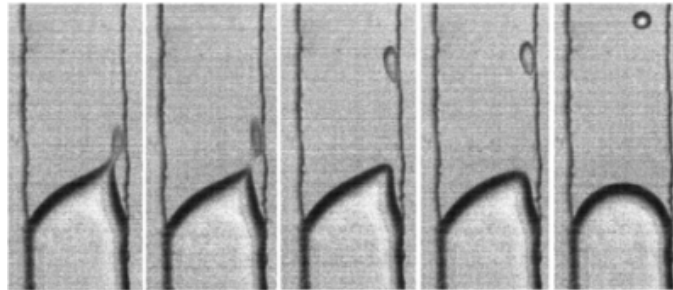


# Electric field induced production and manipulation of droplets in microchannels



Nano- and  
Microfluidics



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Workshop Kleine Volumenströme in der Medizintechnik  
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## Outline

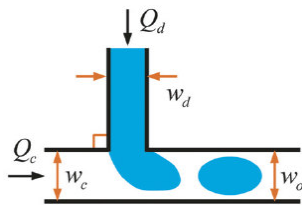


- A brief overview on droplet generation methods
- Results
  - Droplet generation on demand
  - Manipulation of on-demand generated droplets
- Summary and conclusions

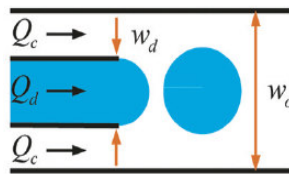
2



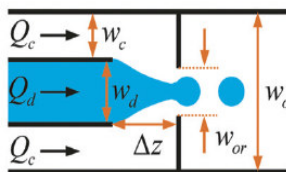
# Common device geometries for droplet generation



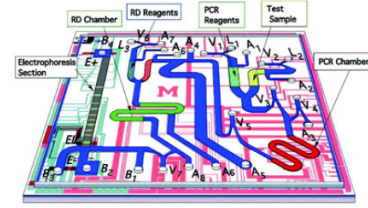
Cross-flow (T-junction)



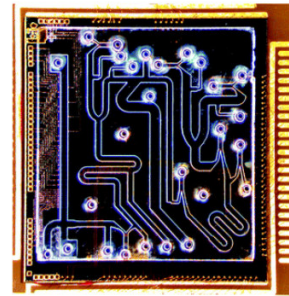
Co-flow



Flow-focusing



(a)



(b)

An integrated microfluidic device capable of performing a variety of genetic assays

Pal et al., *Lab on Chip*, 2005 (7)

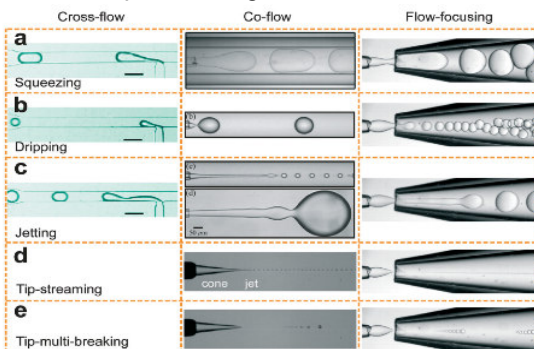
# Droplet generation methods

## Passive droplet generation

Microfluidic two-phase flow is controlled by either syringe pumps or pressure regulators

### Break-up modes

- Squeezing
- Dripping
- Jetting
- Tip-streaming

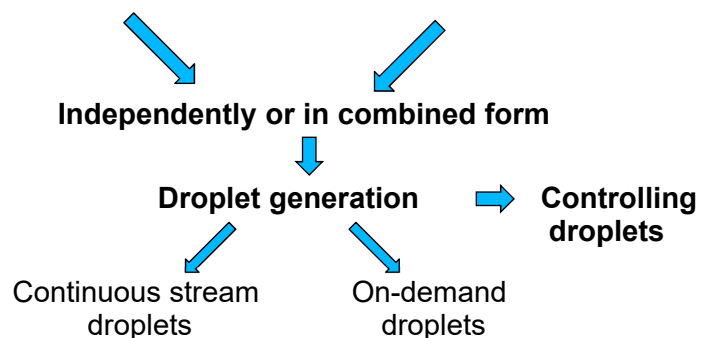


Zhu and Wang, *Lab Chip*, 2017, 17, 34–75

## Active droplet generation

Droplet is generated with the aid of additional energy input by active controls such as

