Microbubble Symposium:
Fabrication, Characterisation and Translational Applications

17th & 18th July 2013

Weetwood Hall, Otley Road, Headingley, Leeds LS16 5PS
Title: Acoustic bubble sorting of ultrasound contrast agents

Abstract:
Ultrasound contrast agents resonate to the driving pressure pulse transmitted by the clinical ultrasound system. These systems operate at a narrow bandwidth optimized for the ultrasound transducer. Due to the large size distribution of commercially available UCA only a small selection of bubbles contribute to the echo signal. Thus the sensitivity in diagnostic imaging can be improved by narrowing down the size distribution. We present a novel lab-on-a-chip bubble-sorting method based on the acoustic forcing of microbubbles. A bubble in a traveling pressure wave experiences a net acoustic radiation force that pushes the bubble in the direction of wave propagation. The magnitude of the radiation force is bubble size-dependent through resonance; bubbles close to resonance experience the largest force\(^1\). We use this acoustic radiation force to sort bubbles in a microfluidic channel made in polydimethylsiloxane (PDMS) with an embedded piezo transducer.

We quantify the physical parameter space of the bubble-sorting device first by scaling up the problem by one order of magnitude to minimize the effects of diffraction and Mie scattering typically experienced in contrast bubble sizing\(^2\). We do this by connecting a flow focusing geometry to the sorting channel to produce and sort bubbles in a 12 – 25 µm size range (Fig 1A).

Next, we connect a smaller flow focusing geometry to the inlet of the sorting channel and show that sorting of bubbles with sizes similar to those of UCA is feasible, see Fig. 1B. Finally, we show that UCA bubbles can be sorted with this novel sorting strategy, see Fig. 1C. We focus them hydrodynamically between two co-flows to produce a bubble train with large enough spacing between the bubbles to minimize bubble-bubble interactions. We find good agreement for the resonance behavior predicted by the Marmottant\(^3\) model coupled to a translation equation with the instantaneous radiation force, the drag force and the added mass force. Typical shell parameters adapted from literature were used\(^4\).

Parallelization of this novel sorting method may lead to an overall improvement of the sensitivity of contrast-enhanced medical ultrasound by at least an order of magnitude.

Figure 1 Figures A, B, and C show the resonance curves as where measured during the sorting experiments with the different bubbles. The red line shows the modeled resonance curve.

References: