Enhanced Water Removal from PEM Fuel Cell Flow Channels by Superimposing Acoustic Wave

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What is a Fuel Cell?

Fuel cell is an energy conversion device that converts chemical energy into electrical energy.

- Electrochemical reaction, no chemical reaction
- High operating efficiency
- No moving parts
- Quick refuel

Proton Exchange Membrane (PEM) Fuel Cell

- Low temperature fuel cell ($30° - 100°$C)
- Hydrogen is used as fuel, air (oxygen) is used as oxidizer
- Anode: $H_2 \longrightarrow 2H^+ + 2e^-$
- Cathode: $\frac{1}{2}O_2 + 2H^+ + 2e^- \longrightarrow H_2O$

Motivation

The water produced in the cathode of a PEM fuel cell:

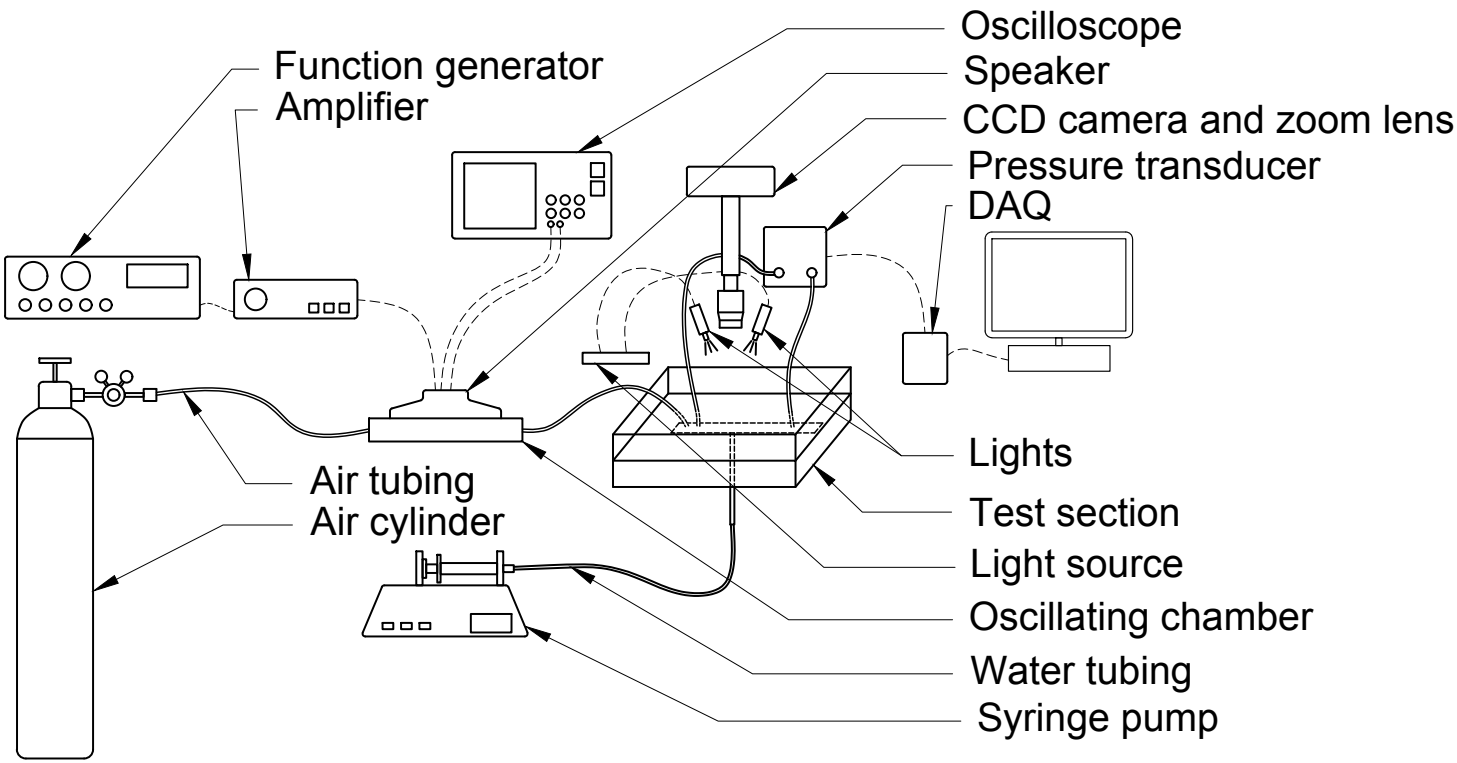
- May hydrate the membrane
- May be *passively* removed (back diffusion to anode, corner flow, evaporation, and etc.)
- May fill open pores of GDL
- May clog the flow channels

