

# Cutting of rising bubbles by a wire without contact

M. Börnhorst<sup>1</sup>, T.A.M. Homan<sup>3</sup>, P. Rohlf's<sup>1</sup>, N.G. Deen<sup>3</sup>, O. Deutschmann<sup>1,2</sup>, M. Wörner<sup>2</sup>

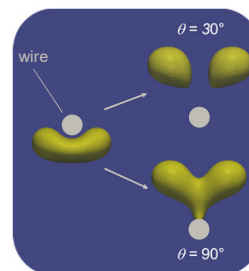
<sup>1</sup>Karlsruhe Institute of Technology (KIT), Institute for Chemical Technology and Polymer (ITCP)

<sup>2</sup>Karlsruhe Institute of Technology (KIT), Institute of Catalysis Research and Technology (IKFT)

<sup>3</sup>Eindhoven University of Technology, Power & Flow Group

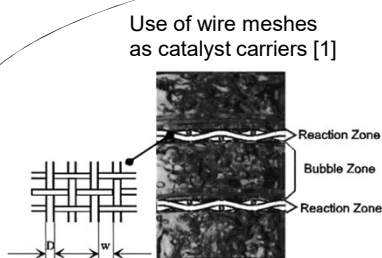
## Motivation

- Widespread use of bubble columns in industry with high optimization potential
- Installation of internals in the reactor to break up the bubbles
  - Increase of the interfacial area
  - Increase of heat and mass transfer



Numerical simulations predict strong effect of contact angle  $\theta$  on bubble breakup behavior [2]

What is the influence of wire material on bubble breakup in reality?



## Experiments

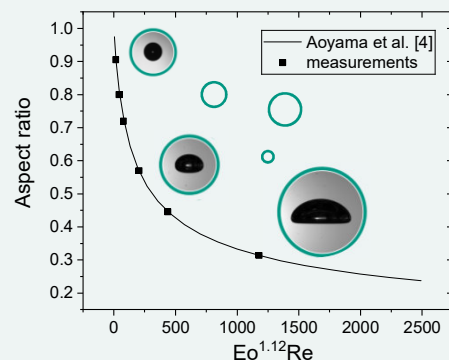
- Experiments with 90 wt.-% viscous glycerol-water solution
- Recording of bubble cutting process by high-speed camera

- Variation of cylinder diameter  $d_c$  and material (contact angle  $\theta$ )

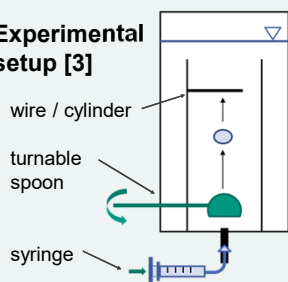
- $d_c = 3\text{mm}, 4\text{mm}, 5\text{mm}$

- Glass  $\theta \approx 40^\circ$ ,
- Teflon  $\theta \approx 90^\circ$ ,
- hydrophobic coating  $\theta \approx 150^\circ$

- Image analysis with Matlab and ImageJ



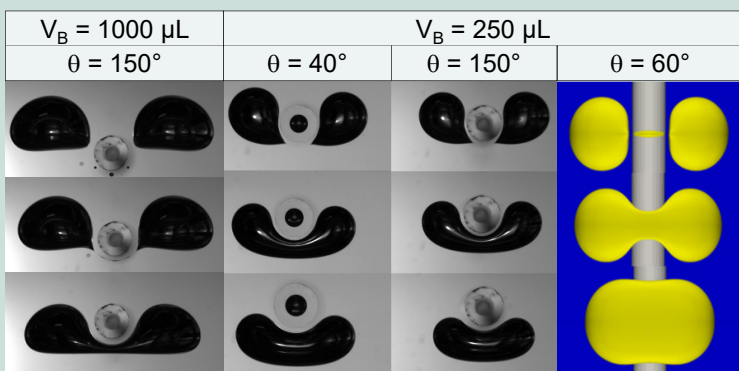
### Experimental setup [3]



Bubble Volumes $V_B / \mu\text{L}$	50, 250, 500, 1000
Equivalent diameter / mm	4.6 - 12.4
Eötvös number $E_o / -$	3.8 - 27.3
Morton number $Mo / -$	0.0164

## Results

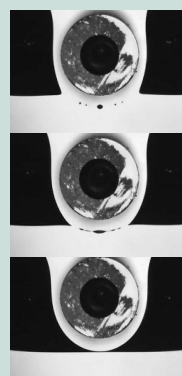
Bubble cutting at various conditions ( $d_c = 4\text{mm}$ )



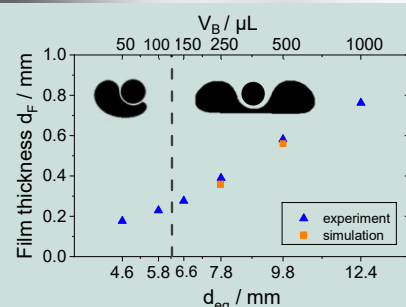
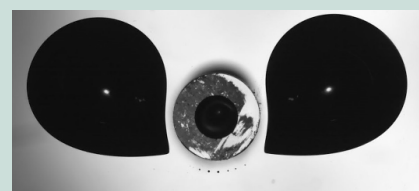
Experimental recordings (side view)

Numerical simulation, bottom view [6]

- Bubble size and velocity affect film thickness during cutting
- Formation of satellite bubbles during breakup of large bubbles



Formation of small satellite bubbles by fragmentation of a gas thread during bubble breakup



Increasing film thickness with  $V_B$  [5]

## Conclusions

- Separation of bubbles and cylinder by a uniform liquid film
- No influence of cylinder wettability on bubble cutting process

[1] Höller et al., *Ind. Eng. Chem. Res.* **40** (2001) 1575–1579  
[2] Cai et al., *Catalysis Today* **273** (2016) 151–160  
[3] Q. Segers, PhD thesis, TU Eindhoven, 2015

[4] Aoyama et al., *Int. J. Multiphase Flow* **79** (2016), 23–30  
[5] P. Rohlf's, Bachelor thesis, KIT, 2018  
[6] S. Wang, Master thesis, KIT, 2019