# Nanostructured Silicon for High Capacity Lithium Battery Anodes

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Electronic Supplementary Information (ESI): The following Data Tables summarize the morphology, composition, and method of preparation of those nanoscale and nanostructured silicon anodes reported in the recent literature, along with their electrochemical performance. When the appropriate electrochemical data was given in the report, we use the data directly. In all other cases, we have estimated the values from the information provided. For full details of the electrochemical performance, the reader is referred to the original report. In the tables, $Q_{d1}$ corresponds to the first discharge (delithiation) capacity. The irreversible capacity in the first cycle ($Q_{irr1}$) is calculated as the difference between the first charge (lithiation) and discharge capacities. The reversible capacity ($Q_{r,N}$) is the discharge capacity in the $N^{th}$ cycle.

**Table ESI-1** Thin Films—Silicon

| Morphology | Composition | Si (wt%) | Method | d Si (nm) | Potential (V) | $Q_{d1}$ (mAh/g) | $C_{irr1}$ (mAh/g) | $Q_{r,N}$ (mAh/g) | N Cycles | Reference |
|---|---|---|---|---|---|---|---|---|---|---|
| Thin film | Amorphous Si | 100 | Vacuum deposition onto pristine Ni foil | 50 | 0.0 - 2.5 | 3750 | | 3800 | 200 | 13 |
| Thin film | Amorphous Si | 100 | Vacuum deposition onto pristine Ni foil | 50 | 0.0 - 2.5 | 3350 | | 3100 | 100 | 13 |
| Thin film | Amorphous Si | 100 | Vacuum deposition onto pristine Ni foil | 100 | 0.0 - 2.5 | | | 1850 | 5 | 13 |
| Thin film | Amorphous Si | 100 | Vacuum deposition onto pristine Ni foil | 150 | 0.0 - 2.5 | 2445 | | 2300 | 200 | 13 |
| Thin film | Amorphous Si | 100 | Vacuum deposition onto pristine Ni foil | 150 | 0.0 - 2.5 | 2390 | 560 | 2390 | 5 | 13 |
| Thin film | Amorphous Si | 100 | Sputtering onto pristine Cu foils | 250 | 0.020 - 1.2 | 3500 | 600 | 3400 | 30 | 31 |
| Thin film | Amorphous Si | 100 | Sputtering onto pristine Cu foils | 1000 | 0.020 - 1.2 | 3080 | 300 | 2920 | 15 | 31 |
| Thin film | Amorphous Si | 100 | Sputtering onto pristine Cu foils | 250 | 0.020 - 1.2 | 3800 | 1280 | 3800 | 29 | 32 |
| Thin film | Amorphous Si | 100 | Sputtering onto pristine Cu foils | 1000 | 0.020 - 1.2 | 3050 | 340 | 3000 | 13 | 32 |
| Thin film | | 100 | Plasma enhanced chemical vapor deposition | 300 | 0 - 2 | 3015 | | 240 | 50 | 33 |
| Thin film—coated | | 100 | Plasma enhanced chemical vapor deposition, thermal evaporation | 300 | | 3260 | | 3000 | 50 | 33 |
| Thin film | Amorphous Si | 100 | Sputtering onto roughened Cu foil | 3000 | 0.01 - 1 | 2200 | | 1035 | 100 | 35 |
| Thin Film | Amorphous Si | 100 | Resistive evaporation | 100 | | 2500 | 1021 | 1800 | 50 | 37 |
| Thin Film | Nanocrystalline | 100 | Physical vapor transport/ballistic nanocrystal consolidation | 100 | | 1000 | 1400 | 525 | 50 | 37 |
| Thin film | | 100 | Vacuum deposition onto pristine Ni foil | 100 | | 2600 | 550 | 2100 | 400 | 38 |
| Thin film | | 100 | Vacuum deposition onto pristine Ni foil | 200 | | 3500 | 550 | 280 | 400 | 38 |
| Thin film | | 100 | Vacuum deposition onto mechanically roughened Ni foil | 340 | | 2300 | 470 | 1700 | 400 | 38 |
| Thin film | | 100 | Vacuum deposition onto mechanically roughened Ni foil | 520 | | 2440 | 560 | 1040 | 400 | 38 |
| Thin film | | 100 | Vacuum deposition onto chemically roughened Ni foil | 1000 | | 2650 | < 100 | 1700 | 200 | 38 |
| Thin film | Amorphous Si | 100 | Pulsed laser deposition onto pristine stainless steel | 1500 | 0.005 - 1.5 | 52.6 $\mu Ah/cm^2$ | 44.1 $\mu Ah/cm2$ | 40.0 $\mu Ah/cm^2$ | 70 | 40 |
| Thin film | Amorphous Si | 100 | Pulsed laser deposition onto pristine stainless steel | 3000 | 0.005 - 1.5 | 51.1 $\mu Ah/cm^2$ | ~ 10.5 $\mu Ah/cm^2$ | 8.24 $\mu Ah/cm^2$ | 70 | 40 |