} are referred to as flooding

Flooding is reported to deteriorate the performance of the cell and should be avoided.

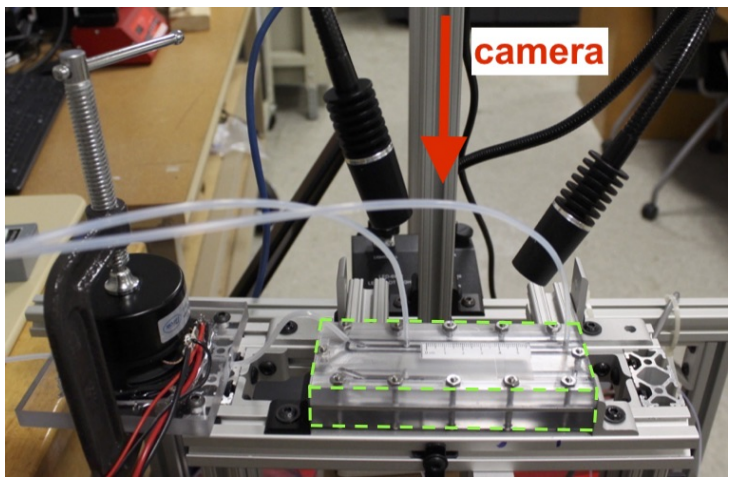
- In this study, water removal from an ex-situ PEM fuel cell flow channel is investigated with an *active* approach.

