Electronic Supplementary Information:

Thermally driven bubble evolution at a heater wire in water characterized by high-speed transmission electron microscopy

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Thermodynamic modeling:

The vapor pressures of 1 mM dissolved O_2, N_2, and H_2 as functions of temperature are shown in Fig. S5. These were calculated using a Henry's law treatment. Temperature dependent Henry's law coefficients were calculated from data in [1] with the van 't Hoff equation:

$$\frac{d\ln H}{d\,(1/T)} = \frac{-\Delta H_{sol}}{R},$$

where H is the Henry solubility (dissolved concentration/vapor pressure), T is temperature, R is the gas constant, and $-\Delta H_{sol}$ is the enthalpy of dissolution. The vapor pressure of water as a function of temperature was calculated using the Antoine equation:

$$\log(p) = a - \left(\frac{b}{T-c}\right),$$

where a, b, and c are parameters extracted from [2].

References:

1 R. Sander, *Atmos. Chem. Phys.*, 2015, **15**, 4399–4981.

2 D. R. Stull, *Ind. Eng. Chem.*, 1947, **39**, 540–550.

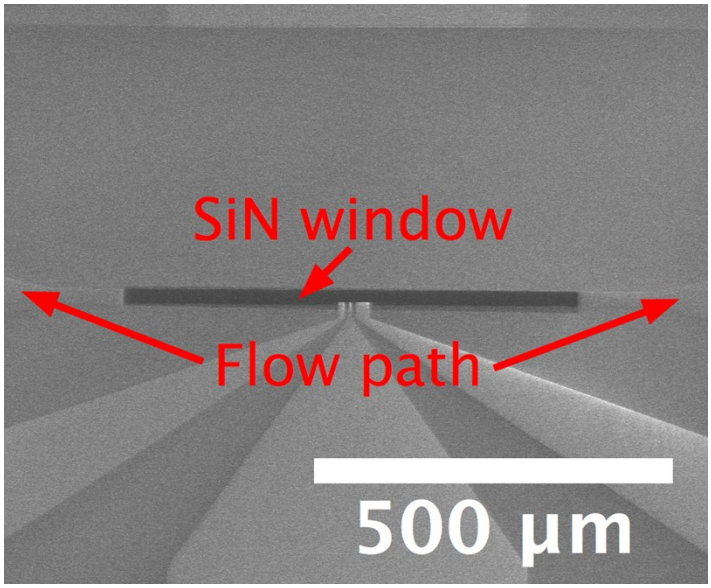
3 M. T. Alam, M. P. Manoharan, M. A. Haque, C. Muratore and A. Voevodin, *J. Micromech. Microeng.*, 2012, **22**, 45001.

Supplementary Video:

Video S1 shows the first 125 ms of bubble evolution in experiments A-E, at heater wire voltages of 0.10, 0.50, and 1.00 V (speed = 1/80 * real time).

Supplementary Figures:

(a)



(b)

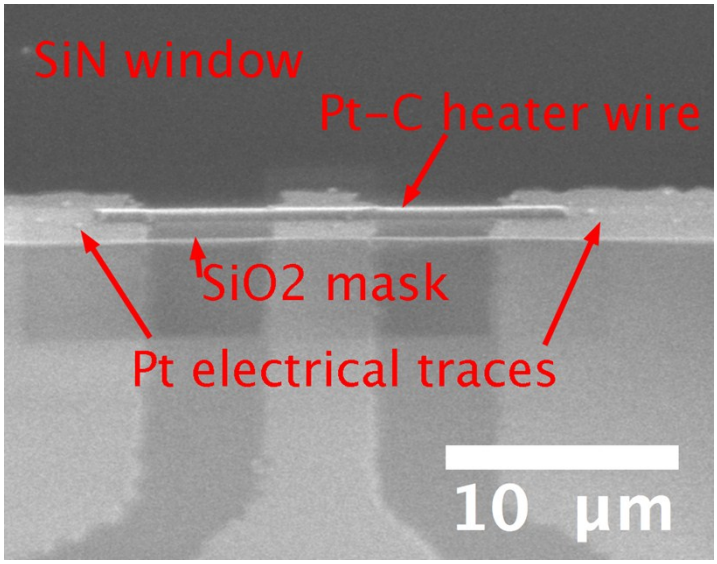


Fig. S1: (a) Low magnification scanning electron micrograph of SiN_x window chip prior to heater wire deposition, (b) scanning electron micrograph of SiN_x window with heater wire and electrical traces. The heater wire is powered by applying a voltage across the two outer traces; the middle trace is not biased. The sample is tilted at 45° to show the relative topography.

