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Supporting Information

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A Novel Electromechanical Actuation Mechanism of a Carbon Nanotube Fiber

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Supporting Information for

A novel electromechanical actuation of carbon nanotube fiber

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Movie S1. The spinning process to obtain a left-handed CNT fiber from a CNT array.

Movie S2. A left-handed CNT fiber upon using a pulsed current between 0 and 4 mA with a frequency of 1 Hz. The CNT fiber was straightened when subjected to a current.

Movie S3. The opposing rotations of the two ends in a left-handed CNT fiber upon passing current observed with optical microscopy. The CNT fiber can quickly return to the original state upon removing the current.

Movie S4. Two paddles anchored near the two ends of a left-handed CNT fiber rotating in opposite directions upon passing a current and quickly returning to the original state upon the removal of the current. These results further confirm the conclusion in Movie S3.

Movie S5. The right part of a right-handed CNT fiber gradually rotating upon the passing of a current increasing from 0 to 5 mA and then returning to the original state as the current decreases to 0 mA. The movie was obtained under an optical microscopy.

Movie S6. An electric motor based on a CNT fiber rotating an object (here a piece of paper) upon passing a current of 5 mA.

Table S1. Comparison between our CNT fiber and other actuation materials.[S1–S4]

	Ferroelectric and electrostrictive materials	**Conducting polymers**	**Polymer gels (silicone)**	**CNT sheet**	**Our CNT fiber**
Stress [MPa]	20	5	0.3	3.2	10
Strain [%]	3.5	2	120	1	2
Work Density [kJ/m^3]	320	100	10	32	>430
Efficiency [%]	/	<1	25	/	>10
Density [g/cm^3]	2	1	1	0.8	0.54
Modulus [GPa]	0.4	0.8	10^{-3}	5.9	20
Cycle Life (Full strain)	/	28000	/	>9	>10^3
Electric Field [kV/m]	10^4	/	10^5	120	1
Conductivity [S/cm]	very low	100	very low	10^2 (estimated)	400
Rotation	no	no	no	no	yes
Media	air	electrolyte	electrolyte	high vacuum	air, water, organic solvents, electrolyte

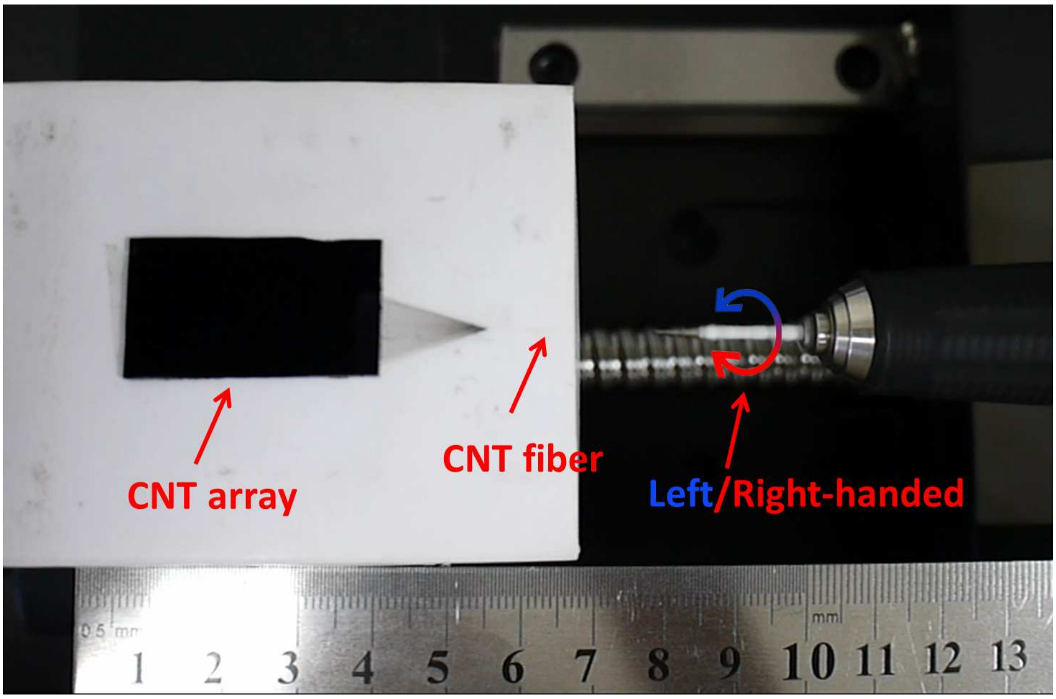

Figure S1. Photograph of the experimental setup to spin CNT fibers. The left- and right-handed fibers were obtained by changing the rotary direction of spinning probe.

