Electronic Supplementary Material (ESI) for RSC Advances.

Supporting Information

Title: Mechanical Bending Property of Sodium Titanate ($Na_2Ti_3O_7$) Nanowires

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Supplementary Figures

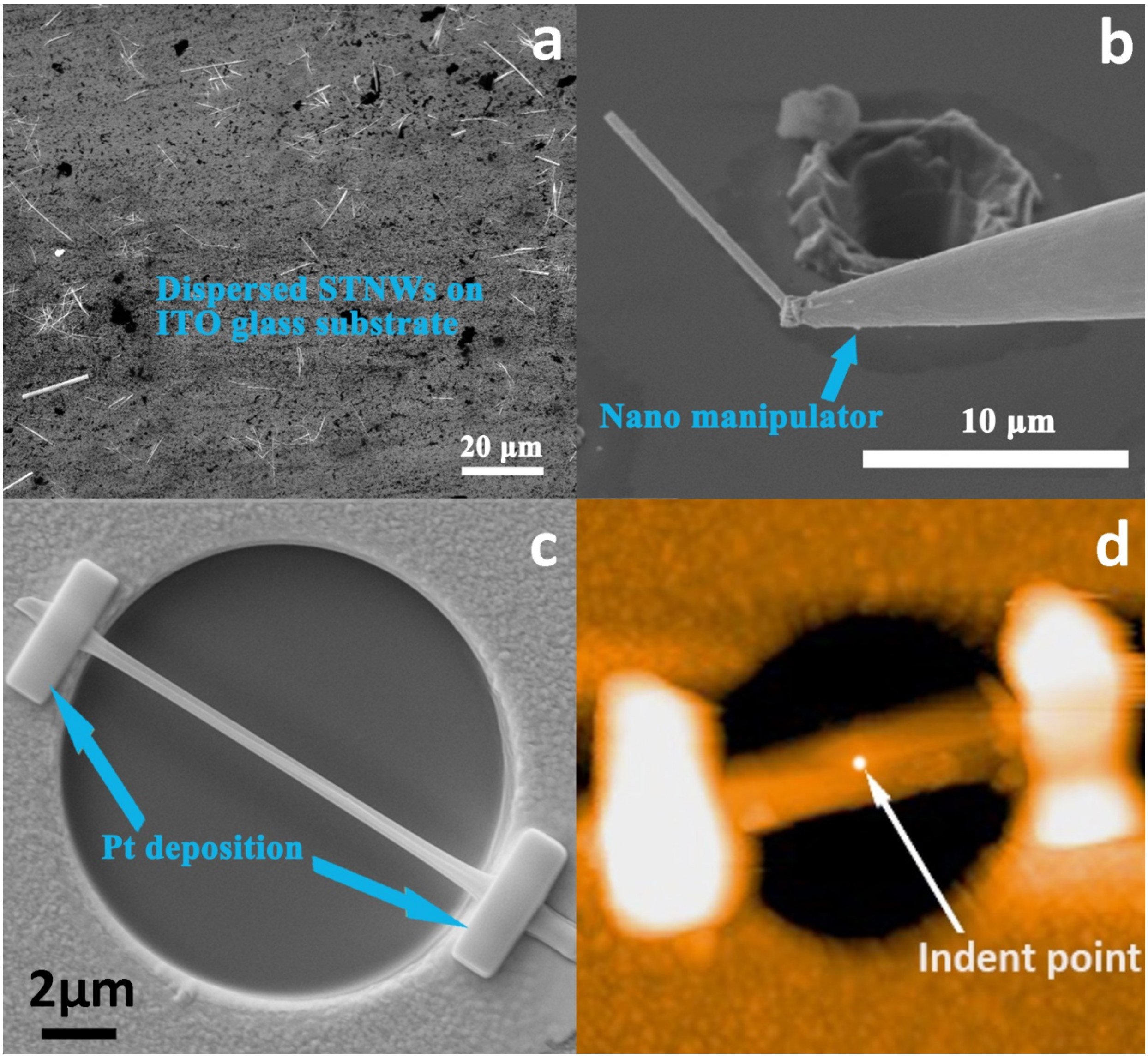

Figure S1. (a) SEM image of sodium titanate nanowires ($Na_2Ti_3O_7$ NW) dispersed over ITO glass surface; graph (b) shows a single $Na_2Ti_3O_7$ NW being picked up by nanomanipulator; image (c) is the completed bending test sample where both ends of the bridged $Na_2Ti_3O_7$ NW is fixed by Pt deposition; image (d) shows the AFM contact mode topography image of a bridged $Na_2Ti_3O_7$ NW sample whose middle point can be accurately determined to apply a force loading.