Experimental Setup

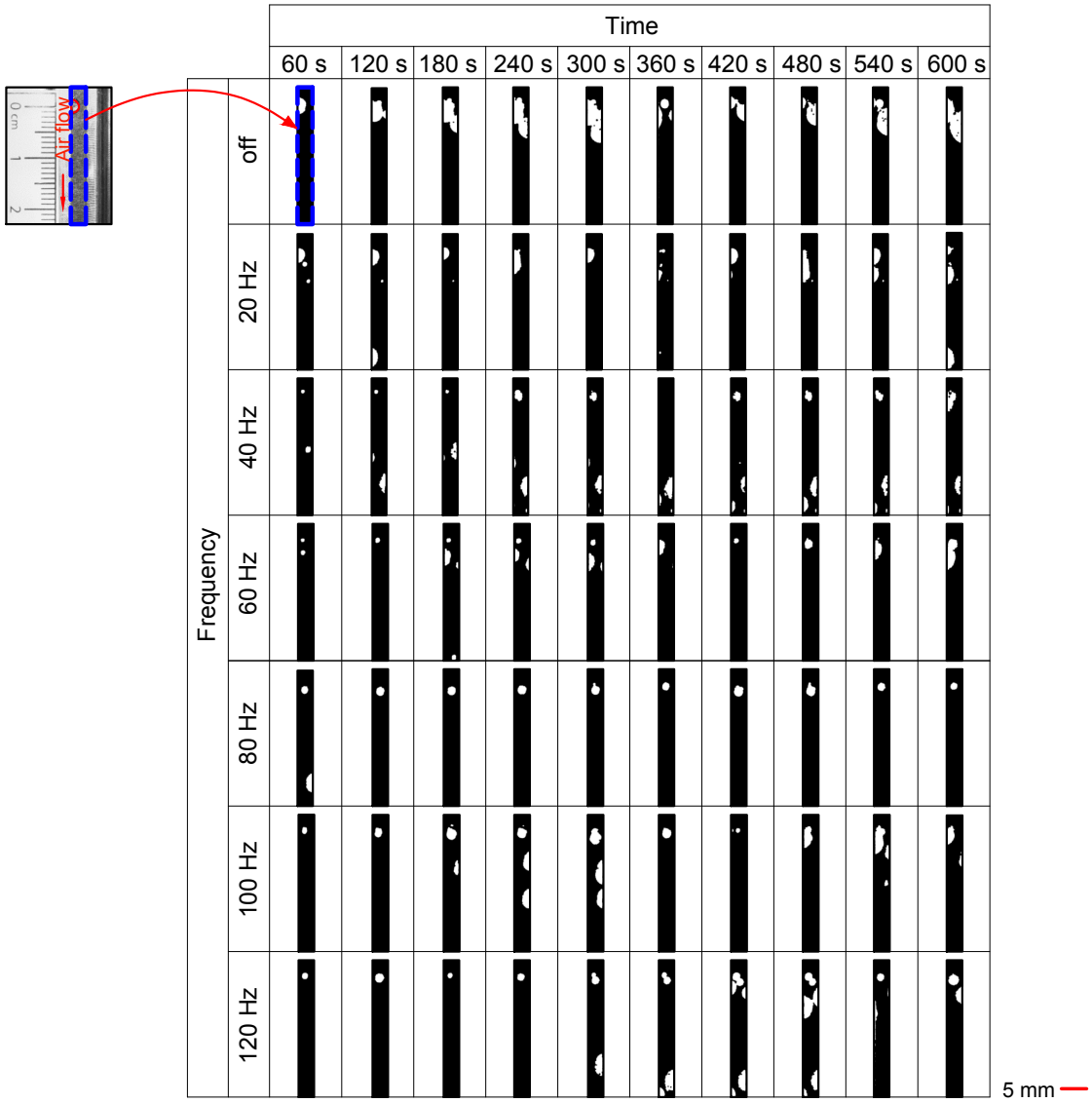


Experimental Conditions

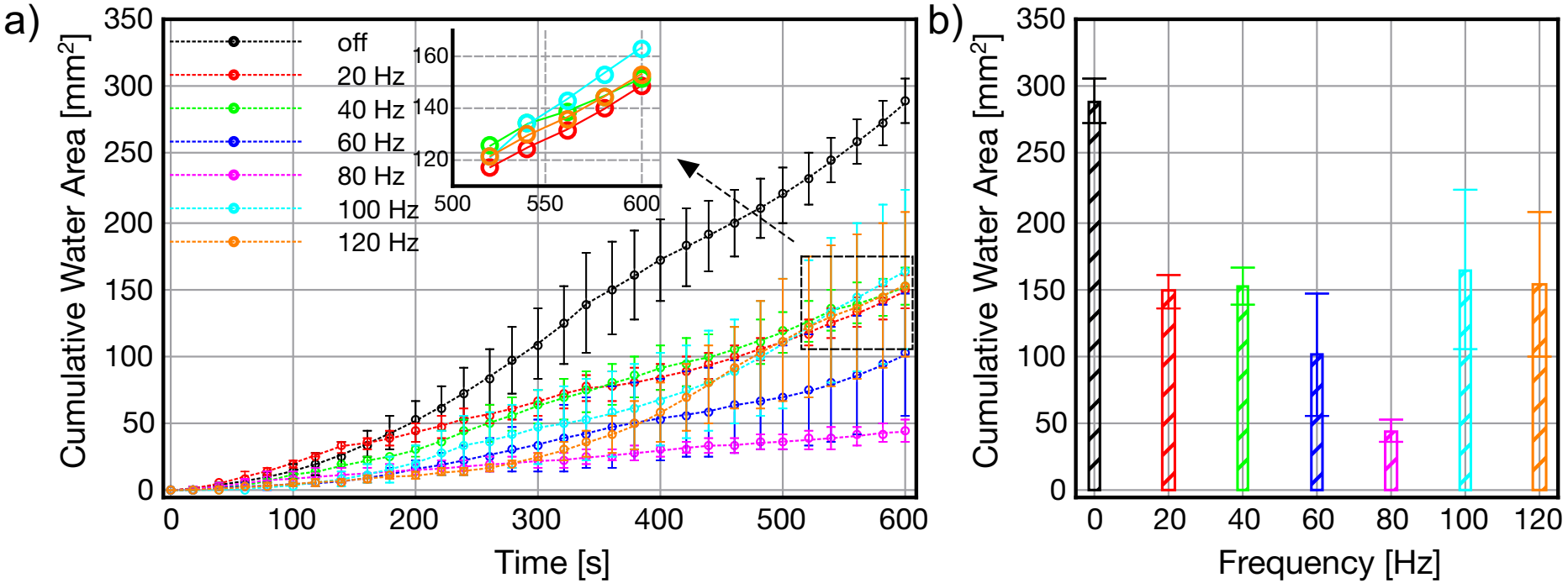
- Flow channel size 3 mm (W) $\times$ 2.4 mm (H)
- Air flow rate 788 ml/min (superficial velocity 1.82 m/s)
- Air Reynolds number 319.2
- Water flow rate 400, 600, and 800 $\mu\ell$/h (superficial velocity 9.25×10^{-4}, 1.38×10^{-3}, 1.82×10^{-3} m/s)
- Water Reynolds number 2.76, 4.14, 5.52
- Frequencies applied 20 to 120 Hz with a 20-Hz interval (sine wave)
- Superimposition methods: (*i*) continuous, (*ii*) pulsating on and off (10 s), and (*iii*) *on demand*