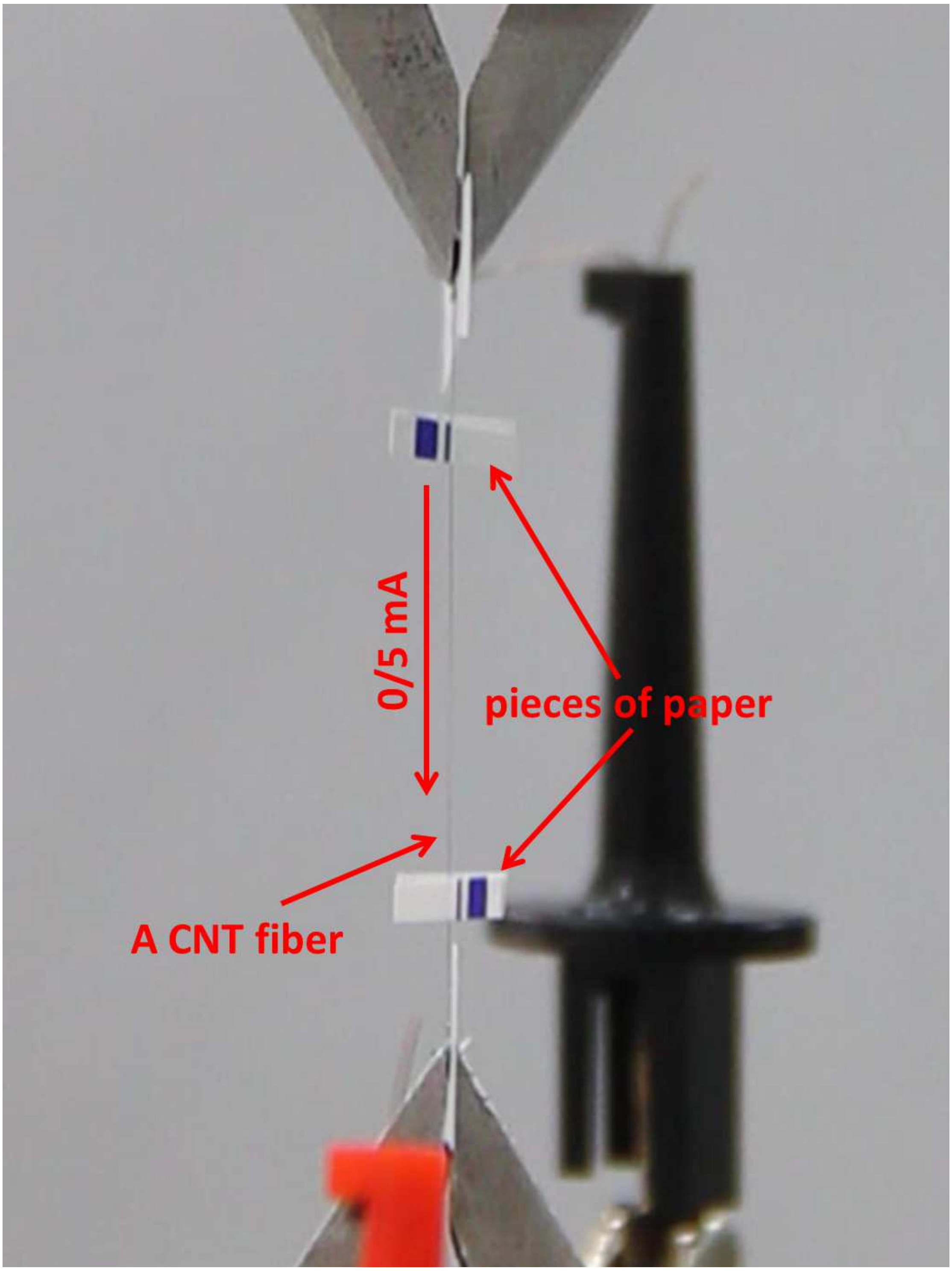

Figure S2. Photograph of the experimental setup shown in Movie 4.