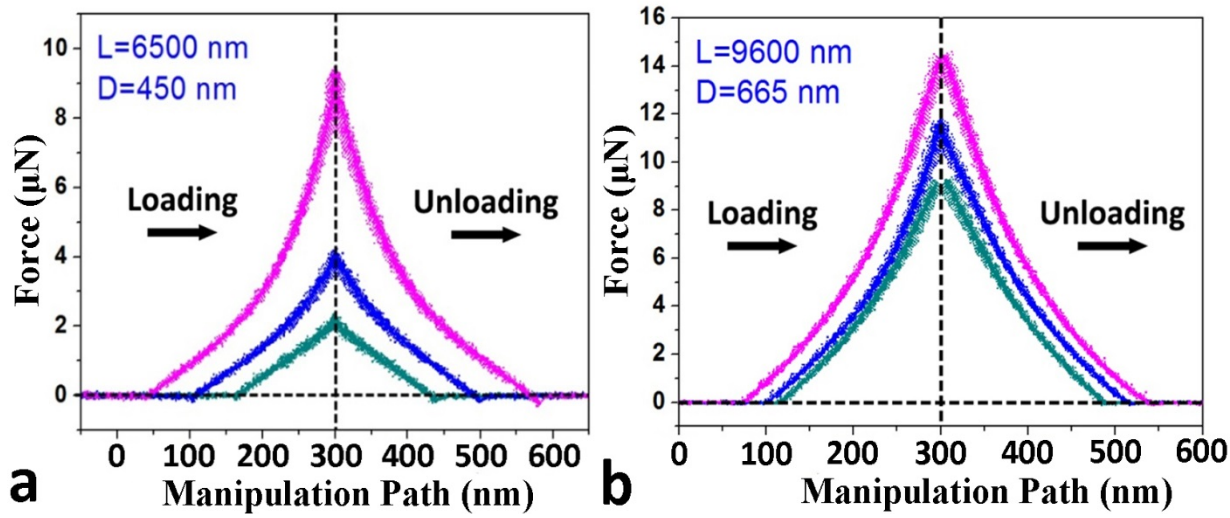

Figure S2. *F-d* curve showing the bending behavior of $Na_2Ti_3O_7$ NWs of different wire size under different force level during loading-unloading manipulations.

