Supporting Information

Bacterial recognition of silicon nanowire arrays

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Methods

Bacterial strains and growth conditions. The Shewanella oneidensis MR-1 (ATCC BAA-1096) were initially grown in sterile LB broth for 48 h at 30°C under aerobic conditions. Subsequently, a 1mL aliquot of the LB-grown cultures was centrifuged (3000 rpm for 10 min) and the pellet was resuspended in sterilized minimal media.[1] The resuspended MR-1 cells were grown at 30°C for another 12 hours under aerobic or anaerobic conditions before the optical imaging experiments.

Silicon nanowire array growth. Silicon nanowire arrays were prepared by the vapor-liquid-

solid (VLS) growth method using a patterned Au film. A 200nm silicon dioxide layer was deposited on a p-Si(111) wafer by thermal oxidation and arrays of circular nanoholes were defined using the photolithographic or nanoimprint process. The holes were transferred to the oxide layer by CHF_3/CF_4 plasma etching and buffered HF etching. The holes were filled with a 120nm Au film by e-beam evaporation, followed by lift-off. The Si nanowires were grown from the patterned Au thin film catalyst with $SiCl_4$ (99.99% Sigma Aldrich) and 10% H_2/Ar at 875°C.[2]

Optical microscopy imaging. For the optical imaging experiments, MR-1 cultures grown in minimal media were inoculated on the silicon nanowire arrays. Then, the behavior of the MR-1 cells on the arrays was monitored with an upright microscope (Eclipse LV100D-U, Nikon) equipped with ×50 and ×100 objectives and recorded with a microscope-mounted camera (Moticam Pro, Motic) under aerobic or anaerobic conditions. For fluorescence imaging, samples were stained with a fluorescent labeling reagent (BacLight bacterial staining kit, Invitrogen).

SEM imaging. For SEM imaging, samples were rinsed with distilled water to remove salts and planktonic bacteria. The samples were then fixed in 4% cacodylate buffered glutaraldehyde in a refrigerator overnight at 4°C, after which they were rinsed with distilled water.[3] These samples were dehydrated in acetone and sputtered with 3 nm of Au. The prepared samples were examined

by field emission SEM (JEOL FSM6430).

Analysis of bacterial trajectories. Bacterial trajectories were extracted from the recorded movie sequences using the Video Spot Tracker software (CISMM). Moments of displacements and diffusion coefficients were then calculated for each trajectory with a homemade Matlab routine. To analyze and quantify MR-1 bacterial trajectories, we utilized the moment scaling spectrum (MSS) theory.[4, 5] The analysis of MR-1 trajectories was done by calculating different *moments of displacement* from individual cells. The assumption in the MSS theory is that each *moment* (μ_v) depends on the *time shift* (δt) in a power law $\mu_v(\delta t) \propto \delta t^{\gamma v}$. The moment of *order v* for a specific *frame shift* Δn (corresponding to a *time shift* $\delta t = \Delta n \Delta t$) is defined as[4, 5]:

$$\mu_v(\Delta n) = \frac{1}{M_l - \Delta n} \sum_{n=0}^{M_l - \Delta n - 1} |x_l(n + \Delta n) - x_l(n)|^v$$

Here, $x_l(n)$ is the position vector at time $n\Delta t$. Δt is the time difference between two subsequent frames and n is equal to $0,1,2,\ldots,M_l - 1$, where M_l is the total number of points in the trajectory. To describe the diffusion mode of the bacterial motions, the mean moment was calculated for v = 0, 1, 2,…, 6 and $\Delta n = 1,\ldots,M_l/3$, and drawn versus δt in a logarithmic plot. For each moment order v, the slope γ^v of log $\mu_v(\delta t)$ vs. log (δt), the scaling coefficient, was determined using a linear least-squares regression. The plot of γ^v (*scaling coefficient)* versus v (*moment order)* is

termed the moment scaling spectrum (MSS) and the slope of MSS (S_{MSS}) is a reliable criterion to distinguish different modes of motions[1, 2]. A S_{MSS} value between 0 and 0.5 indicates subdiffusion (e.g., confined diffusion) and a value between 0.5 and 1 represents superdiffusion (e.g., diffusion with deterministic drift).

