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Sodium-Cutting: A New Top-Down Approach to Cut Open Nanostructures on Nonplanar Surfaces in Large Scale

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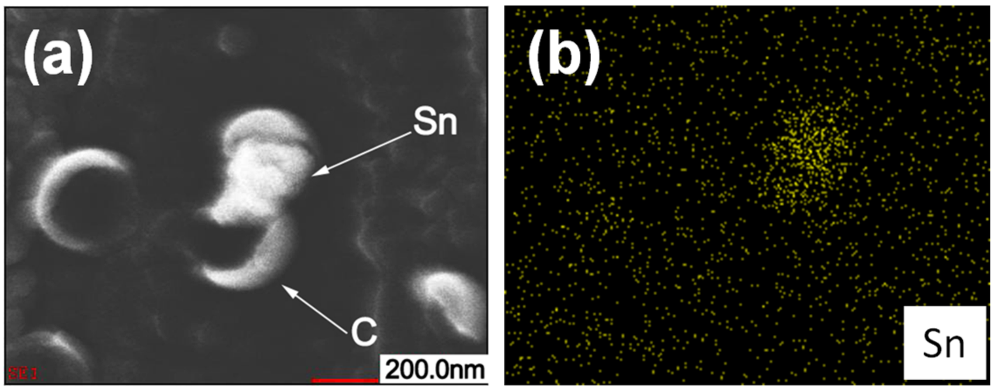

Figure S1. Elemental mapping of the a opened carbon sheath with the expanded Sn core part: (a) the FESEM image selected for elemental mapping, (b) the distribution of element Sn in FESEM image (a).

The asymmetric volumetric expansion of metallic Sn core was directly observed (Figure S1). The expanded Sn core (highlighted by arrow Sn) separated the two carbon bowls (highlighted by arrow C) apart when it grew into elongated shape to cut open the carbon nanosphere. The asymmetric volumetric expansion in Sn upon reversible insertion/extraction of sodium ions was also observed by Wang et al. during in situ TEM observation of pure tin nanoparticles (*Nano Lett*. 2012, 12, 5897). The asymmetric volumetric expansion of spherical tin cores suggests that the insertion of sodium ions into tin may not be symmetric inward radially from the spherical surface, or there could be changes in structures involved. Elemental mapping result of Sn distribution (Figure 3b) matched with the electron microscope image. This result confirms that the sodium alloying with tin core which expanded asymmetrically was the source of volumetric strains to cut open the carbon nanosphere sheaths into bowls.

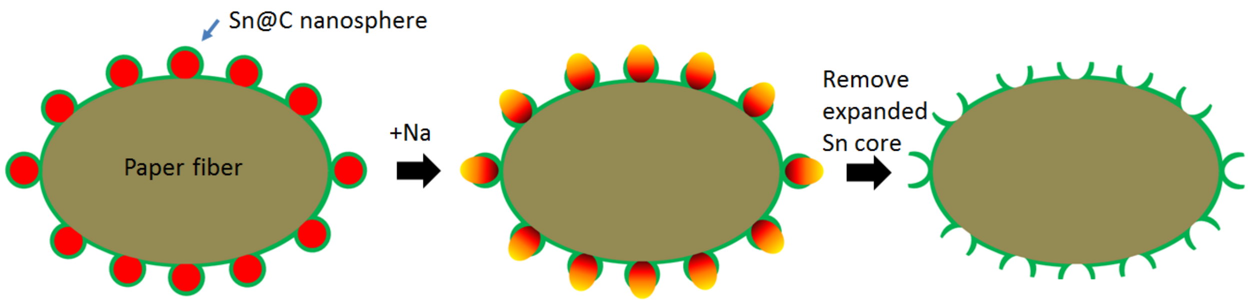

Figure S2. The preliminary results of Sn@C nanospheres on nonplanar paper fiber surface could be considered a special case of the “sodium-lithography” illustrated in Figure 6, where the thin film of carbon (G in Figure 6) encapsulated tin nanoparticles (R in Figure 6) on nonplanar surface of paper fibers (the curved surface in Figure 6) were broken. Instead of cubes, spheres were used in the current case. In another word, the proof-of-concept has been demonstrated in this paper. To better interpret our current results as one special case of “sodium-lithography”, we also used the above schematic to illustrate the “big-picture” of changes in our case of Sn@C nanospheres on nonplanar paper fibers to more clearly highlight the relevance of the current results and the idea of “sodium-lithography” discussed in the paper.

Possible electrochemical reactions involved and the corresponding volume expansions under different degree of sodiation are provided as the following according the literature (*Nano Lett*. 2012, 12, 5897):

(1). $2Sn + Na^+ + e^- \rightarrow NaSn_2$ volume expansion by 56%

(2). $2NaSn_2 + 7Na^+ + 7e^- \rightarrow Na_9Sn_4$ volume expansion by 252%

(3). $Na_9Sn_4 + 3Na^+ + 3e^- \rightarrow 4Na_3Sn$ volume expansion by 336%

(4). $4Na_3Sn + 3Na^+ + 3e^- \rightarrow Na_{15}Sn_4$ volume expansion by 420%

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