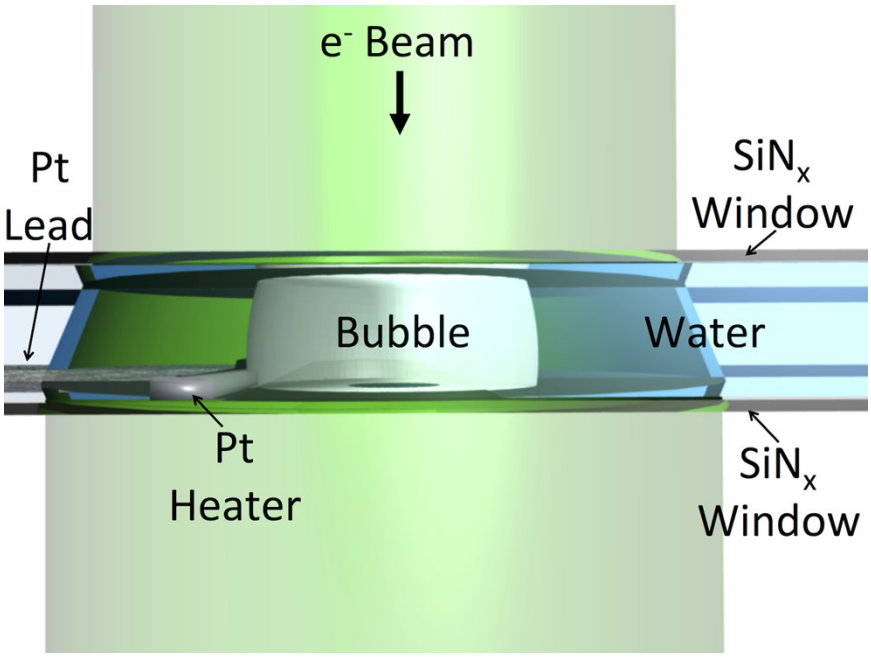
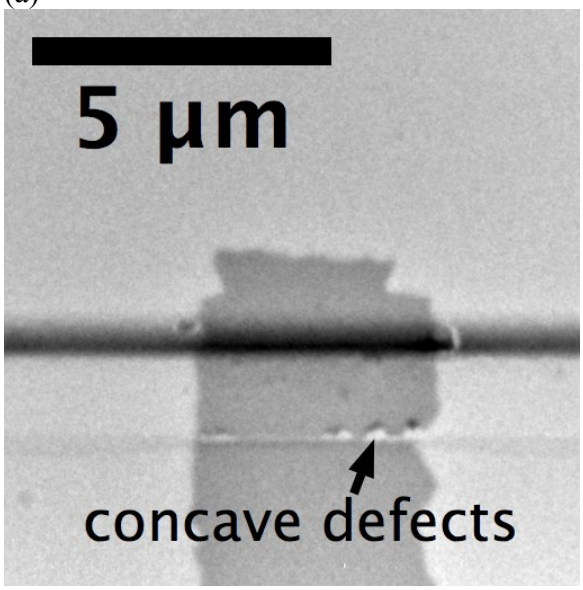


Fig. S2: Schematic of the employed experimental setup and electron beam path. The liquid layer thickness is ~500-1000 nm.

(a)



(b)

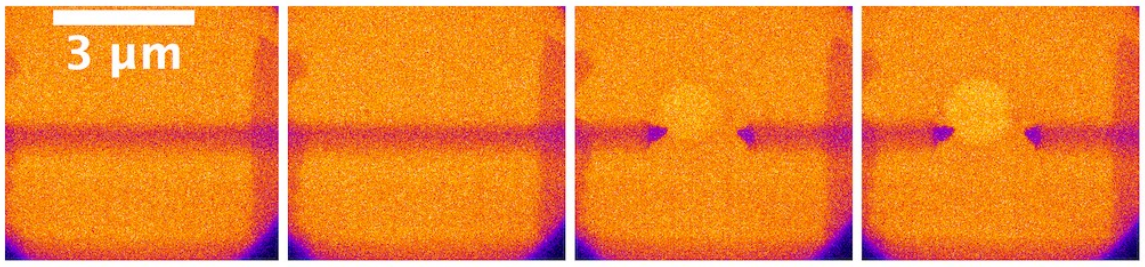


Fig. S3: (a) Transmission electron micrograph showing defects in the middle Pt trace, (b) image sequence, 2.5 ms apart, showing heater wire destruction and subsequent bubble nucleation at large heater power.

