High throughput microfluidic glass devices to form functional materials

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High-throughput production of monodisperse droplets is essential for industrial and scientific applications, such as in the fields of diagnostics, pharmaceutics, cosmetics, materials, and food science. In order to increase the throughput of microfluidic devices, parallelization of a large number of droplet makers is needed. However, up to now, such parallelized devices are limited by either their complicated channel geometry or by their chemically or thermally unstable embedding material.

Here we show a novel, scalable microfluidic step emulsification chip in glass with 364 linearly parallelized droplet makers. The geometry of this device consists of two 120 µm deep channels, which are connected through an array of linearly-ordered 20 µm high nozzles with wedge-shaped droplet makers (Fig. 1) [1]. In this design, the droplets are formed at the step between each nozzle and the continuous phase channel [2-3]. Our microfluidic glass devices are produced using a simple and efficient technique comprising photolithographic, etching, and bonding steps.

The device enables the production of emulsions at a throughput of up to 25 ml/h with a coefficient of variation lower than 3 %. The chemical stability of glass as embedding material allows for the production of a broad variety of functional materials by using any desired solvent together with nanoparticles, polymers, and hydrogels. In addition, the thermal stability of glass enables emulsification at higher temperatures, which opens the possibility to produce microparticles of materials that are solid at room temperature or to increase the throughput by lowering the viscosity (Fig. 2). Moreover, the microfluidic device can be stringently cleaned and recycled through chemical treatment or by heating of the glass chip to 600 °C. This provides the ability to renew our microfluidic device for nearly unlimited use. All in all, the combined benefits of our microfluidic chip facilitate the production of a broad variety of new materials at high throughput.

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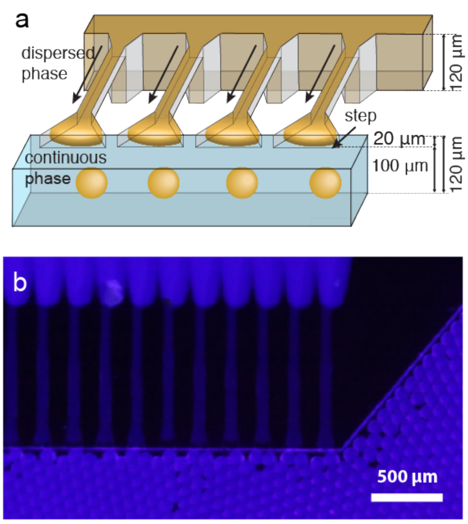

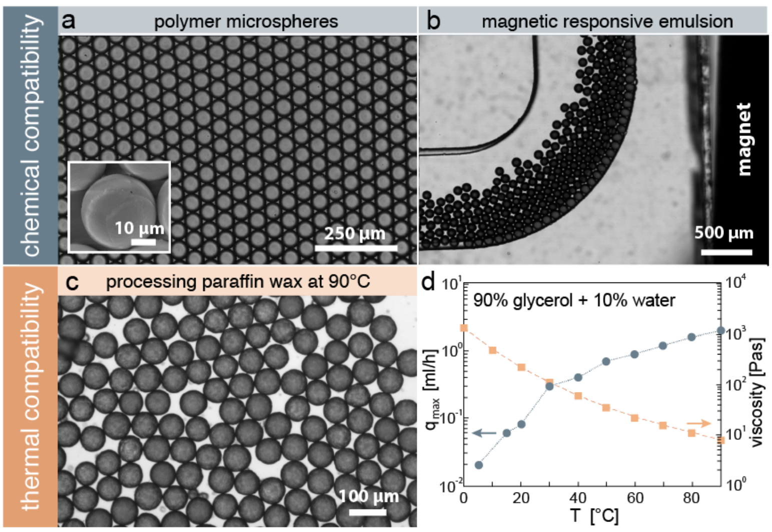

Fig. 1 (left): Schematic of a step emulsification channel arranged with parallelized droplet makers (a) and an actually working device producing monodisperse oil-in-water droplets (b).
Fig. 2 (right): Functional emulsions and microparticles generated in chemically (a,b) and thermally (c,d) compatible microfluidic glass chips.