Supplementary Information

Numerically Controlled Electrochemical Etching of Tungsten Nano-needles for Penetrating the Tough Yeast Cell Wall

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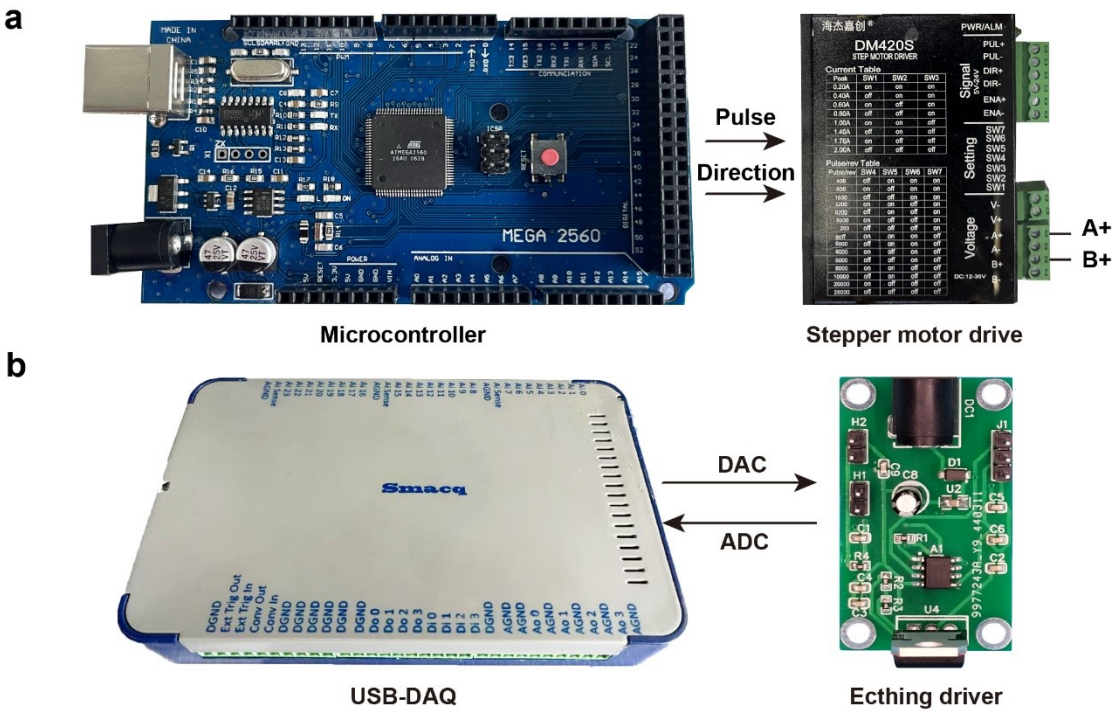

Figure S1： Stepper motor drive and etching current output. (a) Stepper motor drive module, including MEGA-2560 microcontroller and stepper motor driver. (b) Etching current output module, including data acquisition card (USB-DAQ) and etching current drive circuit board.

The hardware of the electrochemical etching platform mainly includes a stepper motor drive module and an etching current output module. When working, the microcontroller (MEGA 2560) outputs a control signal to control the stepper motor driver to drive the stepper motor to drive the tungsten wire upward. The data acquisition card (USB-DAQ) has input and output modes, outputs a controllable voltage at the output end, and the etching current drive circuit board outputs the etching current through the reverse amplifier circuit. The input mode is used to monitor the output of the etching current drive circuit board to prevent the operational amplifier from saturating.