$Q_{d1}$ = 1st delithiation capacity; $Q_{irr1}$ = irreversible capacity loss in the 1st cycle; $Q_{r,N}$ = reversible capacity in the $N^{th}$ cycle; d Si = thickness of Si film.

**Table ESI-1 (continued)** Thin Films—Silicon

| Morphology | Composition | Si (wt%) | Method | d Si (nm) | Potential (V) | $Q_{d1}$ (mAh/g) | $C_{irr1}$ (mAh/g) | $Q_{r,N}$ (mAh/g) | N Cycles | Reference |
|---|---|---|---|---|---|---|---|---|---|---|
| Thin film | Amorphous Si | 100 | Sputtering onto roughened Cu foil | 200 | 0.02 - 1.2 | 3550 | 300 | 2450 | 50 | 41 |
| Thin film | Amorphous Si | 100 | Sputtering onto roughened Cu foil | 200 | 0.02 - 1.2 | 3060 | 650 | 540 | 50 | 41 |
| Thin film | Amorphous Si | 100 | Sputtering onto roughened Cu foil | 200 | 0.02 - 1.2 | 3250 | 330 | 3050 | 10 | 41 |
| Thin film | Amorphous Si | 100 | Sputtering onto roughened Cu foil | 800 | 0.02 - 1.2 | 1300 | 200 | 1350 | 10 | 41 |
| Thin Film | | 100 | E-beam evaporation | 100 | 0.005 - 2 | 3560 | | 3420 | 50 | 42 |
| Thin Film | | 100 | E-beam evaporation | 100 | 0.005 - 2 | 3840 | | 3420 | 80 | 42 |
| Thin film | | 100 | E-beam evaporation | 200 | 0.005 - 2.0 | 3560 | 495 | 3500 | 45 | 43 |
| Thin film | | 100 | E-beam evaporation | 200 | 0.005 - 2.0 | 3600 | 485 | 3000 | 100 | 43 |
| Thin film | Amorphous Si | 100 | Sputtering onto pristine stainless steel | 100 | | 3400 | 950 | 2550 | 38 | 44 |
| Thin film | Amorphous Si | 100 | Sputtering onto roughened Ni foil | 100 | | 2942 | 690 | 2665 | 60 | 45 |
| Thin film | Amorphous Si | 100 | Sputtering onto roughened Cu foils | | 0.01 - 2.0 | 946 | 1480 | 125 | 30 | 46 |
| Thin film | Amorphous Si | 100 | Sputtering onto roughened Cu foils with Ni buffer layer | | 0.01 - 2.0 | 1622 | 1904 | 265 | 30 | 46 |
| Thin film | Amorphous Si | 100 | Chemical vapor deposition | 425 - 540 | 0.0 - 1.5 | 3768 | | 3025 | 40 | 47 |
| Thin film | Amorphous Si | 100 | Sputtering onto pristine Ni foil | 100 | 0.1 - 1.5 | 2530 | 770 | 2510 | 10 | 48 |
| Thin film | Amorphous Si | 100 | Sputtering onto pristine Ni foil | 100 | 0.1 - 1.5 | 1881 | 566 | 210 | 10 | 48 |
| Thin film | Amorphous Si | 100 | Resistive evaporation onto roughened Cu foil | 6000 | 0.01 - 2.0 | 1230 | 1670 | 960 | 20 | 49 |
| Thin film | Nanocrystalline | 100 | Pulsed laser deposition onto pristine stainless steel | 42 | 0.1 - 1.5 | 3500 | 600 | 2200 | 200 | 50 |
| Thin film | Nanocrystalline | 100 | Pulsed laser deposition onto pristine stainless steel | 42 | 0.1 - 1.5 | 4000 | 1750 | 190 | 200 | 50 |
| Thin film | Amorphous Si | 100 | Sputtering onto roughened Cu foil | 275 | 0 - 1.5 | 2148 | | 1317 | 500 | 51 |

$Q_{d1}$ = 1st delithiation capacity; $Q_{irr1}$ = irreversible capacity loss in the 1st cycle; $Q_{r,N}$ = reversible capacity in the Nth cycle; d Si = thickness of Si film.