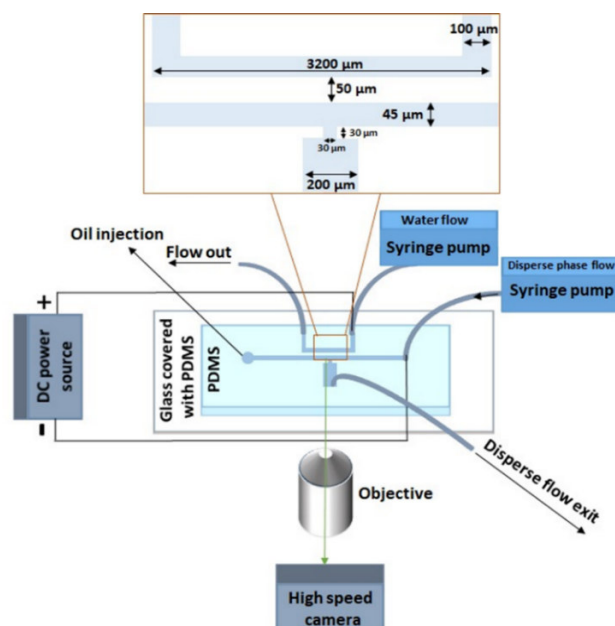
- Electric control
- Magnetic control
- Centrifugal control



# Droplet generation on-demand

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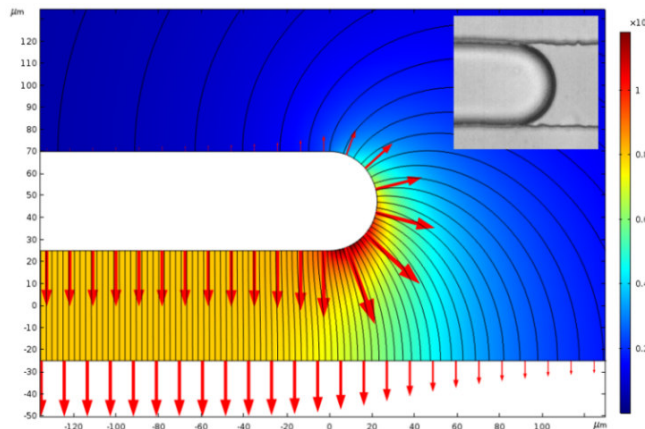
## Experimental set-up



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# Results: Numerical simulation

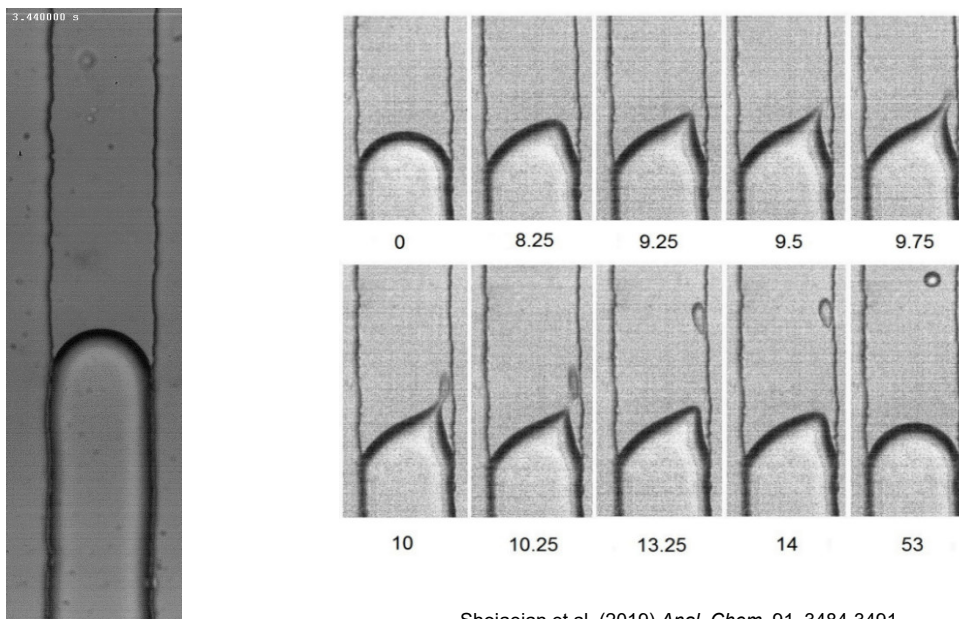
- Numerical simulations were performed using the commercial finite-element solver **COMSOL Multiphysics**.
- The electric field distribution was obtained by solving the Laplace equation, that is,  $\Delta\phi = 0$ , with  $\phi$  being the electric potential.