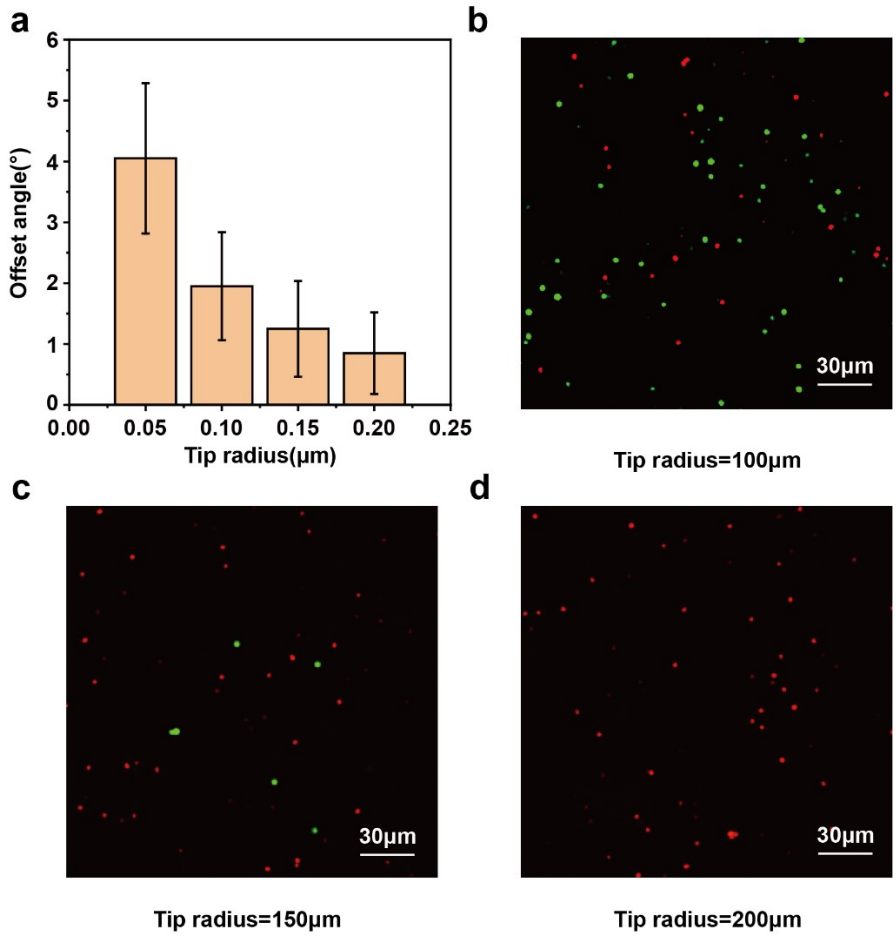

Figure S2: Performance of nanoneedles of different sizes and activity detection after puncturing yeast cells using nanoneedles of different sizes. (a) Deflection angle generated when nanoneedles with a tip radius of 0.05-0.2μm puncture yeast cells. (b) Live and dead staining after puncturing yeast cells using nanoneedles with a tip radius of 0.05μm. Scale bar: 30μm. (c) Live and dead staining after puncturing yeast cells using nanoneedles with a tip radius of 0.1μm. Scale bar: 30μm. (d) Live and dead staining after puncturing yeast cells using nanoneedles with a tip radius of 0.2μm. Scale bar: 30μm.

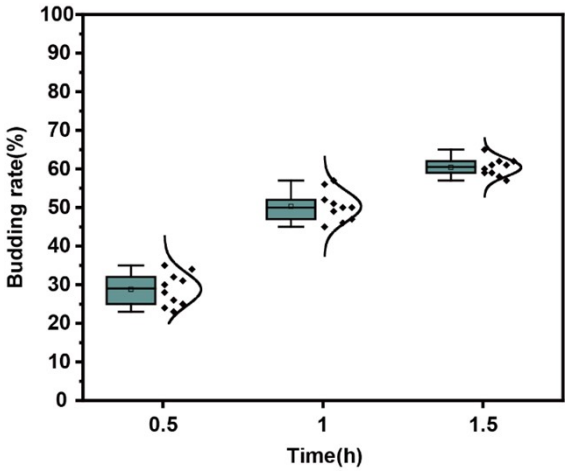

Figure S3: Numerical statistics of budding rates at 0.5h, 1h and 1.5h after yeast cell puncture.

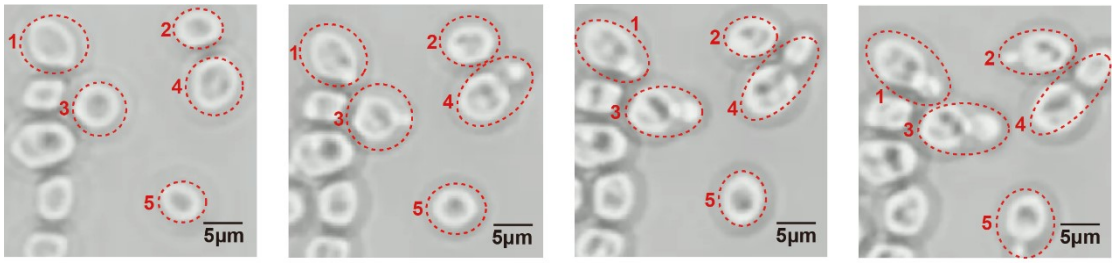

Figure S4: Budding and proliferation of yeast cells after puncturing. The yeast cells with budding and proliferation observed are within the red dotted circle. The time interval between each photo is 30 minutes. The scale bar is 5μm.