Thin film Induced Surface Acoustic Wave actuated Microfluidics for Lab-on-chip applications.

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Abstract
We have deposited piezoelectric Zinc Oxide (ZnO) and Aluminum Nitride (AlN) thin film materials on Silicon substrates[1,2] to generate surface acoustic wave (SAW) for lab-on-chip microfluidics applications. Thin film based SAWs and their interactions with particles/fluids have been modelled and experimentally characterized.

Experimental work on microdroplets showed that there are prospects for lab on chip integration on one integrated circuit board ICs along with their power supply electronics which could result in commercially low cost and enabled to fit in device mass production lines. Increasing the applied power from 1.0 dBm to 10 dBm in a device operating at 70.35 MHz frequency showed that streaming, pumping, jetting and nebulization could be achieved for a droplet of volume one micron litre. Biological experiments on the thin film SAW devices has been carried out for cell alignment, sorting and in-vitro microbiomanuplation using Jurkat cells and 1 to 10 micron diameter size UPVC polymer beads.

FEM simulations using Comsol Multiphysics software were performed in order to understand the vibration behaviour of piezoelectric films on substrates. Modal analysis of surface acoustic waves showed that increasing the wavelength of SAW (in the range 64 microns up to 800 microns) and the thin film thickness (from 500 nm to 10 microns) would change the operating frequency by 20 times on a 100 MHz scale and the wave mode as well. Rayleigh waves or Lamb waves can be produced, depending on optimization of the device design and fabrication.

Figure 1: a.Vibrational Mode for the 11.8 MHz of a 5 μm ZnO/ SiO SAW, b. Vibrational Mode for the 11.8 MHz of a 5 μm ZnO/ SiO SAW

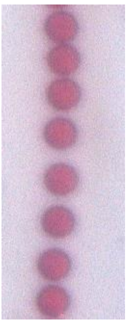

Figure 3: μBeads Alignment(10μ diameter).

Figure 4: μDroplet Jetting.

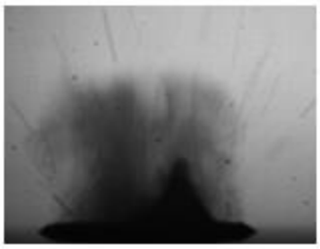

Figure 5: μDroplet Nebulization.

[1] Leslie Y. Yeo and James R. Friend, Surface Acoustic Wave Microfluidics, Annual Review Fluid Mechanics. 2014. Volume 46: Pages 379–406.

[2] J. Zhou, M.DeMiguel-Ramosd, L.Garcia-Gancedoe, E.Iborrad, J.Olivaresd, H.Jina, J.K. Luo, A.S.Elhady, S.R.Donga, D.M.Wang, Y.Q.Fu, Characterisation of aluminium nitride films and surface acoustic wave devices for microfluidic applications, Sensors and Actuators B: Chemical 202, 2014, Pages 984–992.