**Table ESI-2.** Thin Films—Composite

| Morphology | Composition | Si (wt%) | Method | d Si (nm) | Potential (V) | $Q_{d1}$ (mAh/g) | $C_{irr1}$ (mAh/g) | $Q_{r,N}$ (mAh/g) | N Cycles | Reference |
|---|---|---|---|---|---|---|---|---|---|---|
| Thin film | Amorphous alloy with nanocrystalline phases | 86 | Sputtering onto roughened Cu foil | 3100 | 0.01 - 1 | 2000 | | 1210 | 100 | 35 |
| Thin film | Amorphous alloy with nanocrystalline phases | 60 | Sputtering onto roughened Cu foil | 3450 | 0.01 - 1 | 1800 | | 1240 | 100 | 35 |
| Thin film | Amorphous alloy with nanocrystalline phases | 27 | Sputtering onto roughened Cu foil | 4770 | 0.01 - 1 | 1500 | | 1180 | 100 | 35 |
| Thin film—multilayered | Fe/Si layers | | E-beam evaporation | 630 | 0 - 1.2 | 386 $\mu Ah/cm^2$ | | 376 $\mu Ah/cm^2$ | 46 | 39 |
| Thin film—multilayered | Fe/Si layers | | E-beam evaporation, annealing | 630 | 0 - 1.2 | 490 $\mu Ah/cm^2$ | | 436 $\mu Ah/cm^2$ | 50 | 39 |
| Thin film—codeposition | Nanocrystalline Cu embedded in amorphous Si | | Sputtering onto pristine Cu foil | | 0.0 - 2.0 | 405 $\mu Ah/cm^2um^1$ | 335 $\mu Ah/cm^2um^1$ | 350 $\mu Ah/cm^2um^1$ | 40 | 53 |

$Q_{d1}$ = 1st delithiation capacity; $Q_{irr1}$ = irreversible capacity loss in the 1st cycle; $Q_{r,N}$ = reversible capacity in the Nth cycle; d Si = thickness of composite film.

**Table ESI-3** Nanowires and Nanotubes—Silicon

| Morphology | Composition | Si (wt%) | Method | d Si (nm) | Potential (V) | $Q_{d1}$ (mAh/g) | $C_{irr1}$ (mAh/g) | $Q_{r,N}$ (mAh/g) | N Cycles | Reference |
|---|---|---|---|---|---|---|---|---|---|---|
| Pillars | Silicon | 100 | Reactive ion etching of Si substrates | 580 | 0.025 - 2 | 54 $\mu Ah/cm^2$ | 52 $\mu Ah/cm^2$ | 41 $\mu Ah/cm^2$ | 50 | 54 |
| Nanowire | Silicon | 100 | Chemical vapor deposition | 89 | 0.01 - 2.0 | 3124 | 1153 | 3120 | 10 | 55 |
| Nanowire | Silicon | 100 | Chemical vapor deposition | 89 | 0.01 - 2.0 | 3600 | | 3400 | 20 | 55 |
| Nanowire | Crystalline core/Amorphous shell | 100 | Chemical vapor deposition | | 0.01 - 2.0 | 2500 | 610 | 1975 | 30 | 56 |
| Nanowire | Crystalline core/Amorphous shell | 100 | Chemical vapor deposition | | 0.15 - 2.0 | 1060 | 200 | 900 | 100 | 56 |
| Nanotube | Polycrystalline Si | 100 | Chemical vapor deposition | 120 | 0.01 - 2.0 | 3360 | 500 | 2670 | 50 | 57 |
| Nanotube | Polycrystalline Si | 100 | Chemical vapor deposition | 120 | 0.01 - 2.0 | 2645 | 279 | 2160 | 50 | 57 |
| Nanowire | Silicon | 100 | Metal catalytic etching of Si | 20 - 300 | 0.02 - 2 | 2267 | 1390 | 1130 | 10 | 59 |
| Nanowire | Silicon | 100 | Chemical vapor deposition | 100 | 0.01 - 2.0 | 3706 | 119 | 1600 | 50 | 66 |

$Q_{d1}$ = 1st delithiation capacity; $Q_{irr1}$ = irreversible capacity loss in the 1st cycle; $Q_{r,N}$ = reversible capacity in the Nth cycle; d Si = diameter of nanowire or nanotube.