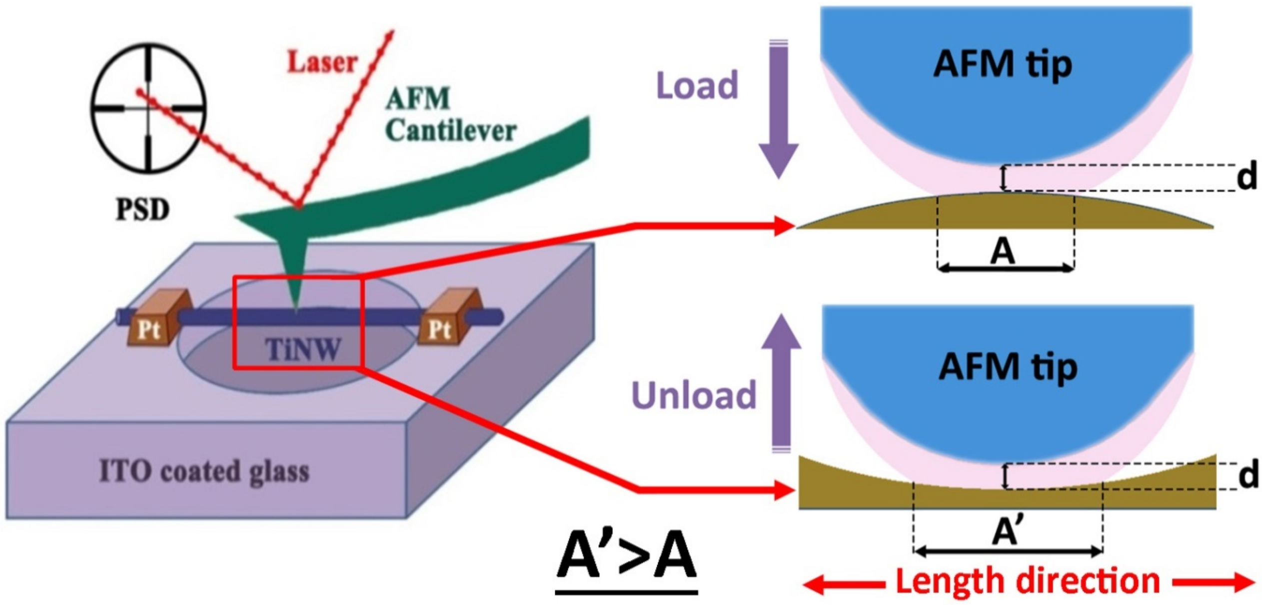

Figure S3. Schematic illustration of difference in attractive force between loading and unloading situations on a bridged $Na_2Ti_3O_7$ NW indented by AFM tip. At the same distance (d) between the AFM tip and sample surface, the contact area (A) is larger in the case of unloading than during loading.

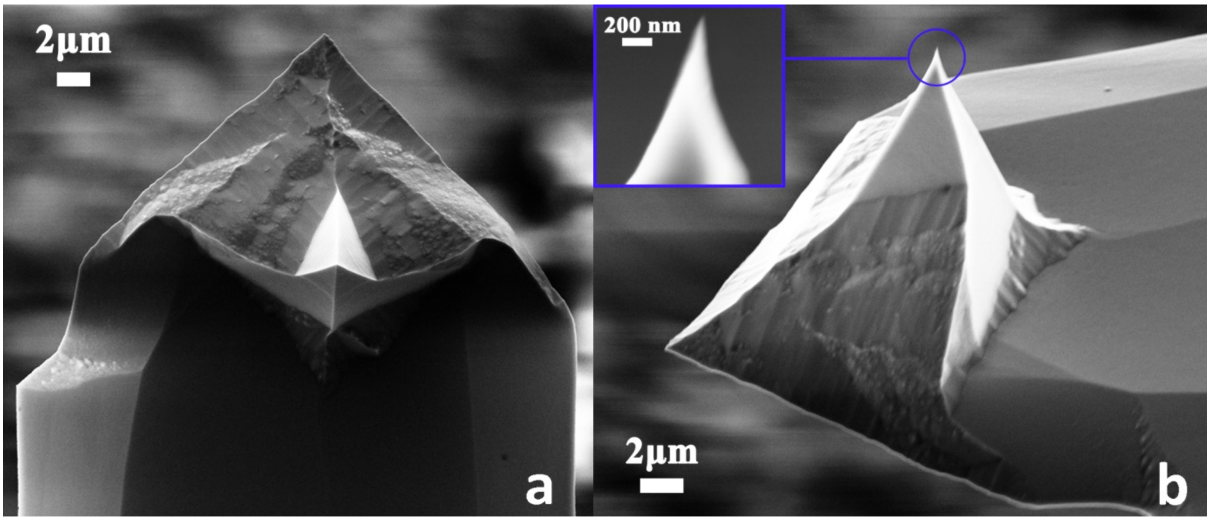

Figure S4. SEM image of the ACL-A cantilever from (a) top view and (b) side view; the blue inset shows the cantilever tip which has a tip radius of 10 nm.