Results, Flow Channel Images

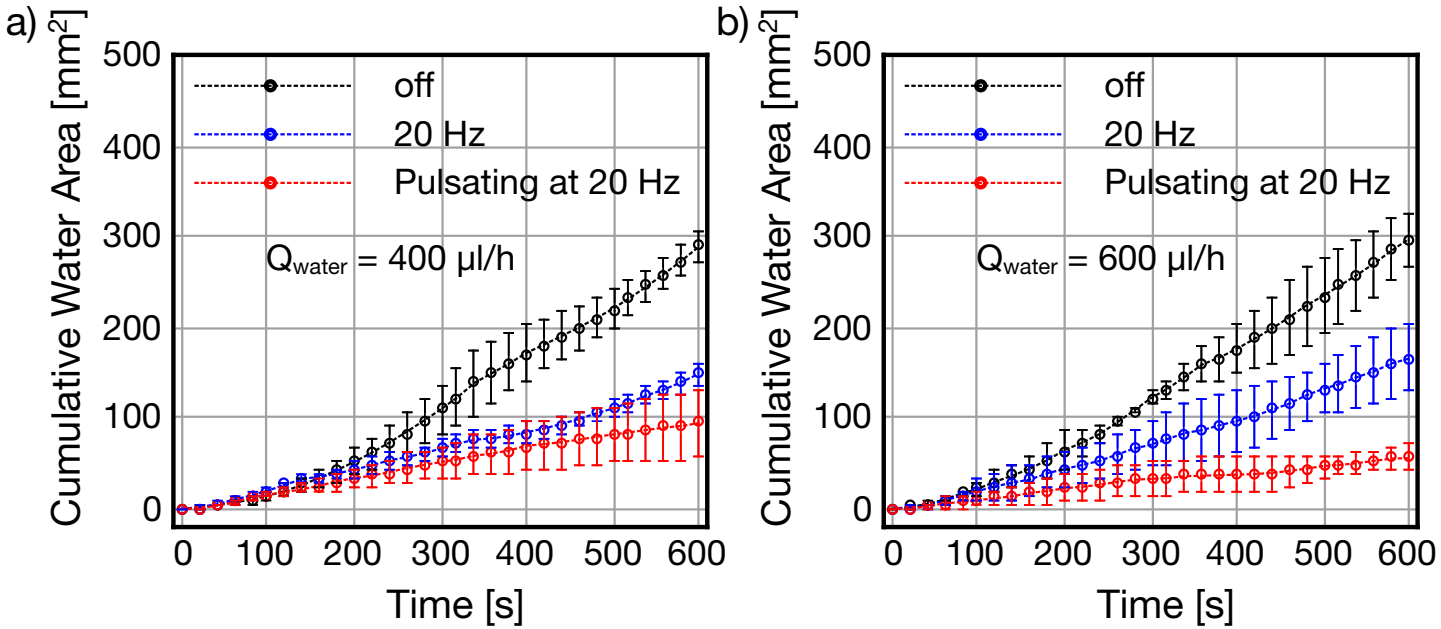


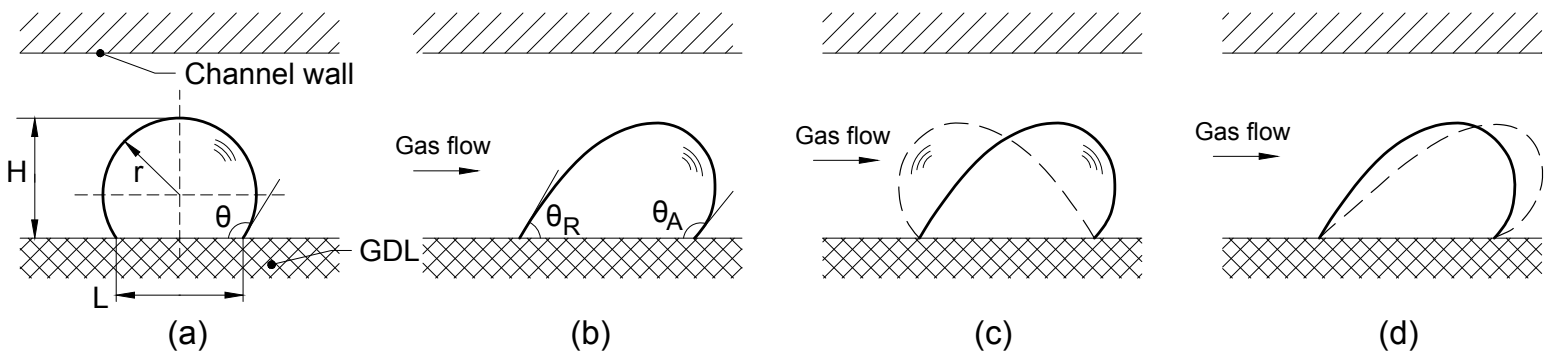
Results, Cumulative Water Area



