



Fig. 2 FFT patterns and structural model of a T-carbon nanowire. FFT patterns with **a** zone axis of $[2, 1, 1]$, **b** zone axis between $[3, 1, 0]$ and $[5, 1, 0]$ with an angle from **a** of 27° , and **c** zone axis close to $[5, 1, 1]$ with an angle from **a** of 18° and an angle from **b** of 10° (scale bar = 5 nm^{-1}). **d** Structural model of T-carbon (Fd $\bar{3}m$, lattice constant = 7.80 \AA)

quartz container with an optical path length of 40 mm and preserved under a nitrogen atmosphere. A Q-switched laser with a wavelength of 532 nm (doubled from a Nd:VAN laser with a wavelength of 1064 nm), pulse duration of 10 ps, repetition frequency of 1000 Hz, and pulse power of 75 mW was applied. The laser was focused 0.5 cm away from the front wall of the self-designed container with a beam size of 0.5 mm. The suspension was irradiated by the laser beam for 1 h while it was kept under a nitrogen atmosphere and stirred with a magnetic stirring bar. The suspension became transparent after the laser reaction. The as-produced gas was collected for further analysis.

Lattice structures of T-carbon. Many unreacted MWCNTs and amorphous phases in addition to the NWs were observed by HRTEM from the suspension after laser irradiation (Supplementary Fig. 2). The NWs were observed to have the same crystal planes and interplanar crystal spacings, which are distinguishable from unreacted MWCNTs (Fig. 1a and Supplementary Fig. 3a) and amorphous phases (Supplementary Fig. 3b). Two sets of crystal planes with an interplanar crystal spacing of $1.95 \pm 0.01 \text{ \AA}$ intersected with an interplanar angle of $90 \pm 2^\circ$ were observed (Fig. 1b). A fast Fourier transform (FFT) pattern calculated from the HRTEM image is shown in Fig. 1c. The FFT pattern shows a square pattern with vector OR_1 corresponding to a lattice fringe spacing of $2.76 \pm 0.01 \text{ \AA}$ and vector OR_2 corresponding to a lattice fringe spacing of $1.95 \pm 0.01 \text{ \AA}$, indicating a cubic or tetragonal crystal system. FFT patterns were used instead of selected area electron diffraction (SAED) for structure analysis since the NWs were

unstable under SAED measurement conditions where an electron flux of several orders of magnitude larger than $10^5 \text{ [e] nm}^{-2} \text{ s}^{-1}$ was used. Tilting the NWs to other desired zone axes is a big challenge since the NWs are only about 10–20 nm wide (hard to observe Kikuchi lines). The analysis of many NWs with different zone axes parallel to the electron beam direction was adopted for further lattice characterization. The FFT of another NW gives a hexagonal pattern corresponding to lattice fringe spacing of $2.76 \pm 0.01 \text{ \AA}$ as shown in Fig. 1d. The square and hexagonal FFT patterns of the as-produced NWs suggest a cubic crystal lattice.

The reagents in the reaction system include MWCNTs and methanol only. Hence, only carbon, oxygen, and hydrogen elements are contained in the products. Electron energy loss spectroscopy (EELS) was adopted to determine the valence, chemical bonding, and atomic composition of the as-produced NWs (Fig. 1e)³⁴. Background correction was carried out for the EELS spectra before calculation of the σ/π ratio to eliminate the effects of carbon film. Only the electron transition from 1-s level to σ^* band was observed from the carbon *k*-edge spectrum, where the electronic transition from 1-s level to π^* band is negligible (Fig. 1e). The $(\pi^*/(\pi^* + \sigma^*))$ ratio of the NWs was estimated to be 0.04 ± 0.01 . The sp^2 ratio was calculated to be $16 \pm 4\%$ due to the surrounding amorphous structures. The carbon NWs are supposed to be composed of only sp^3 carbon, which is similar to diamond³⁵. The $(\pi^*/(\pi^* + \sigma^*))$ ratio of the unreacted MWCNTs (Supplementary Fig. 3a) was estimated to be 0.13 ± 0.01 according to the carbon *k*-edge (Supplementary Fig. 3c). The ratio of sp^2 carbon is calculated to be $51.6 \pm 0.03\%$ ^{13, 36}. The high sp^3 ratio of the NWs is consistent with the T-carbon structure.