Dynamic Observation on the Growth Behaviors in Manganese Silicide/Silicon Nanowire Heterostructures

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Supporting video-2: The video shows the dynamic growth process of MnSi in Si/Al_2O_3 core-shell nanowire structure at 500 ℃.

Supporting video-3: The video shows the high magnitude of the dynamic growth process of MnSi in Si/Al_2O_3 core-shell nanowire structure at 500 ℃.

Silicon nanowires synthesized through thermal evaporation and condensation method via VLS mechanism in the horizontal three zone furnace. The morphology was demonstrated by JOEL-6500F field emission scanning electron microscope. The structural identification was examined by Cs-corrected STEM.

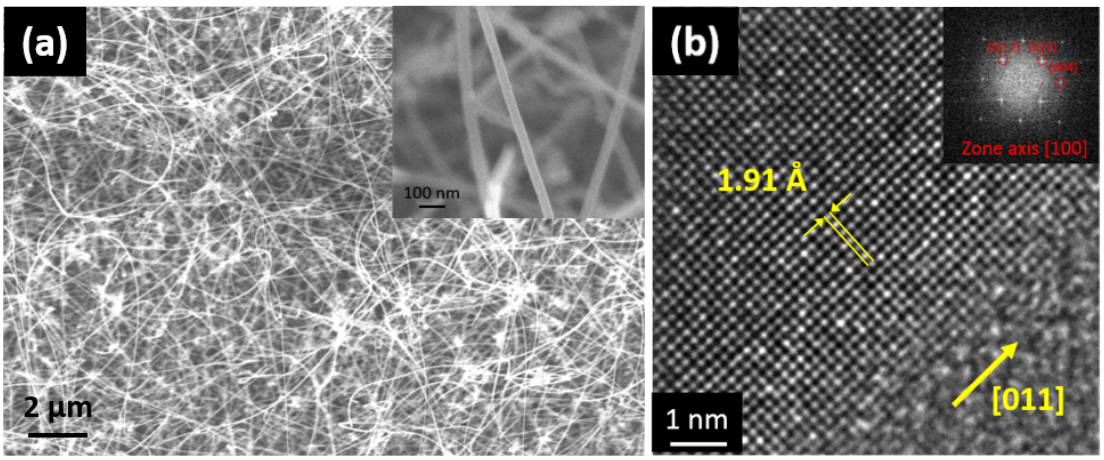

Fig. S1 (a) SEM image of the as-grown silicon nanowires. The inset shows the image of Si NWs with high magnification. (b) High-resolution TEM image of the Si NW. The inset is the corresponding fast fourier transform diffraction pattern, indicating the [100] zone axis and [011] growth direction.

To prepare the specimens for *in-situ* TEM observation, nanowire were dispersed onto Si_3N_4 (60nm) membrane by wet transport method. Then, coating the PMMA and e-beam lithography was carried out to define the pads where the Manganese was deposited by E-gun evaporator at the following step. After lift-off process, the reaction device fabrication was completed.

