Electronic Supplementary Material (ESI) for Energy & Environmental Science

Supplementary Information

Highly Stable Si-based multicomponent anodes for practical use in lithium-ion batteries

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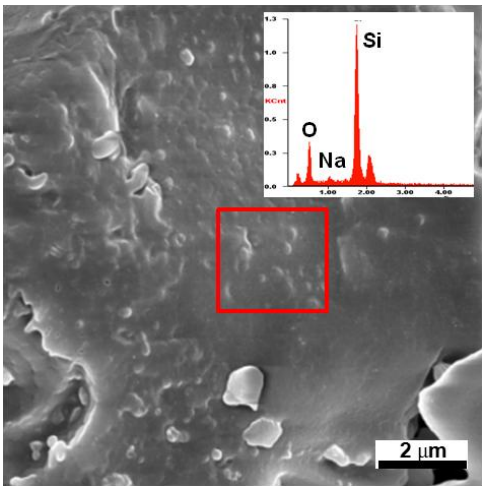

Figure S1. Characterization of Si-SiO-SiO_2 three-component prepared by thermal annealing of SiO particles in the presence of NaOH. Sodium silicate was formed on the surface of Si-based particles. Sodium peak was detected by EDAX profile. Sodium silicate was not detected by XRD due to a limited amount.

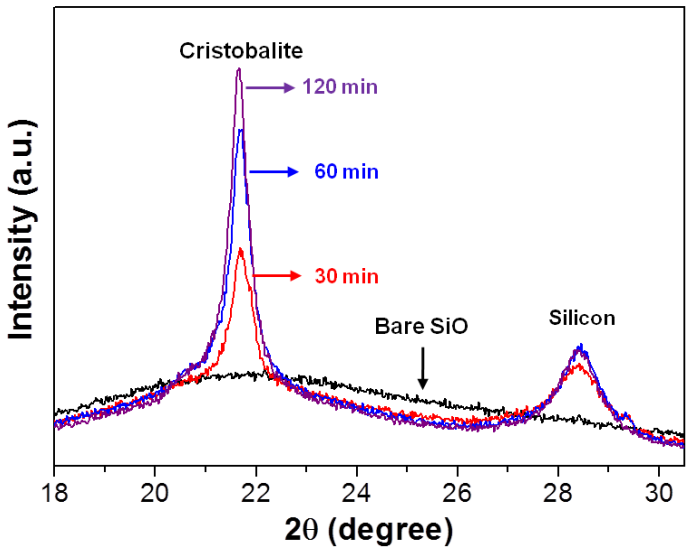

Figure S2. XRD patterns of bare SiO and Si-SiO-SiO_2 three-components prepared by three different annealing times at a fixed temperature of 800 ^{o}C. As the annealing time increased, the peak intensities of cristobalite and silicon increased with an increasing annealing time.

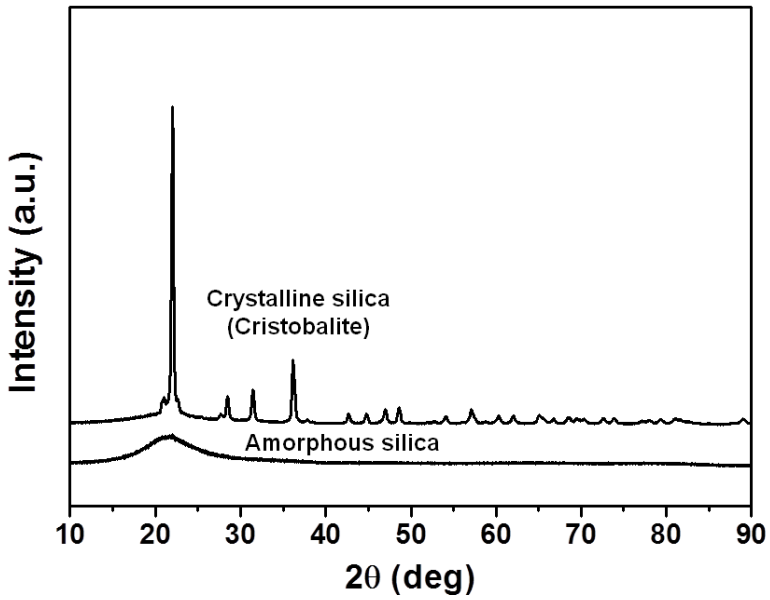

Figure S3. Crystallization of amorphous silica in the presence of NaOH (weight ratio of SiO to NaOH = 20:1) at 800 ^{o}C for 10 min . A great part of amorphous silica was converted into crystialline silica (cristobalite phase).