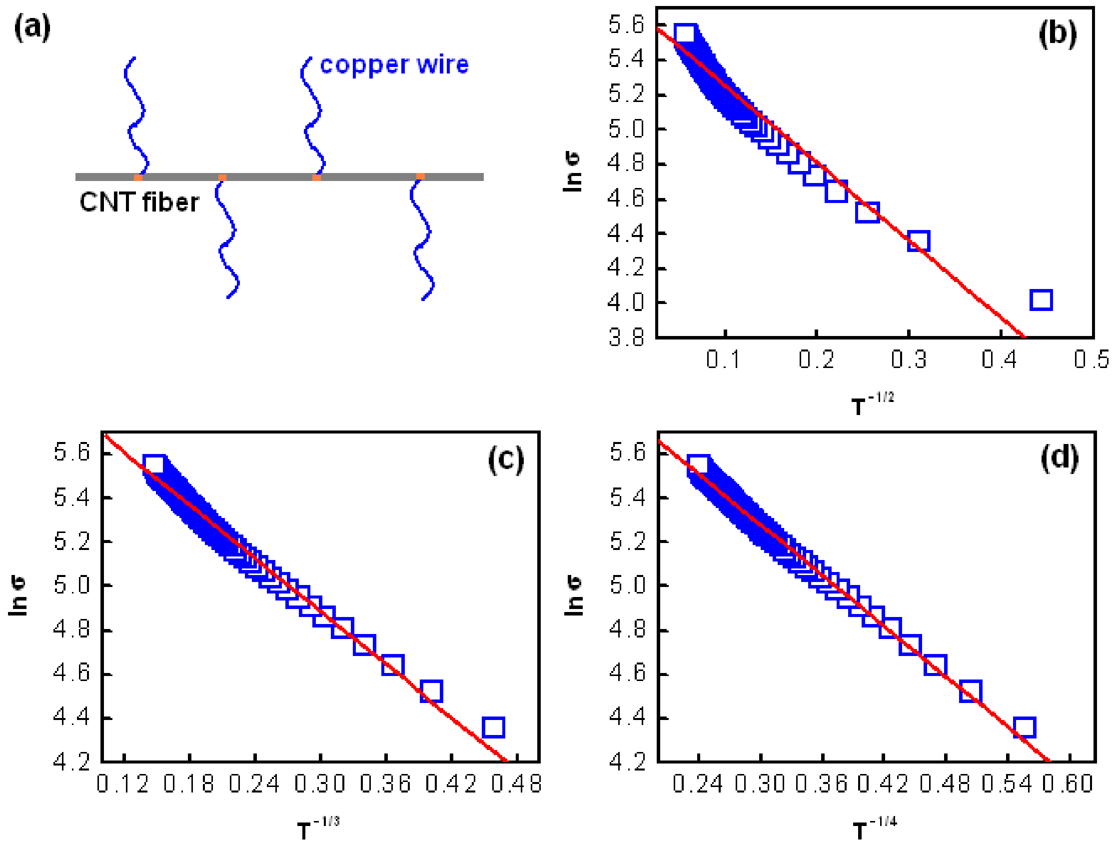

Figure S3. Scaling of electrical conductivity (σ) with temperature (T) according to the equation of $\sigma \propto \exp(-A/T[1/(d+1)])$ based on the Mott's hopping model, where A is a constant and d is the dimensionality. **a.** The schematic illustration of the measurement based on a four-probe method. **b.** The plot of lnσ versus $T^{-1/2}$ (for d = 1). **c.** The plot of lnσ versus $T^{-1/3}$ (for d = 2). **d.** The plot of lnσ versus $T^{-1/4}$ (for d = 3). The results also indicate that the electron transport of CNT fiber is consistent with a three-dimensional hopping mechanism. [S5]

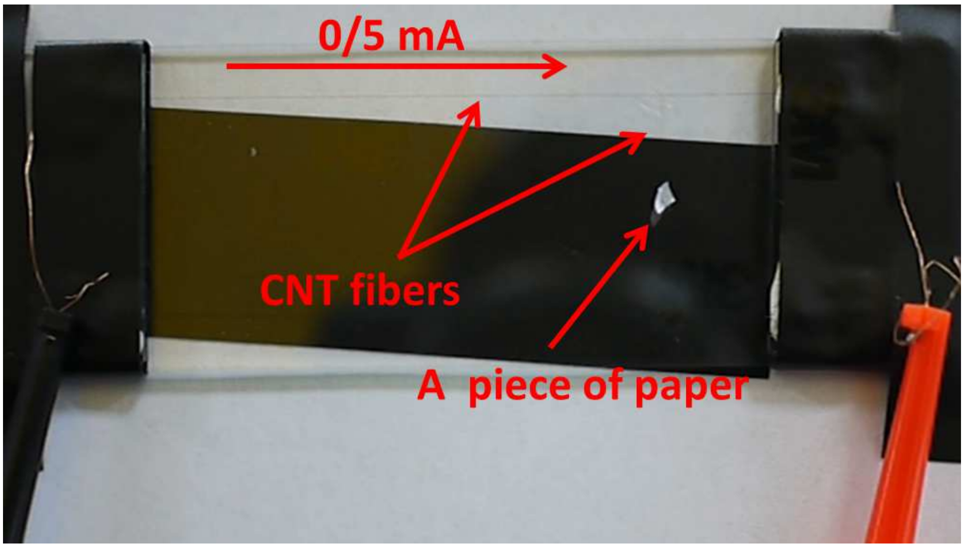

Figure S4. Photograph of the experimental setup shown in Movie S6. The CNT fiber which saw the current had a length of 4 cm, while the CNT shaft between the object and the CNT fiber had a length of 8.5 mm.

Reference for the Supporting Information

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