Electronic Supplementary Material (ESI) for Lab on a Chip.
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Contactless, high throughput determination of electrical conductivity of one-dimensional nanomaterials by solution-based electro-orientation spectroscopy†

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Supporting Information

Electro-orientation torque *vs* Brownian motion: The electro-orientation torque $|\overrightarrow{T}_e|$ experienced by a spheroid suspended in a liquid of permittivity ε_f due to a uniform AC electric field $\vec{E}$ acting on an induced dipole moment $\overrightarrow{p}$ is[1]

$$|\vec{T}_e| = |\overrightarrow{p} \times \overrightarrow{E}| = \frac{\pi}{3} a b^2 \varepsilon_f \mathbf{Re}[\underline{K}] E_0^2 \sin 2\theta \,, \tag{S1}$$

where a and b are the semi-major and semi-minor axes of the prolate spheroid. Re($\underline{K}$) is the real part of the complex Clausius-Mossotti factor $\underline{K}$ which is a strong function of electrical properties of the particle and the fluid, the frequency of the applied electric field and the aspect ratio of the particle:

$$\underline{K} = \frac{\underline{\varepsilon}_p - \underline{\varepsilon}_f}{3[\underline{\varepsilon}_f + (\underline{\varepsilon}_p - \underline{\varepsilon}_f) L_{\|}]} \,, \tag{S2}$$

where the complex permittivities are $\underline{\varepsilon}_p = \varepsilon_p - \frac{\sigma_p}{\omega} j$ and $\underline{\varepsilon}_f = \varepsilon_f - \frac{\sigma_f}{\omega} j$, and L_i is the depolarization factor given by $L_{\|} \approx \frac{1}{\beta^2}[\ln 2\beta - 1]$. The aspect ratio of the prolate spheroid is defined as $\beta \equiv a/b$.

The electro-orientation torque can be compared to the thermal energy, $k_B T$, associated with the Brownian motion. For a typical electric-field strength of 100 V/mm, we find the ratio of orientational to thermal energies is on the order of 10^4, suggesting that the Brownian motion is negligible. To further minimize

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the effect of Brownian motion, we find the alignment rates by fitting the measured angular position of the nanowires over relatively long times on the order of 3 seconds. For these reasons, we believe that the uncertainty in alignment rate due to Brownian motion is minimal in these measurements.

Supporting Figures

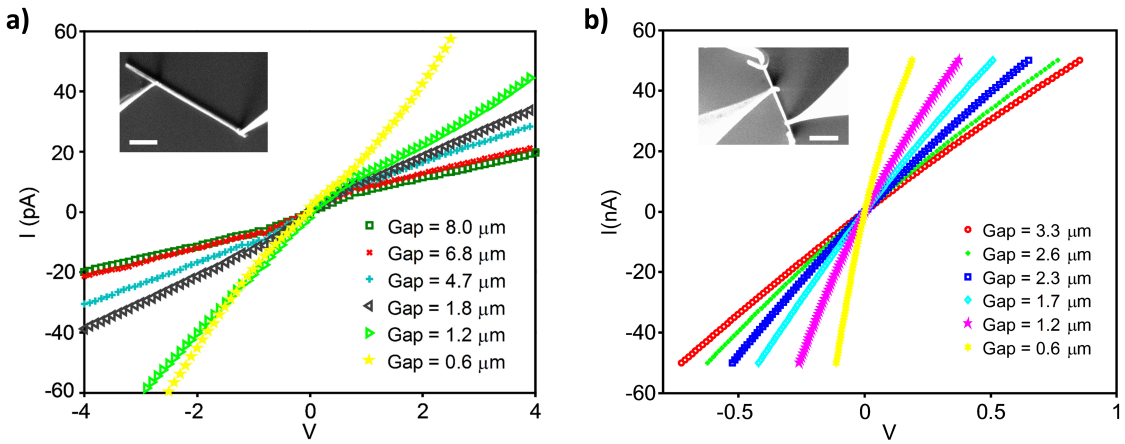

Figure S1: Direct-contact STM measurement of the *I-V* curves with different probe spacings a) 2P-STM measurement of Si nanowire, b) 4P-STM measurement of Ge nanowire. Insets: SEM image showing the nanowires being measured by STM probes. The scale bars correspond to 2 μm.

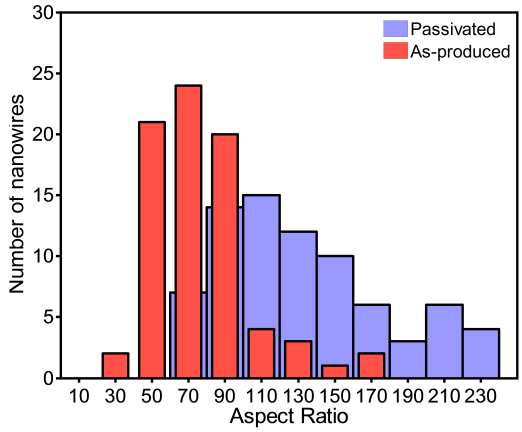

Figure S2: Aspect-ratio measurements of as-produced and passivated Si nanowires by SEM. Passivation of Si nanowires increases the aspect-ratio by decreasing the diameter of as-produced Si nanowires.

Supporting Movie Legend

Supporting Movie 1: Alignment of two individual Si nanowires at different frequencies under slow-rates and demonstration of sorting according to their electrical conductivities.

References

(1) Jones, T. B. *Electromechanics of Particles*; Cambridge University Press, 2005.