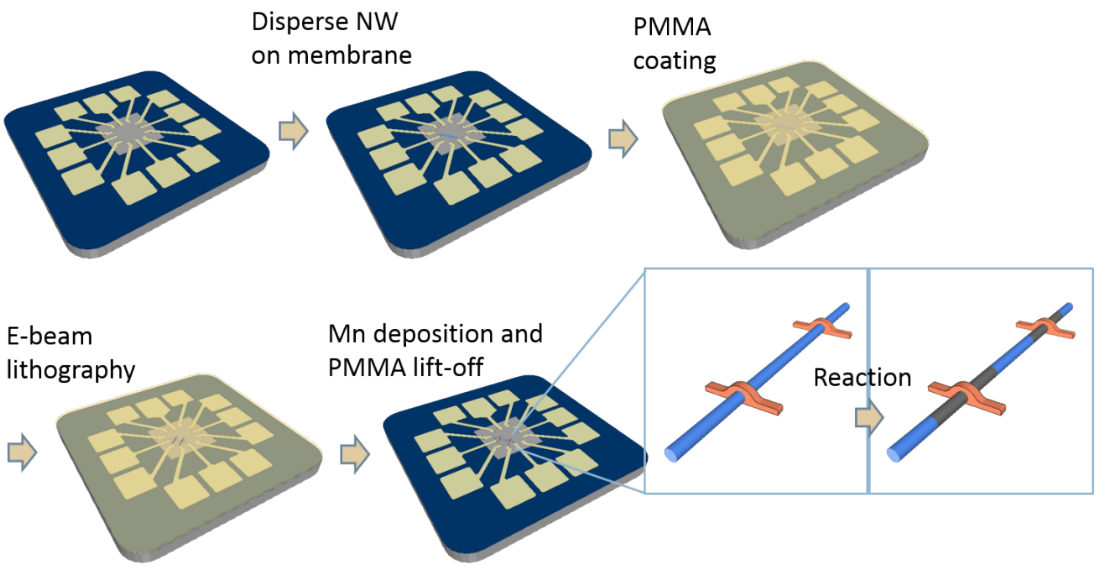

Fig. S2 The fabrication procedures of *in-situ* TEM samples and the schematic illustration of the reaction device.

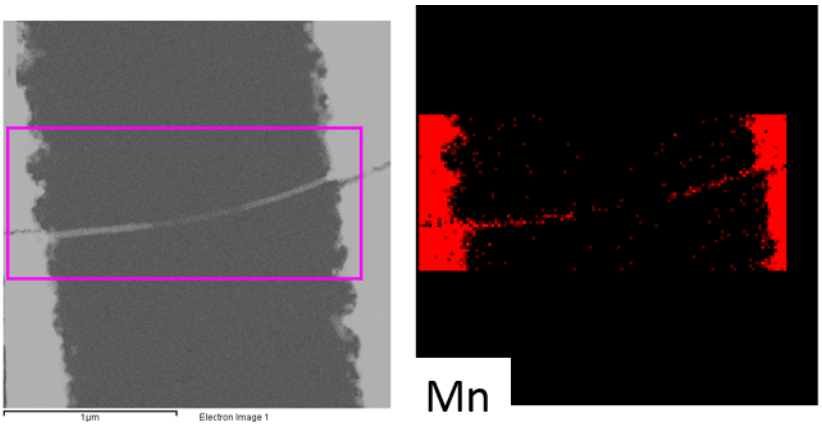

Fig. S3 EDS mapping of Mn silicide/Si/Mn silicide nanowire heterostructure.

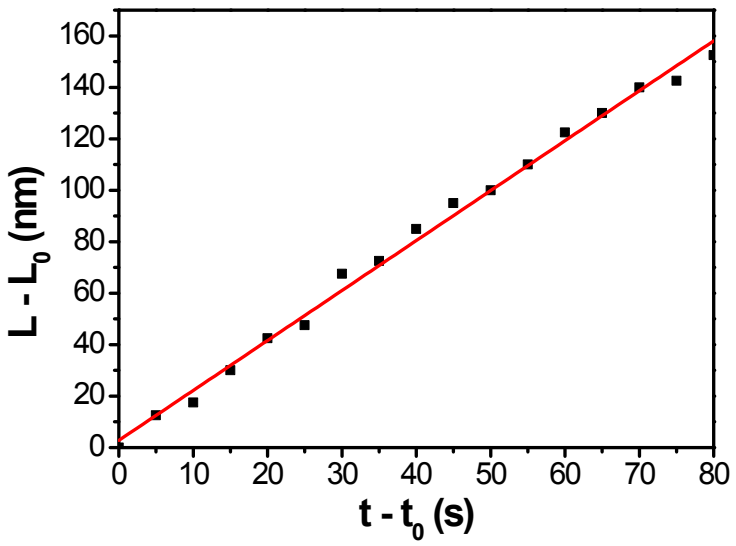

Fig. S4 The plot of MnSi reaction length as a function of time in the Al_2O_3-coated Si nanowire.