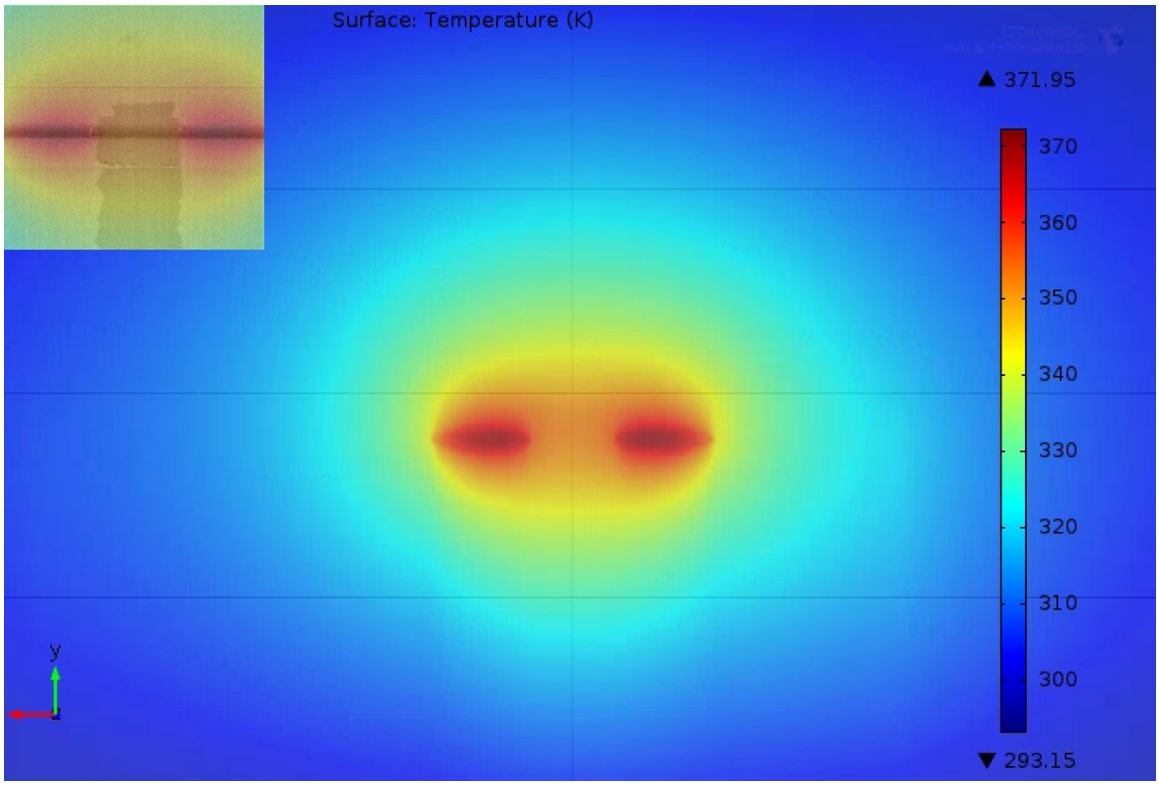


Fig. S4: Steady state temperature profile of the window (bottom view) with heater wire (modeled in COMSOL), voltage = 0.10 V, and liquid layer thickness of 750 nm, assuming thermal conductivities in water and SiN_x of 0.6 and 2.0 W m^{-1} K^{-1} [3], and no electrical resistance in the middle Pt trace. Inset shows a merged transmission electron micrograph of the experimental system with overlaid temperature profile.