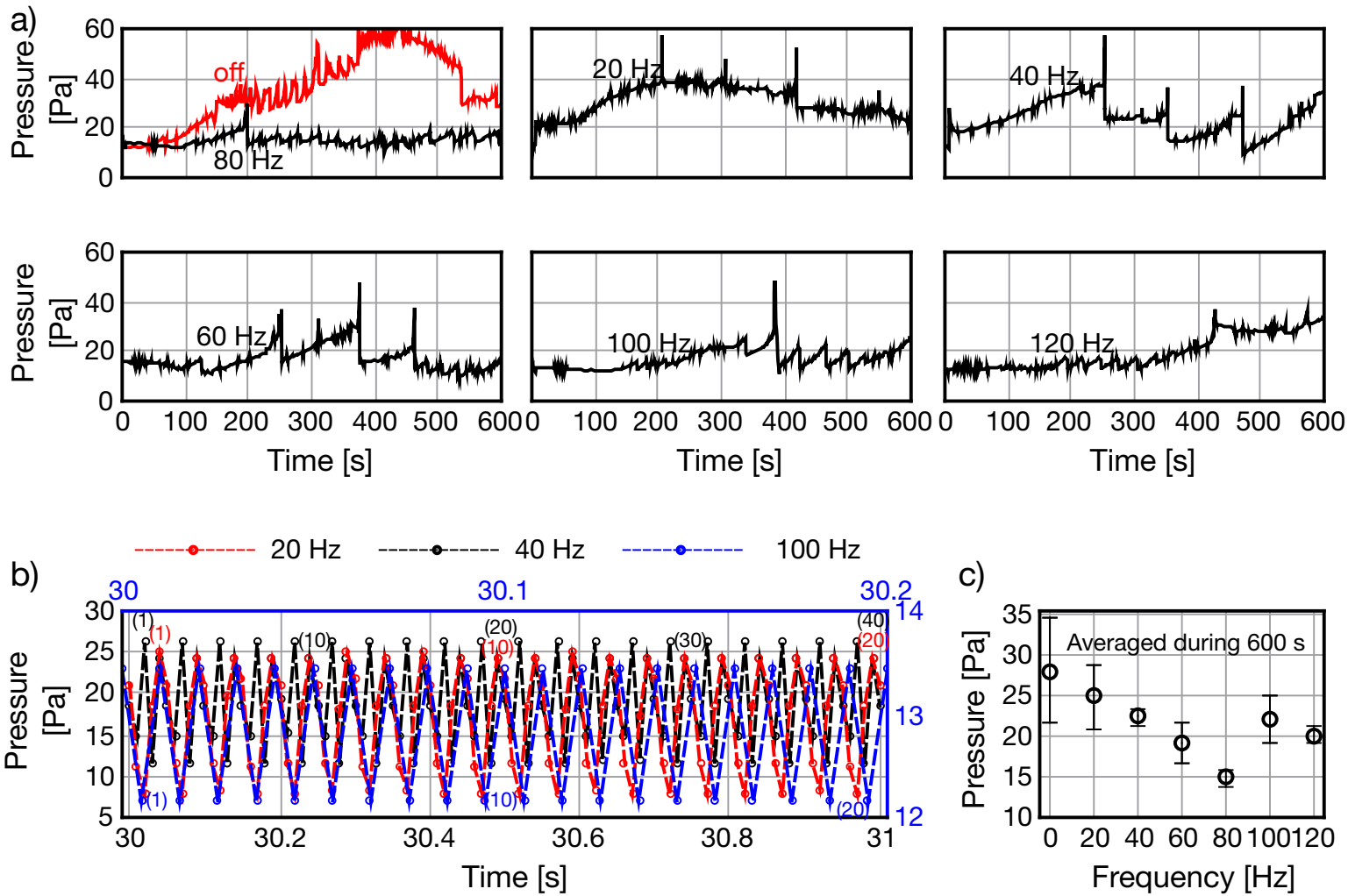
$$\text{cumulative area at time t} = \sum_{i=1}^{\text{t}} \text{area of water droplet in image at time t}$$