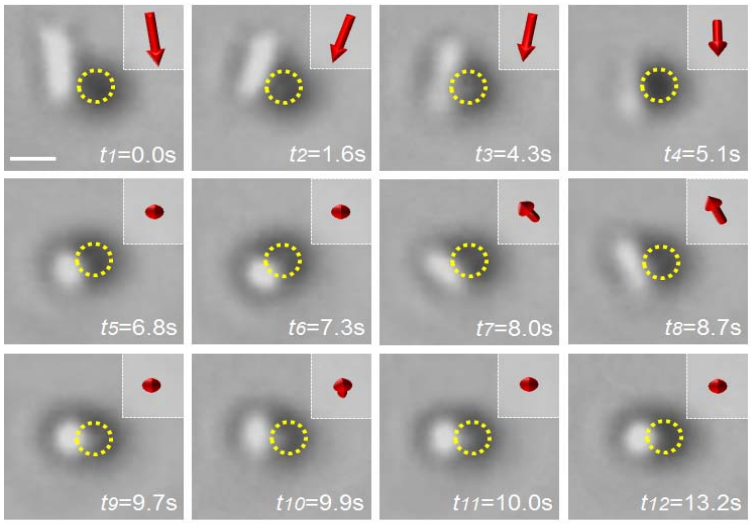

Figure S1. Motions of MR-1 around Si nanowire. After the MR-1 bacterium approached the nanowire, the cell stayed around the nanowire while changing the orientations of its body against the nanowire, but still maintaining a close contact with the nanowire for a long period of time (> 5 min).

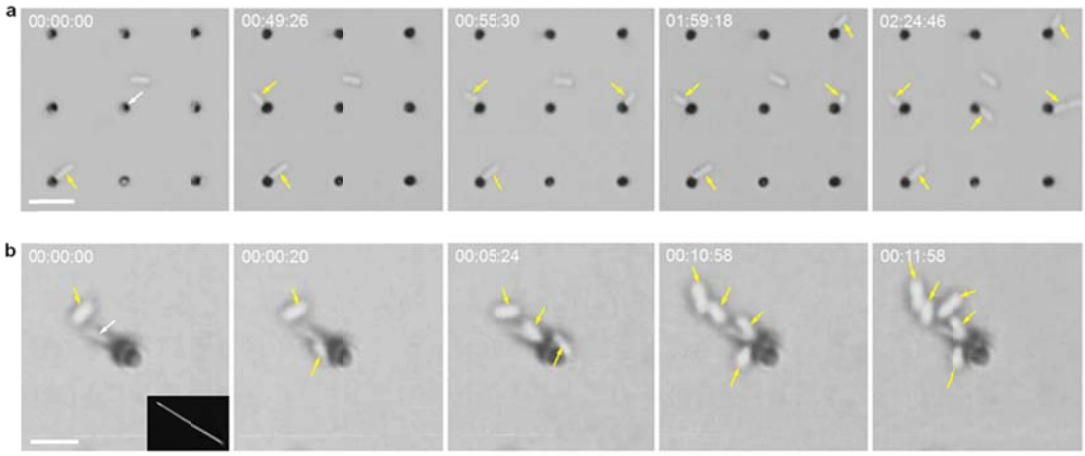

Figure S2. Time-lapse optical imaging of MR-1 cells on substrates with Si nanowires. (a,b) Time-lapse optical images of MR-1 cells on substrates with patterned Si nanowire arrays with a 15μm pitch (300 nm diameter and 3 μm length) (a) and angled Si nanowire with ~a 15 μm length (b). The angled Si nanowire was grown on Si(110) wafer. White arrows indicate Si nanowires and yellow ones indicate MR-1 cells. Scale bars, 10 μm.

Movie S1. Bright-filed movie showing the single MR-1 movement on the patterned Si nanowire arrays with a 15μm pitch. The video speed is 3× the actual speed.

Movie S2. Bright-filed movie showing the single MR-1 movement on the patterned Si nanowire arrays with a 10μm pitch.

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