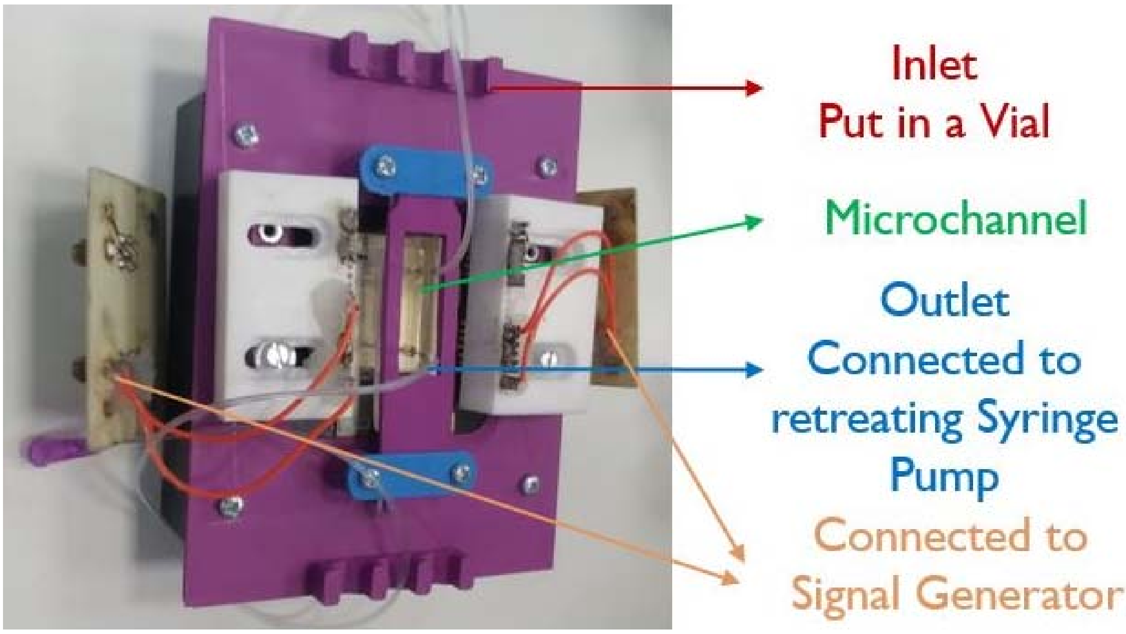

Figure 2 SAW device and its holder.

In the next step we connected the SAW device to the network analyser to measure and analyse the device's s-parameter and the device's working frequency.

After that we established the experimental setup. The experimental setup for this research to study the effect of acoustic waves on the micro-particles includes the following:

1. The SAW device.
2. A RF signal generator to set the input power and frequency of the SAW.
3. A syringe pump to make the fluid-microparticle mixture flow in the microchannel.
4. A microscope to observe the tracks of the microparticles.
5. A mobile phone to capture videos of the microscope output.

The tunings were added to connect the microchannel to the syringe pump. The RF signal generator is connected to the SAW device to power it. The device is placed under the microscope zoomed in to get a clear view of the experiment. Figure 3 shows the experimental setup.

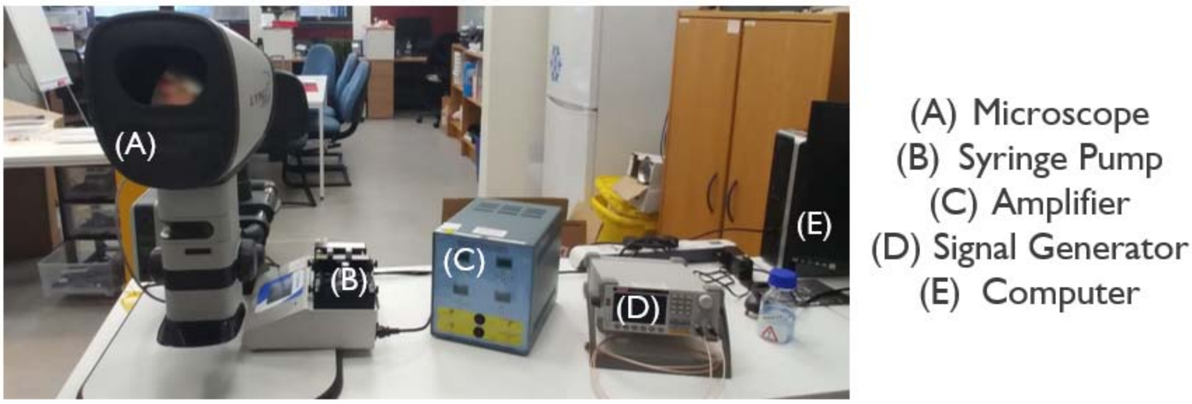

Figure 3 Experimental setup.