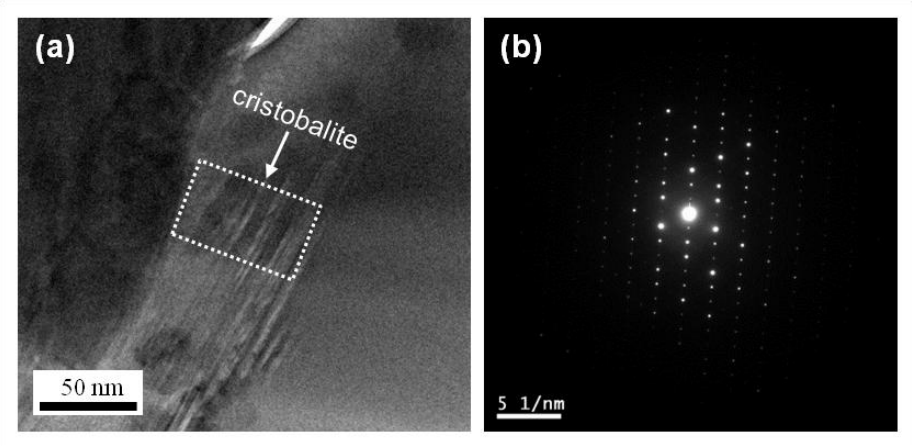

Figure S4. Characterization of Si-SiO-SiO_2 multicomponents. (a) TEM image showing cristobalite layers in the outer shell of samples annealed at 800 ^{o}C for 2 hr. Box area in the figure indicates the crystalline silica, cristobalite. (b) Selected area diffraction pattern obtained from the cristobalite layer.

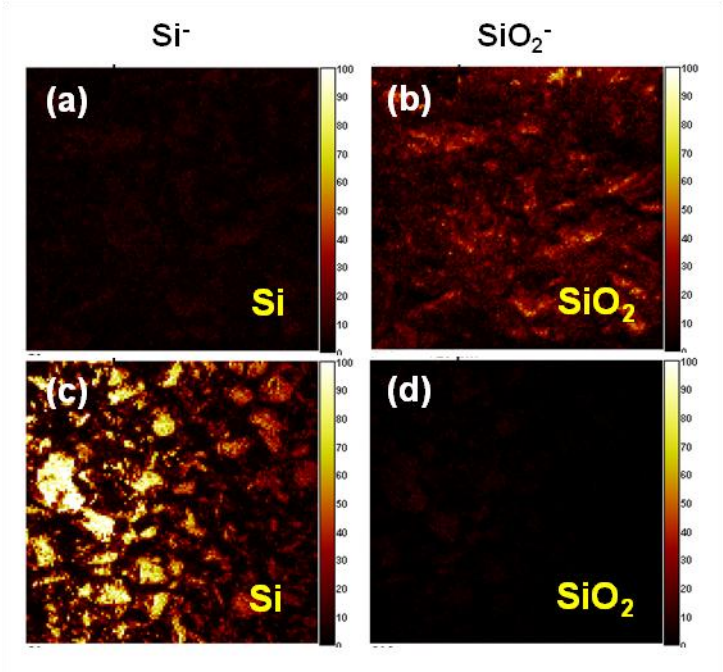

Figure S5. Time-of-flight secondary ion mass spectroscopic mapping of as-prepared Si-based multi-component (a, b) and depth profiled samples (c, d). The Si-based multi-component was prepared at 800 ^{o}C for 10 min in the presence of NaOH. The as-prepared Si-based multi-component showed that the SiO_2 phases were clearly detected on the top surface. After depth profiling (~10 nm), the intensity of Si phases were much stronger than those of SiO_2 phases. It indicated that most SiO_2 layer was etched out in the Si-based multi-component.

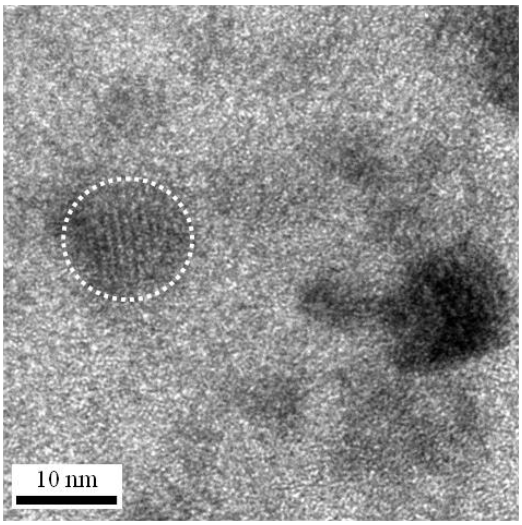

Figure S6. Bright-field TEM image showing nanocrystalline silicon dispersed in a SiO matrix. The dotted circle shows the crystalline silicon.

