Final report on: Replacing glued-on PZT with ZnO transducers to overcome a sticking point in the development of 1-3 MHz acoustofluidic chambers

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Our ambitious plan for the project was to show that the usual workhorse for ultrasound generation, PZT (Lead zirconate titanate), could be replaced by thick film ZnO-coated interdigitated electrodes (IDEs) in our general purpose acoustofluidic device.

PZT plates are a hard ceramic: the flexing is microscopic and the forces are large. The fundamental resonance of PZT is dependent on the plate thickness (2 mm plates resonate near 1 MHz). ZnO films can be sputtered onto a wide range of materials – we used a polyamide sheet. These flexible devices have a set of IDEs to one side which sends a SAW wave across the ZnO/polyamide bi-layer. The repeat distance for the IDE electrode-plus-gap is the main factor determining the fundamental frequency: at 1 MHz it is ~ 1 mm. Usually ZnO devices are manufactured to operate at 10-100 MHz, but fortunately Richard Fu's lab had a 1.37 MHz ZnO device, which we compared to my 1 MHz PZT. Our test system was a microscope slide with a cover-slip 0.75 mm above its surface. The gap was filled with suspensions of particles ranging from 1 µm to 10 µm diameter.

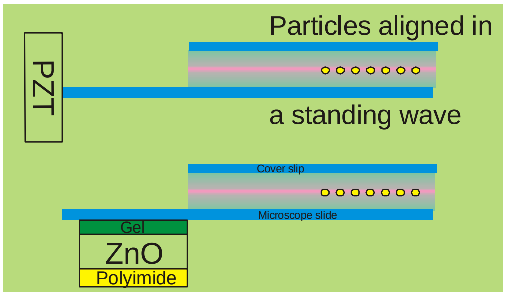

Figure 1 *Connection methods: Transverse and thickness direction connections were used with both the PZT and ZnO drives.*

The slide was made to vibrate by connecting it to either PZT or ZnO drives. Two connection methods were tested with both drives: 1/ Direct connection through the end of the slide. We did not expect that the ZnO device would be able to generate enough force for this configuration. 2/ Using a coupling gel through to the slide face (Figure 1). When the sound was turned on, particles of all sizes formed clumps within 10 s. When the frequency was increased from 1 to 14 MHz the clumps became smaller and closer together.

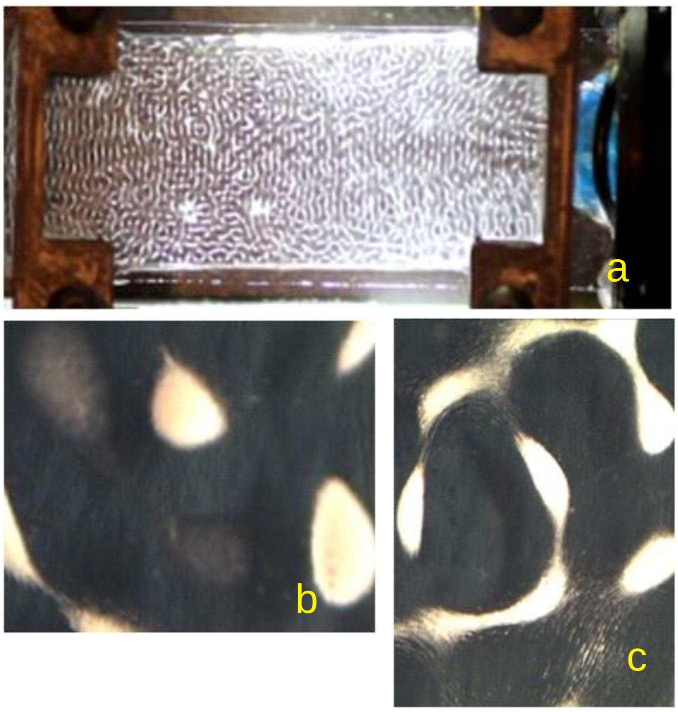

Figure 2 *Views of particle suspensions from above: clumps of 6 µm diameter Si particles, formed at ~1 MHz. a) View of whole cover slip. b) Two layers of clumps form; one on the lower surface and one of "levitated" clumps in the bulk fluid (in shadow). c) At high magnification some fine details of particles aligned on field lines are seen in the surface clumps (not usually seen clearly in water based acoustofluidics experiments).*

Bottom line: Results were much better than we expected, we could not tell the difference between systems using PZT and ZnO drives.