Afterwards we filled the microchannel with the fluid-microparticle mixture to see if there is any leakage and turned the signal generator on to observe microparticle patterning. Then we kept the pump running to have a continuous flow and watched as the SAW was applied the microparticles start to move in lines corresponding to the pressure node lines.

We tried to fix a mobile phone in front of the microscope to capture videos but the quality was undesirable. Figure 4 shows a photo captured by a mobile phone from the microscope.

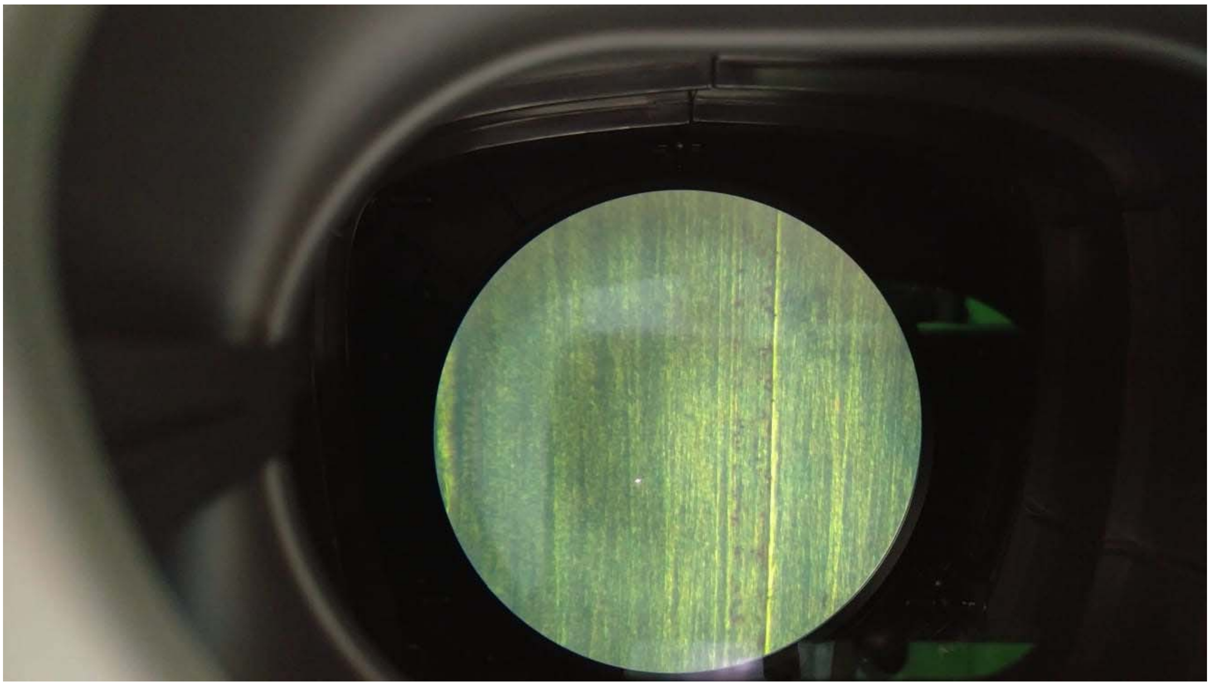

Figure 4 A photo captured by a mobile phone from the microscope.

Outcome: We were successful in making proper PDMS microchannels as well as designing a jig and SAW device setup to do the experiments. We observed the fluid-microparticle mixture filling the microchannel without flowing under the microscope and watched as the signal generator was turned on the particles patterned on the pressure node lines. After that we ran the pump to introduce the flow and we were able to run the flow without any leakage for seconds. Also we observed the microparticles moving in lines corresponding to the pressure node lines mixture under the microscope as the signal generator was turned on.

Future works: Using the jig and the SAW device setup we created at Cardiff University, I plan to continue to do the experiments back at Northumbria University and I will stay in touch with Cardiff University about the progress and results of the experiments.
The steps I plan to take to continue the work are as follows:

1. Run the fluid-microparticle mixture flow in microchannel without leakage.
2. Apply normal SAW to the problem to study the interaction.
3. Apply pulsed SAW to the problem to study the interaction.
4. Study the difference between using normal and pulsed SAW.
5. Simulate the two cases in 3D and compare the experimental data with the 3D simulation results.

The experiments will be done to study the effects of various parameters such as different wave power and wavelength, different particle size, different fluid properties and different microchannel geometries.

