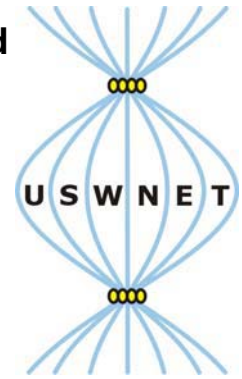


Two dimensional acoustic standing wave fields in open and closed systems

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Introduction

In *micro total analysis* systems the physical handling of micron sized particles (e.g. coated beads, cells) is often a necessary step in addition to the actual biochemical analysis. The use of acoustic forces has revealed itself to be a valid solution. Most acoustic devices are operated in flow-through mode [1-3], where suspended particles are concentrated into parallel planes in one dimensional standing pressure fields while they are flowing down a channel. Some applications, however, require operation in batch mode. For instance, when prolonged observation of the sample or when drug screening has to be performed, particles or cells need to be trapped at specific locations. On the other hand, in the field of planar microfluidics, once a chemical reaction has taken place by mixing the fluid with suspended coated beads, these could be extracted from the fluid by concentrating them in the middle of a droplet and then removed by means of a pipette or through an orifice. Both of these applications require two dimensional positioning of the sample itself (assuming the sample sits on the bottom of a channel in the third direction).

Method

The excitation of two dimensional acoustic fields relies on constraints set by the fluidic cavity geometry or on the superposition of fields acting in different directions. In the case of a rectangular chamber, resonances are set up in each direction at different frequencies and hence full plate actuation using the sum of two signals would suffice to gather suspended particles into circular clumps at the intersection of the lines that would be formed by the one dimensional standing pressure fields. However, it is preferable to have a method which is independent of the cavity geometry, and which can be applied for instance to a square chamber. This can be achieved by having displacement fields in the solid structure containing the fluid cavity, which couple to the fluid in different directions. A method to do this consists in the use of different transducers [4] to excite resonances in different directions. Another method is discussed here, which is based on the excitation of displacement fields on the same piezoelectric plate, by the activation of different areas, defined on the transducer surface in form of stripes. This method is particularly suited for systems of reduced size [5], as it permits to have the actuation exactly where needed, by keeping the heat generation at low level.

Results

The piezoelectric transducers can be operated to produce desired pressure fields in the fluid. Here we complete the set of strategies described previously [6] with the addition of a new one, in which the electrodes are excited individually but alternately. As the force fields resulting from each electrode are not created concurrently, the resulting overall force field can be found by a further time average of these two individual force fields. Hence the particles will be collected at the areas in which both force fields have potential minima, or rather as close to that as possible given volumetric restraints. This method has been used for the creation of two dimensional arrays in a

rectangular chamber (5 x 5.9 x 0.2 mm). At 2210 kHz (z-direction) and 2750 (x-direction), respectively, both one dimensional standing pressure fields have the same wavelength and hence the lines intersect in a regular square grid when switching is done.

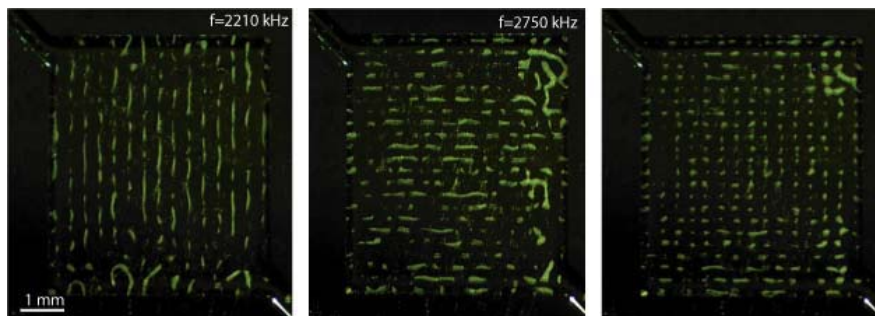


Fig. 1 Creation of two dimensional patterns in a rectangular chamber by the alternate excitation of two orthogonally oriented electrodes at different frequencies. The first two pictures show the one dimensional standing pressure fields, whereas the third one depicts the resulting two dimensional pattern when switching is performed.

Furthermore, this method has been used for the concentration of 16 μm particles at the centre of a droplet (diameter 3 mm) deposited on a glass surface excited by a piezoelectric transducer located beneath it [7]. Firstly the electrode which runs along the horizontal axis of the image is activated, and a line formed (a), then the signal is switched to the orthogonal electrode and a line is formed approximately parallel to the vertical axis of the image (b) already this line is shorter than the first formed. The switching is repeated twice more, in order to form a clump of particles at the centre of the droplet (d).

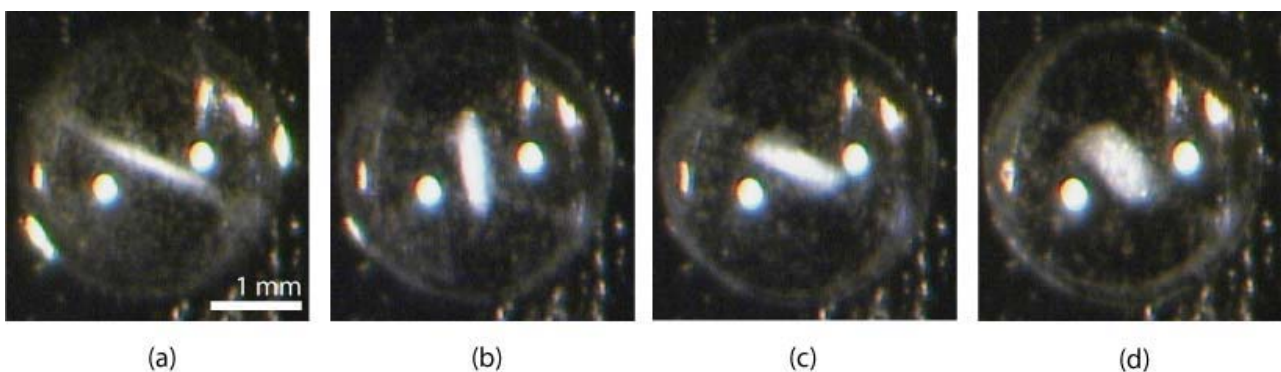


Fig. 2 Concentration process of 16 μm particles in a droplet by alternatively exciting single electrodes. Particles align approximately parallel to the excited electrode. It can be seen in moving from (a) to (b) that the particles in the broad ends of the line are pulled into the centre of the droplet when the switch occurs, hence a higher proportion of the particles are held in this single location. The two bright dots are the reflections of the lamp on the droplet surface

Conclusions

Different strategies for the excitation of two dimensional pressure fields by the use of a single transducer have been reviewed here and their application on different systems has been shown.

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