Digital microfluidics using pressure driven flow

Making droplet in capillary or microfluidic device often met two problems:

- Droplet need an **equilibration time to become stable in size**
- **Droplet size oscillates** depending on the imposed flow rate and the materials used

These effects are due to the combination between flow rates driven flow and elasticity of materials (tubing, syringe, device...). **Those problems can be overcome using pressure driven flow instead of syringe pump since pressure driven flow do not oscillate and shift almost instantaneously.**

Most of the researcher actually use syringe pump since pressure regulator need installation of comprimed air line or air compressor. For this reason we now propose intuitive and stand-alone instrument which both generate pressure and regulate it with precision as low as 100µbar.

As an example, the image below shows a simple droplet generator setup using pressure driven flow. It shows the fast response of droplets size to pressure driven flow instruction change. Six seconds after pressure instruction change ($P_{\text{water}}$ from 80mbar to 90 mbar) droplets size have changed and form another homogenous train of drops:

Why droplet size and speed oscillate when using a syringe pump to control flow?

The step motor which allows the rotation of the infinite screw of the syringe pump produces periodic vibration. Those vibrations are transmitted to the syringe piston translation and then generate periodic variation of the flow rate. Those periodic variations of the flow rate induce variation in size and displacement speed of the droplets.

Contrary to syringe pump pressure generator do not generate vibration since pressure is regulated through a pressure controller.
Why droplet generation needs equilibration time to become stable when changing flow rate of the syringe pump?

When changing the flow rate of your syringe pump the pressure in the device slowly change. The increase of pressure is partly is absorbed by deformation of the fluidic system (syringe, tube, device...). Then flow rates in the capillary stabilize only after complete deformation of the fluidic system. Depending of the system elasticity and the flow rate, the stabilization can take several minutes or hours.

With pressure driven flow the pressure almost instantaneously changes all over the fluidic system leading to almost instantaneous stabilization of the flow rate and droplet uniformity.

Another solution to decrease the stabilization time of the flow when using syringe pump is to decrease the elasticity of the fluidic system. For example you can use glass syringe and glass capillary. This method reduce the stabilization time of the flow rate since fluidic system have lower elasticity but increase the oscillating effect of the syringe pump on the flow rate since the fluidic system do not act anymore as a fluidic low-pass filter.

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