Supplementary Text

Surface Effects

According to Zhan and Gu,[1] a more comprehensive relation between the force and displacement can be derived by including the influences from the surface elasticity E_s, surface residual stress τ_0, intrinsic residual stress, and the axial extension into the beam theory (denoted as EBT-SA):

$$F = \frac{192(EI)^*}{L^3} d \left(1 + \frac{\mu H^0 L^2}{48(EI)^*} + \frac{(EA)^* + 2\mu E_s h}{24(EI)^*} d^2\right) \tag{1}$$

Here, the effective bending rigidity $(EI)^* = EI + E_s bh^2/2 + E_s h^3/6$, and the effective extensional rigidity $(EA)^* = EA + 2E_s b + 2E_s h$. The residual surface stress is $H^0 = 2\tau_0 h$, and μ is a constant related to the intrinsic residual stress. Considering all mechanical properties as variables including E, E_s, τ_0 and μ, we adopted the F-d data with $d<0.5h$ to fit with Eq. (1) and the remainder were fitted using the data for $d>0.5h$ while keeping the other parameters constant.

Calibration of AFM Cantilever

The force-deflection (*F-d*) curves show the deflection of the AFM cantilever at the free end as it press downward the sample (increasing force) and away from the sample surface (decreasing force). The movement of the *Z* axis scanner is generated by the internal strain gauge of the AFM, while the force is measured *via* the output of the position-sensitive detector (PSD). Calibration of the spring constant and deflection sensitivity of the cantilever is practiced to convert the voltage signal to force. For the calibration, a well-know Sader's method is used to determine the spring constant of each cantilever used in the test.[2] To obtain the displacement of the nanowire in length, deflection sensitivity is first calibrated *via* indenting the AFM tip on a hard ITO surface where the dash curve (Figure S5a) is obtained. The solid line was obtained from contacting the tip with the bridged titanate nanowire. The deflection of the nanowire bridge at a certain force f is given by $\Delta Z = Z'(f) - Z(f)$, where a point force of load f is applied at middle point. Both the cantilever and the nanowire can be regarded as a tiny spring and both the tip and the nanowire can move during the bending process. Since there is deflection occurred on the nanowire, the *Z* scanner must move further on applying the same force. As a result, the *F-d* curve slope is smaller than that on the hard surface. Therefore, the deflection (ΔZ) of the nanowire at certain force could be derived as below:

$$\Delta Z = Z'(f) - Z(f) = f\,\frac{\tan\alpha - \tan\beta}{\tan\alpha \tan\beta} \tag{2}$$

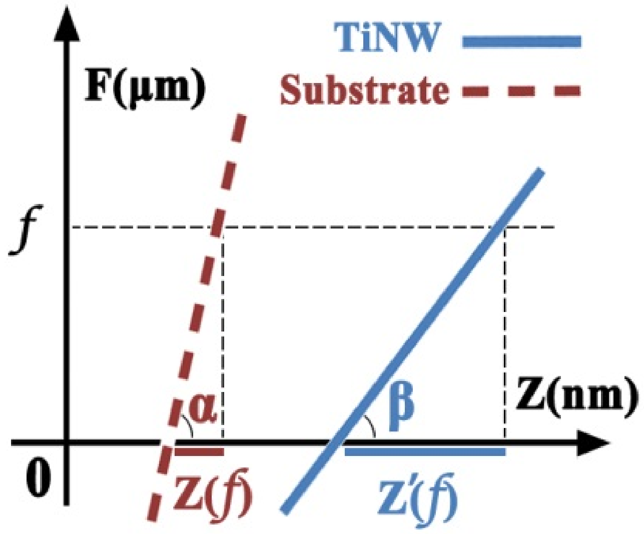

Figure S5 Diagram of a linear part of force-deflection (*F-d*) curve. The dash line represents the curve obtained from tip contact on the rigid ITO substrate, and the solid line represents that obtained from tip contact on the nanowire.

Reference

[1] H. Zhan, Y. Gu, Modified Beam Theories for Bending Properties of Nanowires Considering Surface/Intrinsic Effects and Axial Extension Effect. *J. Appl. Phys*. **2012**, *111*, 0843051.

[2] J.E. Sader, J.W. Chon, P. Mulvaney, Calibration of Rectangular Atomic Force Microscope Cantilevers. *Rev. Sci. Instrum.* **1999**, *70*, 3967.