Improved positioning and detectability of microparticles in droplet microfluidics using two-dimensional acoustophoresis

We have fabricated a silicon-glass two-phase droplet microfluidic system capable of generating sub 100 μm-sized, \( \varphi = (74 \pm 2) \) μm, spherical droplets at rates of up to hundreds of hertz. By implementing a two-dimensional (2D) acoustophoresis particle-positioning method, we show a fourfold improvement in both vertical and lateral particle positioning inside the droplets compared to unactuated operation. The efficiency of the system has been optimized by incorporating aluminum matching layers in the transducer design permitting biocompatible operational temperatures (<37 °C). Furthermore, by using acoustic actuation, (99.8 ± 0.4)% of all encapsulated microparticles can be detected compared to only (79.0 ± 5.1)% for unactuated operation. In our experiments we observed a strong ordering of the microparticles in distinct patterns within the droplet when using 2D acoustophoresis; to explain the origin of these patterns we simulated numerically the fluid flow inside the droplets and compared with the experimental findings.