An Integrated Automatic Microfluidic System for Simultaneous Multichannel Emulsification in BEAMing Digital PCR Technology

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1. Introduction:
For highly sensitive detection and quantification of mutant DNA molecules, BEAMing Digital PCR technology has been developed by combining emulsion PCR with magnetic beads and flow cytometry. A microfluidic system was then proposed by our team to improve the operation efficiency and results robustness of BEAMing processes. As one essential process of microfluidic BEAMing, an integrated automatic system for simultaneous multichannel emulsification was constructed by this work for large-scale clinical application.

2. Experiments and Methods
As shown in Figure 1a, a multichannel chip has been developed for emulsification of DNA samples. A flow controlling unit was employed to drive DNA samples and buffer solution through the micro channel chip. Air pressure and flow rate of the system were programmed with high precision and fast response. With the help of flow resistor and feedback signals from flow sensors, flow rate of sample solution and buffer reagent were controlled separately and stably in all micro channels. The applied flow rate ranged from 0.1 μl/min to 5 μl/min in our experiments.

3. Results and Discussion
Using the automatic system, emulsification has been accomplished simultaneously in 6 micro channels with few satellite droplets, emulsification monitoring graphs of which are given in Figure 1b. Diameters of generated emulsion droplets were found to be evenly distributed (Figure 1c) with CV of less than 10%. The obtained results enable efficient and homogenous emulsification in multi channels simultaneously, which will further accelerate the application of microfluidic BEAMing system in large-scale clinical application.

Figure 1 Integrated automatic emulsification system, a: controlling mechanism; b: monitoring graphs of simultaneous emulsification; c: distribution of generated droplet size.