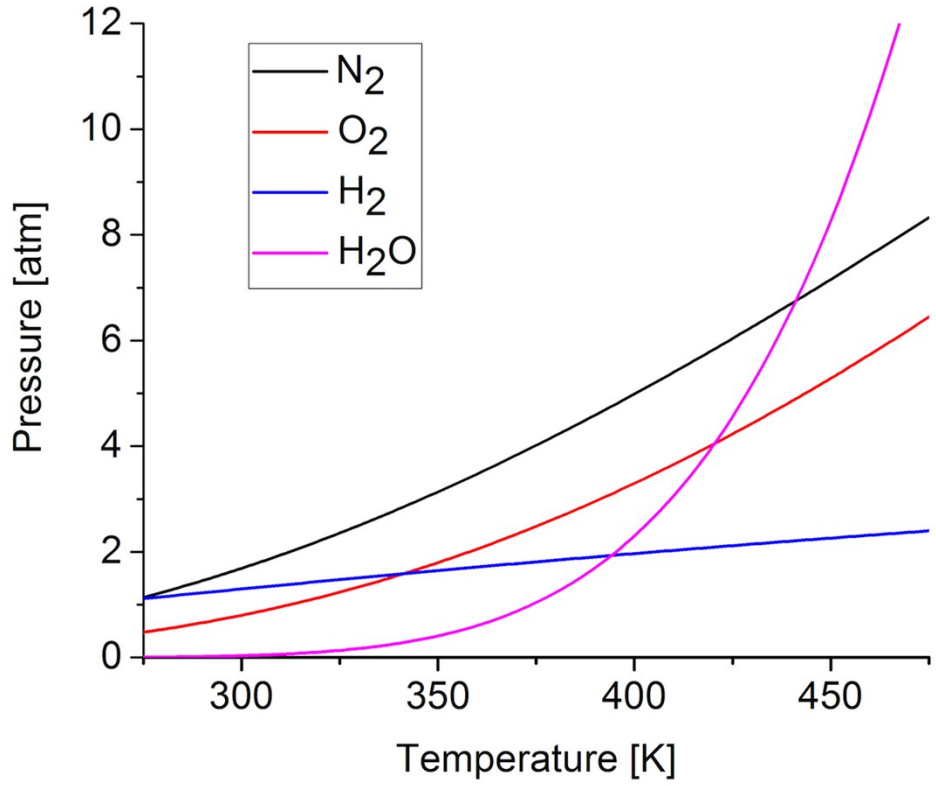


Fig. S5: Partial pressure of dissolved 1 mM H_2, O_2, and N_2 using a Henry's Law treatment and saturated water vapor vs. temperature.

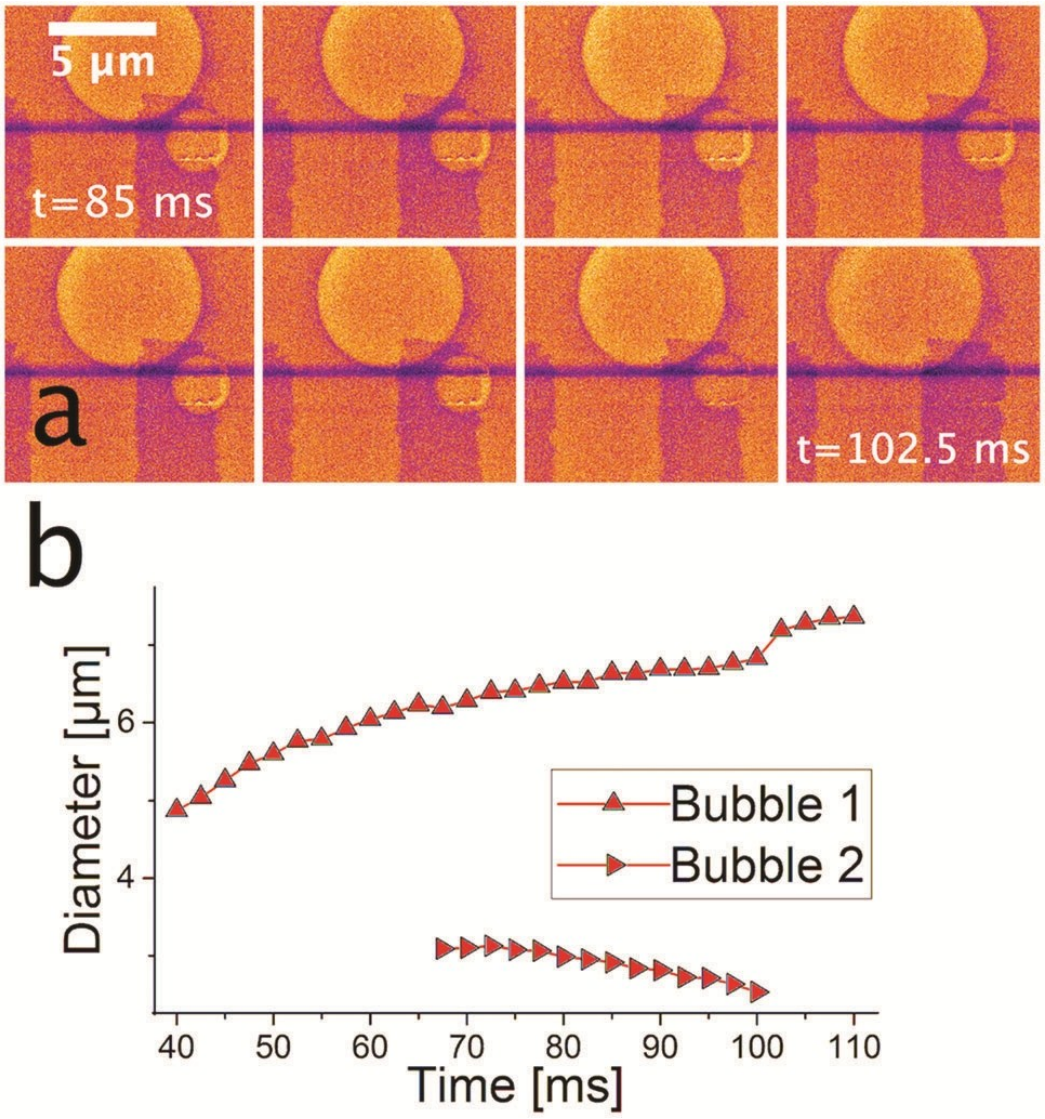


Fig. S6: (a) Image series showing Ostwald ripening and subsequent bubble collapse in experiment C, (b) the diameters of the two bubbles with time.