Short Research Visit
Cardiff University 9th Acoustofludics SIG Meeting
16th to 17th October 2019
By Sadaf Marami

Title: Numerical & Experimental Study of Acoustic Streaming in a Microchannel

Aim: The aim of this presentation was experimental and numerical study of acoustic streaming effects on fluid and micro-particles caused by TSAW and SSAW inside a micro-channel and also numerical study of mixing of liquids caused by acoustic streaming inside a micro-channel.

Introduction: Introducing SAWs in microfluidic set ups can change the behaviour of the fluid flowing in the microchannel and microparticles suspended in it. The two main effects of a SAW field on fluid-microparticle mixture are acoustic streaming which affects both fluid and microparticles and acoustic radiation which only affect microparticles. The dominant force for each microparticle depends on density and size of each micro-particle. Using the interaction between SAWs, fluid flow microparticles' movement can provide a tool to manipulate and control the fluid and micro-particles.

Presentation: After introducing the theory and governing equations, the experimental set up and simulation method were presented. Then the experimental and numerical results showing the effects of SAW on fluid and microparticles inside a microchannel was presented.
Figures 5, 6, 7 and 8 shows some of the experimental and numerical results.

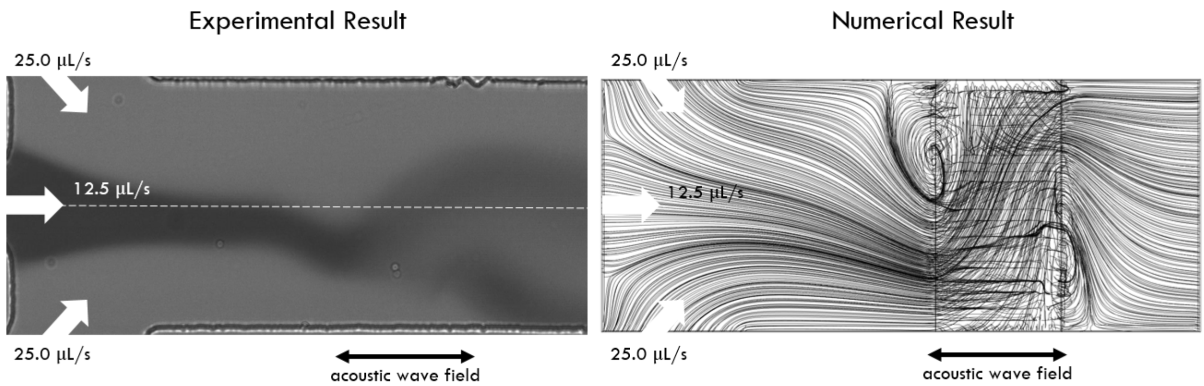

Figure 5 Experimental and numerical results of dyed water for TSAW with Power = 50.12 mWatt.

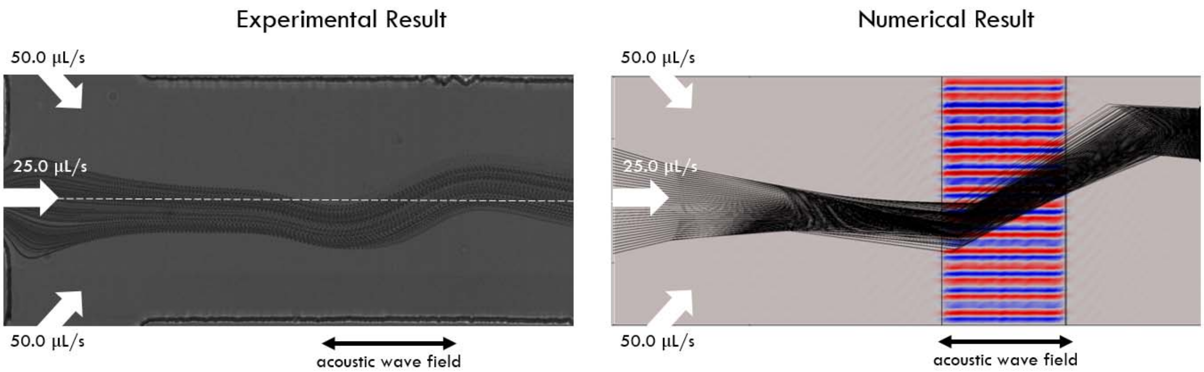

Figure 6 Experimental and numerical results of 1 micron microparticles for TSAW with Power = 50.12 mWatt.