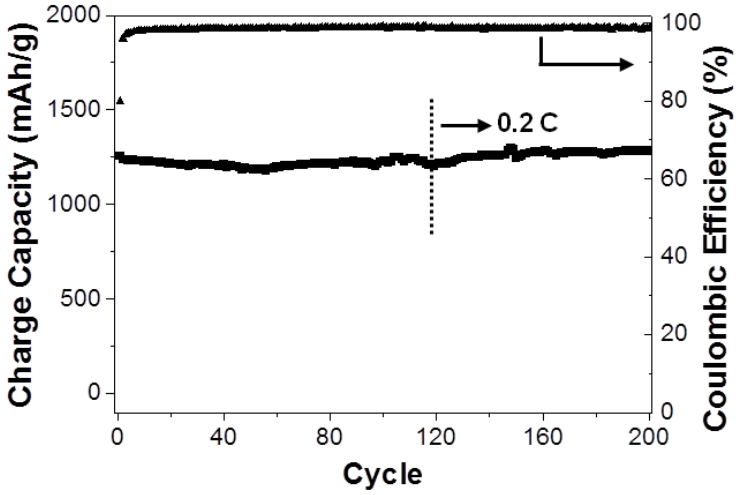

Figure S7. Cycling performance of c-Si-multi-20-1 electrode at 0.1C (1-120 cycles) and 0.2C (121-200 cycles) in the range of 0.005-2.0V.

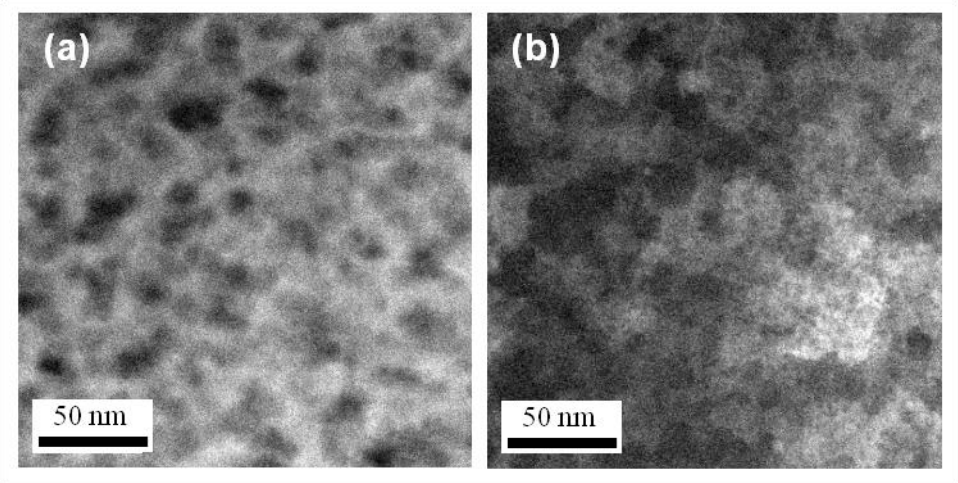

Figure S8. TEM images of c-Si-multi-20-1 and c-SiO electrodes after 100 cycles at a rate of 0.2C. The c-Si-multi sample showed that Si nanoparticles having an average diameter of 15 nm were uniformly dispersed in the SiOx matrix. However, a serious arregation of Si phase was observed in the c-SiO.

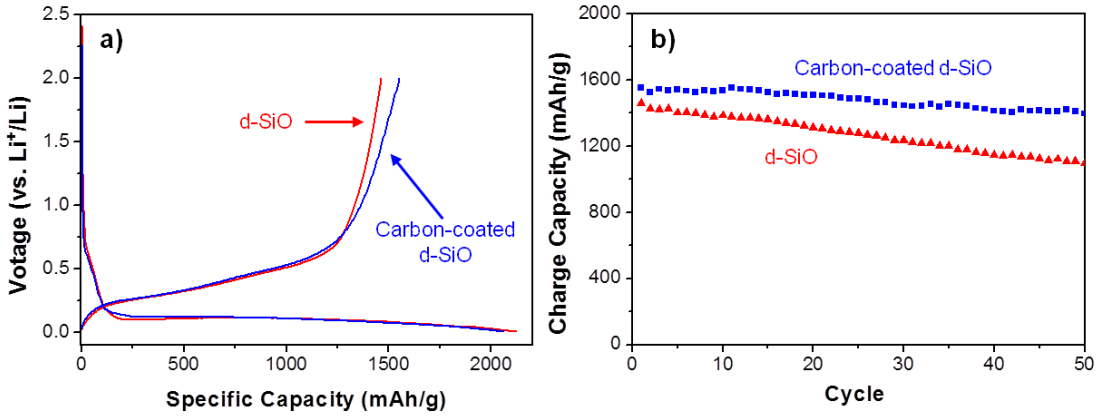

Figure S9. Electrochemical performances of SiO thermally annealed at 1000 ^{o}C for 3 hr without NaOH. a) Voltage profiles (First cycle) of disproportionate SiO (d-SiO) and the carbon-coated d-SiO obtained at 0.1 C rate in the range of 0.005 and 2.0 V. b) Cycle retention of the d-SiO and the carbon-coated d-SiO.