Results cont., Cumulative Water Area

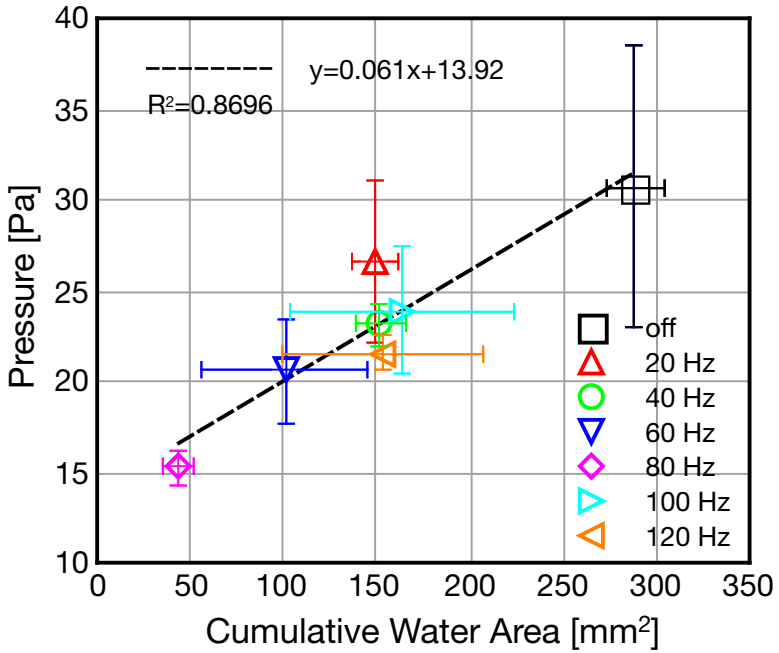




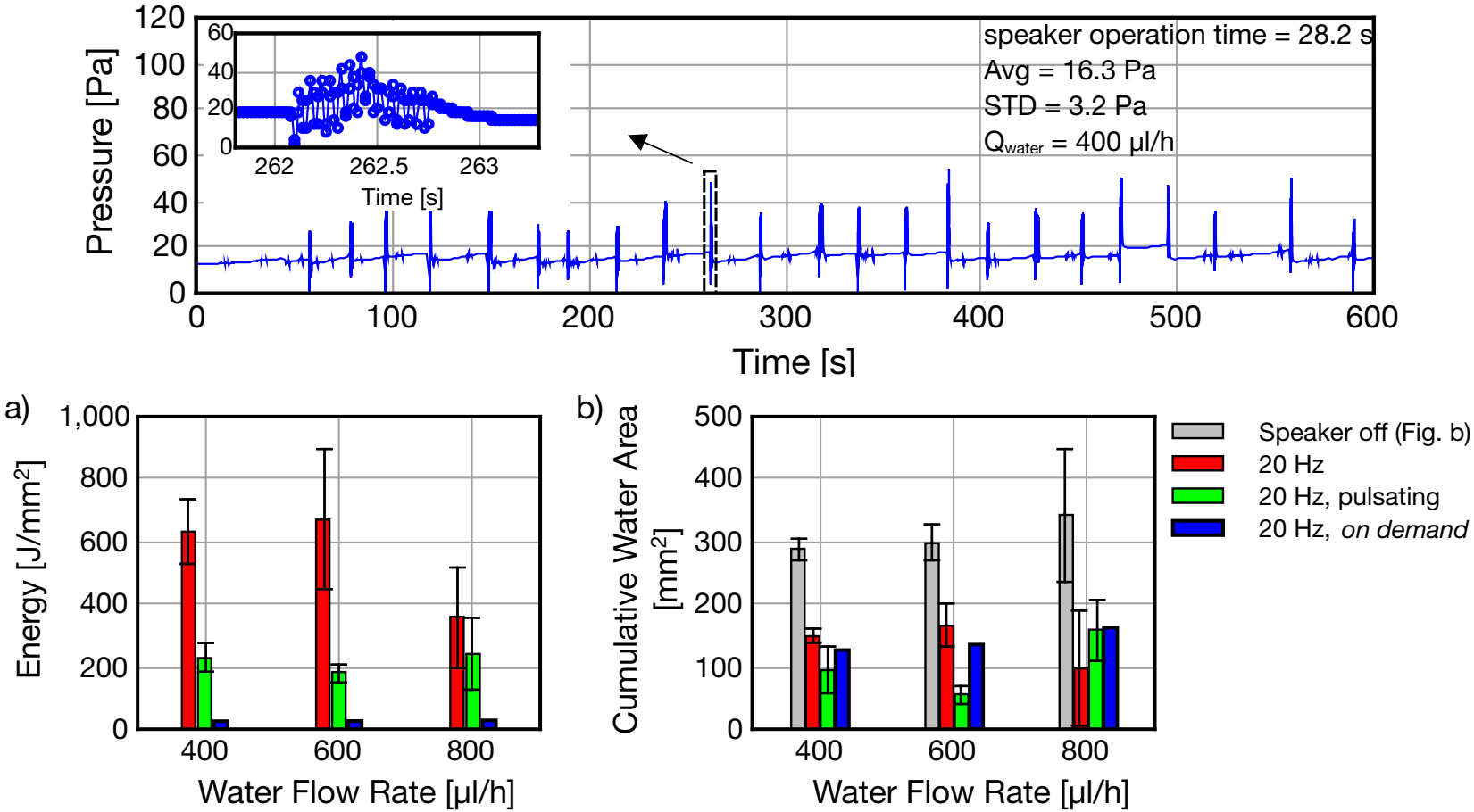
Results cont., Pressure Drop



Results cont., Pressure Drop



Results cont., *on Demand*



Reference:
Mehdi Mortazavi, Anthony D. Santamaria, Jingru Z. Benner, and Vedang Chauha, *Enhanced Water Removal from PEM Fuel Cells Using Acoustic Pressure Waves*, Journal of The Electrochemical Society, 166 (7) F1-F11 (2019)

Thank you!

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