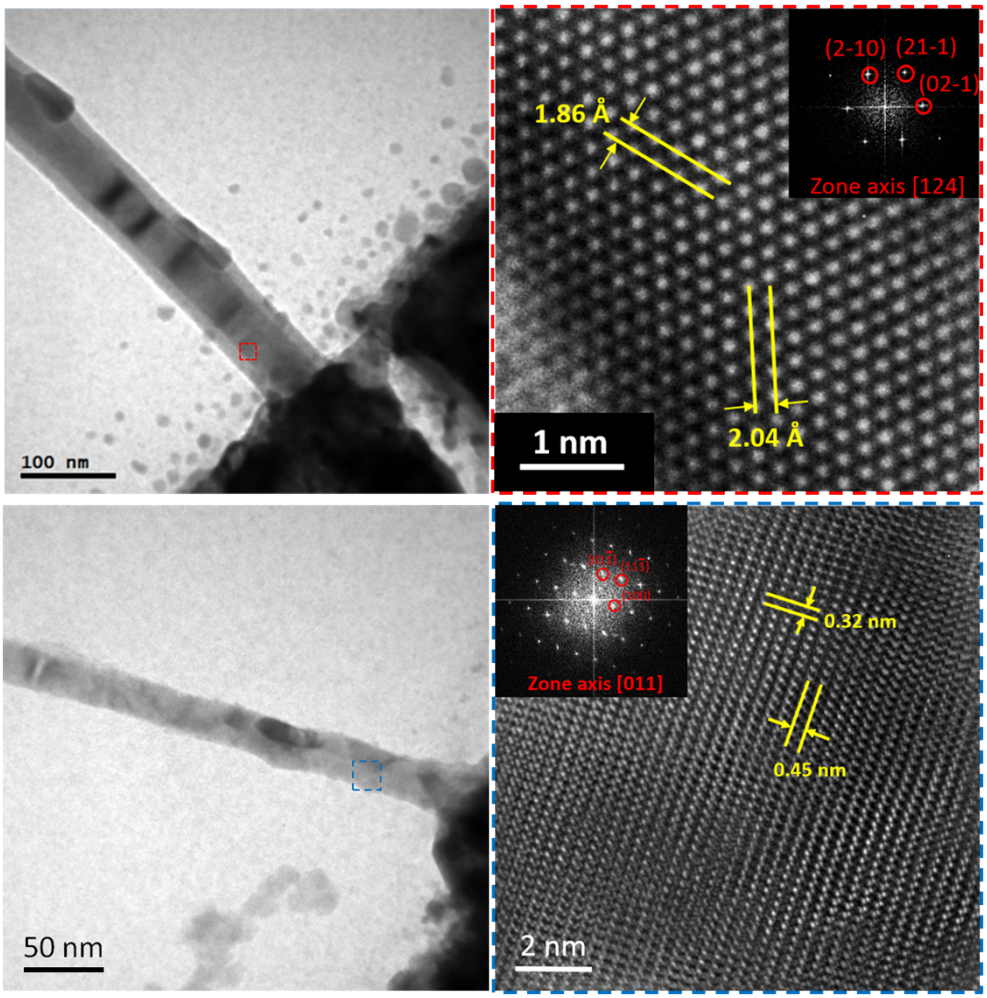

Fig. S5 TEM images and High resolution TEM images of both conditions (Bare Si nanowire and Si nanowire coated with Al_2O_3). Only one phase, MnSi, was observed.

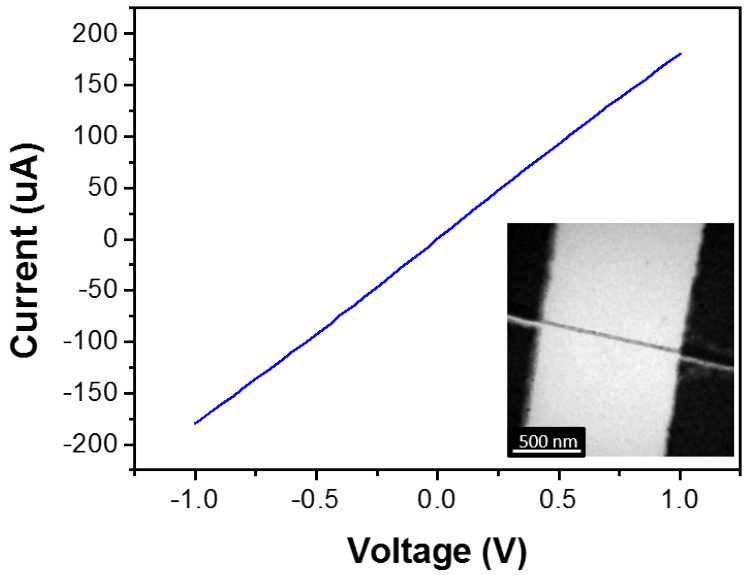

Fig. S6 I-V measurement of single MnSi nanowire. The inset is the SEM image of MnSi NW which was measured.

I-V measurement of the MnSi/Si/MnSi nanowire heterostructures depicted the Schottky-diode-like (SDL) behavior. The result shows that the current increases as the channel length decreases and according to the formula in fig. S5(d), we calculate the effective barrier height ψ_B with a value of 0.42 eV.