Shojaeian et al. (2019) *Anal. Chem.* 91, 3484-3491

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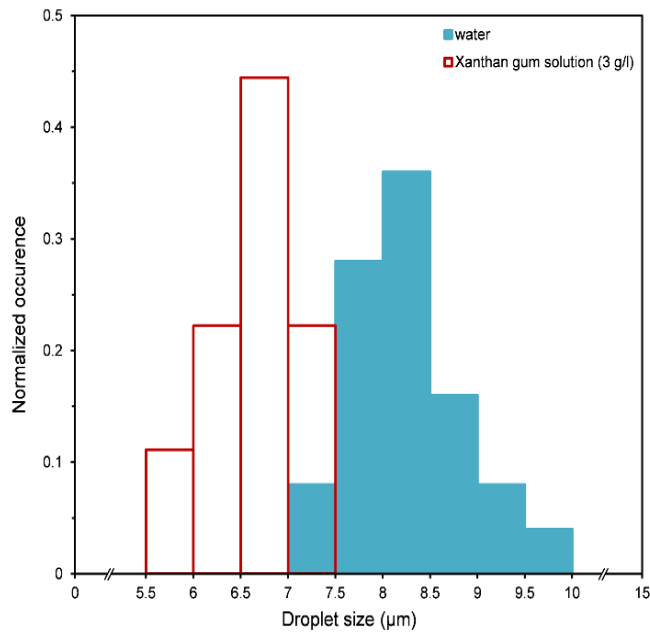
# Experimental results: Production of single femtoliter droplets



Shojaeian et al. (2019) *Anal. Chem.* 91, 3484-3491

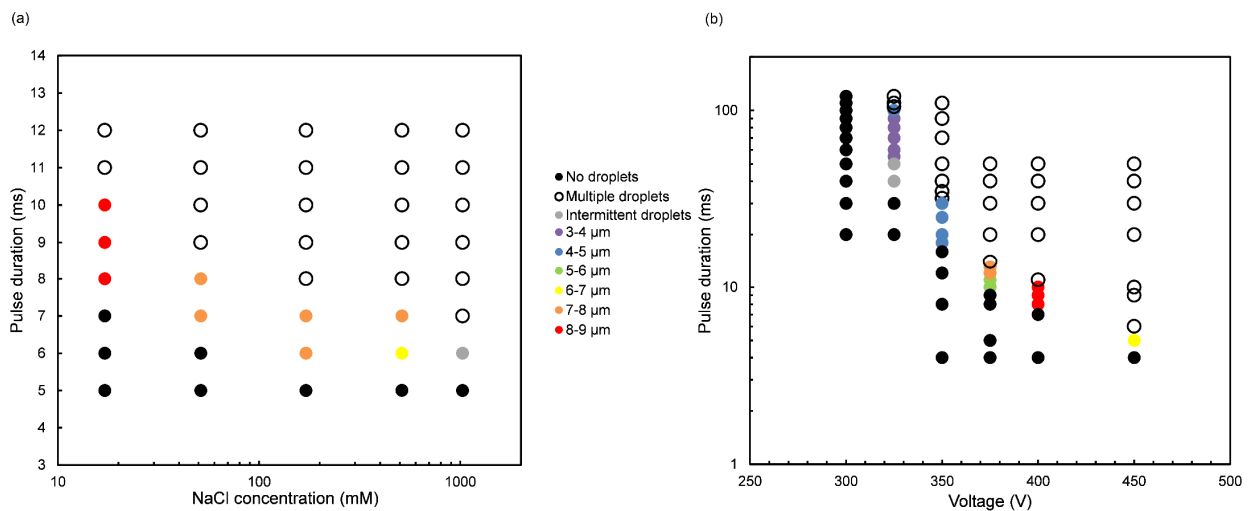
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# Droplet size distribution



Shojaeian et al. (2019) *Anal. Chem.* 91, 3484-3491

# Droplet formation: Influence of voltage and salt concentration



Shojaeian et al. (2019) *Anal. Chem.* 91, 3484-3491

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# Summary, Conclusions & Outlook

- Droplets can be *actively* produced on demand by application of appropriate pulsed electric fields in a microchannel
- *On-demand* droplet generation is highly dependent on electric parameters such as voltage amplitude and pulse duration as well as geometric design and fluidic parameters such as salinity

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# Thank you !