$FeSn_5$ and $CoSn_5$ new phases and their applications as high-performance anodes for Li-ion batteries

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We prepared uniform nanospheres (Figure 1) of the intermetallic $FeSn_5$ and $CoSn_5$ phases by a nanocrystal conversion-chemistry method. We resolved the crystal structures of $FeSn_5$ and $CoSn_5$, which were not established in the existing Fe-Sn and Co-Sn phase diagram. Both $FeSn_5$ and $CoSn_5$ nanospheres have tetragonal phase in P4/mcc space group. $FeSn_5$ nanospheres have the defect structure $Fe_{0.74}Sn_5$, whose 929 mAh g^{-1} theoretical capacity is the highest to date for the reported M (electrochemically inactive)-Sn intermetallic anodes. The cell performance of $Fe_{0.74}Sn_5$ nanospheres as an anode in Li-ion batteries has been studied. The measured capacity of $Fe_{0.74}Sn_5$ is around 750 mAh g^{-1} (Figure 2). As anodes in Li-ion batteries, $Co_{0.83}Sn_5$ has a theoretical capacity of 917 mAh g^{-1}; our nanospheres exhibit a relative stable capacity above 500 mAh g^{-1}. The change in the cycling profiles of the $Co_{0.83}Sn_5$ anode is much less pronounced than that of the $Fe_{0.74}Sn_5$ anode, so partially explaining why the cycling stability of $Co_{0.83}Sn_5$ is better.

Our work has two major implications: (1) Nanocrystal conversion-chemistry affords a powerful “bottom-up” approach to generate novel phases that are difficult to realize via other synthetic strategies; (2) the identical morphology and uniform size of $Co_{0.83}Sn_5$ and $Fe_{0.74}Sn_5$ nanospheres guarantee the validity of directly comparing their anode performance, so paving the way to identify which Sn-M alloy performs better.

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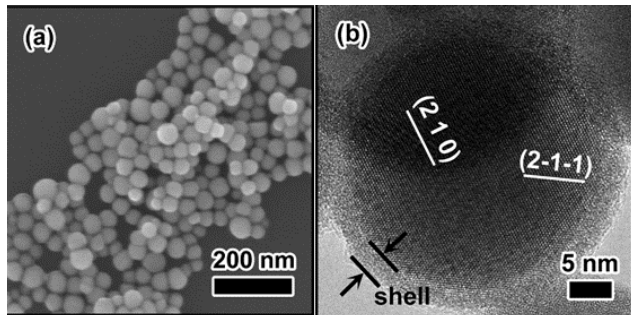

Figure 1. a) SEM image, and b) TEM image of $FeSn_5$ nanosphere.

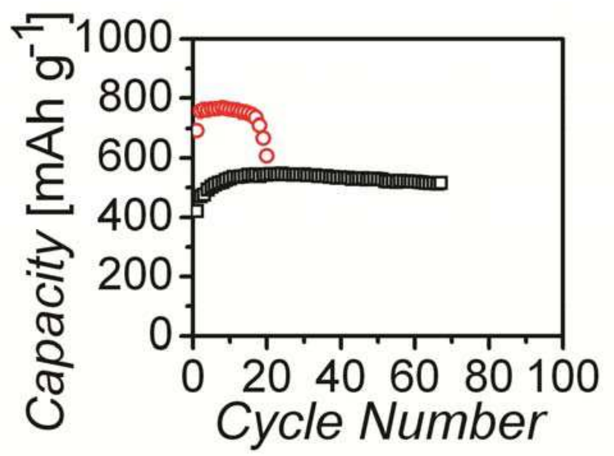

Figure 2. Reversible capacities of the $Co_{0.83}Sn_5$ nanospheres and the $Fe_{0.74}Sn_5$ nanospheres upon cycling.