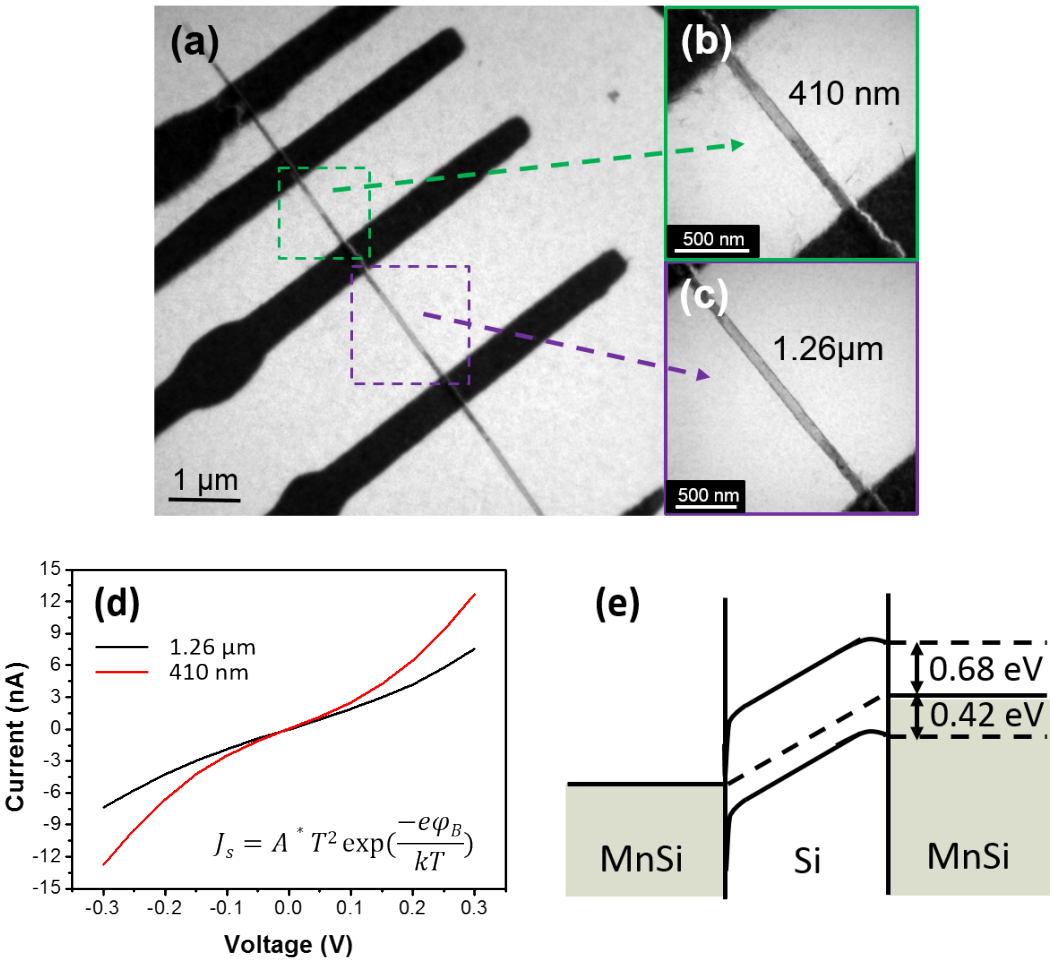

Fig. S7 (a) Low magnitude TEM image of MnSi/Si/MnSi nano-heterostructures device. (b) and (c) show different channel lengths of 410 nm and 1.26 μm formed by solid-state reaction at 500 °C, respectively. (d) The electron transport property of MnSi/Si/MnSi nano-heterostructures device. (e) Band diagram of the MnSi/Si/MnSi nano-heterostructures

In-situ TEM videos of the dynamic reaction of the manganese silicide/Si/manganese silicide nanowire heterostructures.

Supporting video-1: The video shows the dynamic growth process of MnSi at 500 ℃. This video shows that the formation of the first MnSi was formed at the surface of nanowire.

Supporting video-2: The video shows the dynamic growth process of MnSi in Si/Al_2O_3 core-shell nanowire structure at 500 ℃. It suggests that the radial growth of MnSi starts from the center rather than from the edge of the nanowire.

Supporting video-3: The video shows the high magnitude of the dynamic growth process of MnSi in Si/Al_2O_3 core-shell nanowire structure at 500 ℃. The curvature presented near the edge of Si/oxide interface during the growth process may due to the high surface energy of silicide/oxide interface. Thus, it would impede the formation of silicide.