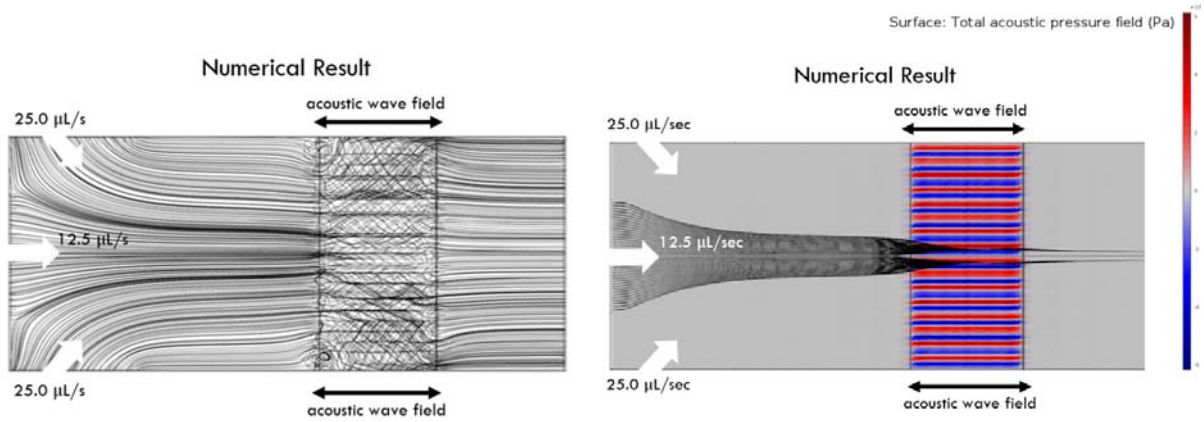

Figure 7 Numerical results of water (left) and microparticles (right) for SSAW with Power = 7.94 mWatt.

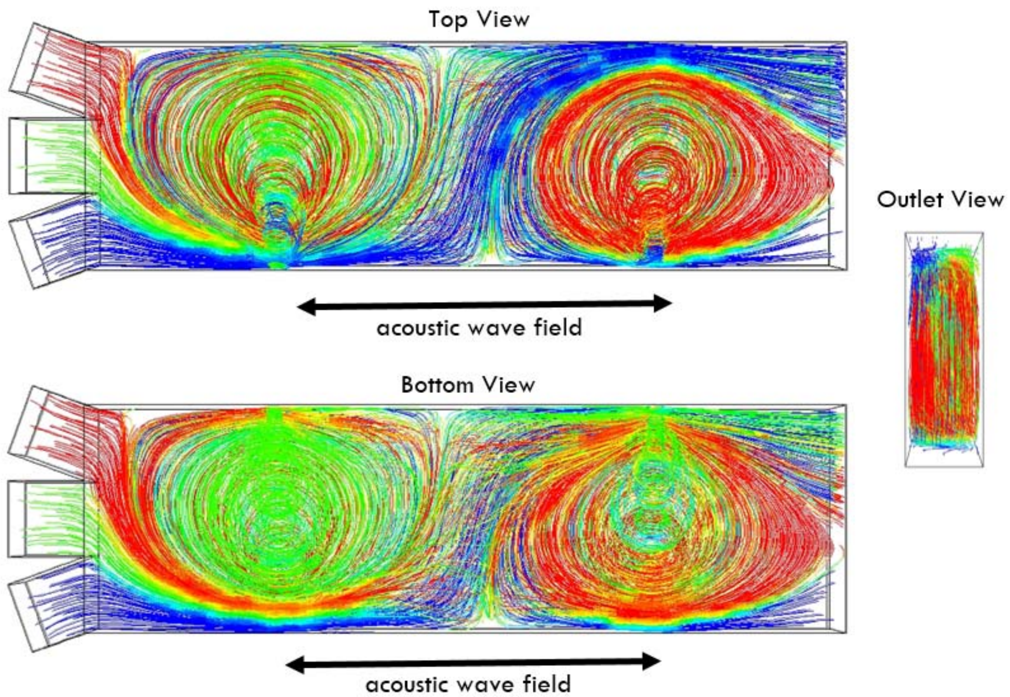

Figure 8 Numerical results for TSAW mixing three fluids with Power = 430 mWatt.

Future works: I plan to continue to study the effects of SAW and acoustic streaming inside microchannels both do the experimentally and numerically.

The steps I plan to take to continue the work are as follows:

1. Doing experimental work to study acoustic streaming caused by TSAW and SSAW and compare the data with the simulation results.
2. Doing experimental work to study mixing of liquids caused by acoustic streaming and compare the data with the simulation results.
3. Doing experimental work to study acoustic radiation on micro-particles & compare the data with the simulation results.