**Table ESI-4** Nanowires and Nanotubes—Composite

| Morphology | Composition | Si (wt%) | Method | d Si (nm) | Potential (V) | $Q_{d1}$ (mAh/g) | $C_{irr1}$ (mAh/g) | $Q_{r,N}$ (mAh/g) | N Cycles | Reference |
|---|---|---|---|---|---|---|---|---|---|---|
| Nanowire | Butyl-capped Si gel | | Chemical reduction | | 0 - 1.5 | 3163 | 501 | 2738 | 80 | 58 |
| Nanowire | Silicon nanowires/ Carbon coating | | Metal catalytic etching of Si, pyrolysis | 20 - 300 | 0.02 - 2 | 2810 | 534 | 1326 | 40 | 59 |
| Nanofiber | Silane - Carbon nanofibers | 88 | Chemical vapor deposition | | 0.01 - 1 | 2015 | 222 | 1710 | 50 | 60 |
| Nanotubes | Butyl-capped Si gel - $SnO_2$ nanotubes | 40 | Chemical reduction | 10 | 0 - 1.2 | 1838 | 990 | 1600 | 90 | 61 |
| Nanowire | Butyl-capped Si gel | | Chemical reduction | 200 - 250 | | 3247 | 401 | | | 62 |
| Nanowire | Silicon - sucrose – carbon black | 82 | Supercritical fluid-liquid-solid growth, pyrolysis | 25 | 0.01 - 1 | 2453 | 2997 | 410 | 75 | 63 |
| Nanowire | Silicon - sucrose - multi-walled carbon nanotubes | 98.5 | Supercritical fluid-liquid-solid growth, pyrolysis | 25 | 0.01 - 1 | 1500 | 2750 | 1050 | 75 | 63 |
| Nanowire | Silicon - graphite | 15 | Electroless Etching | 100 - 200 | 0.01 - 1.5 | 600 | 211 | 512 | 64 | 50 |
| Nanotube | Silicon - carbon nanotubes | | Chemical vapor deposition | 40 | 0.02 - 1.2 | 2049 | 503 | 2050 | 25 | 67 |

$Q_{d1}$ = 1$^{st}$ delithiation capacity; $Q_{irr1}$ = irreversible capacity loss in the 1$^{st}$ cycle; $Q_{r,N}$ = reversible capacity in the N$^{th}$ cycle; d Si = diameter of nanowire or nanotube.

## **Table ESI-5** Nanoparticles—Silicon

| Morphology | Composition | Si (wt%) | Method | d Si (nm) | Potential (V) | $Q_{d1}$ (mAh/g) | $C_{irr1}$ (mAh/g) | $Q_{r,N}$ (mAh/g) | N Cycles | Reference |
|---|---|---|---|---|---|---|---|---|---|---|
| Microcrystalline Si | Si | 100 | Milling | 3000 - 5000 | 0.05 - 1.2 | 900 | 100 | 800 | 10 | 78 |
| Microcrystalline Si | Si | 100 | Milling | 3000 | 0 - 1.2 | 500 | | 200 | 5 | 90 |
| Microcrystalline Si | Si | 100 | Milling | < 2000 | 0 - 1.2 | 765 | | 595 | 55 | 90 |
| Nanoparticles | Si | 100 | Commercial powder | 100 | | | 350 | 1200 | 700 | 91 |
| Nanocrystalline Si | Si | 100 | Solvothermal | 5 | 0 - 1.5 | 2649 | 1794 | 1880 | 40 | 114 |
| Nanocrystalline Si | Si | 100 | Solvothermal | 10 | 0 - 1.5 | 3380 | 830 | 2738 | 40 | 114 |
| Nanocrystalline Si | Si | 100 | Solvothermal | 20 | 0 - 1.5 | 3467 | 613 | 2323 | 40 | 114 |

$Q_{d1}$ = 1$^{st}$ delithiation capacity; $Q_{irr1}$ = irreversible capacity loss in the 1$^{st}$ cycle; $Q_{r,N}$ = reversible capacity in the N$^{th}$ cycle; d Si = diameter of nanoparticle.

## **Table ESI-6** Other Morphologies—Silicon

| Morphology | Composition | Si (wt%) | Method | d Si (nm) | Potential (V) | $Q_{d1}$ (mAh/g) | $C_{irr1}$ (mAh/g) | $Q_{r,N}$ (mAh/g) | N Cycles | Reference |
|---|---|---|---|---|---|---|---|---|---|---|
| Nest-like | Si | 100 | Solvothermal | | 0.02 - 1.6 | 3952 | | | | 106 |
| Nest-like | Si | 100 | Solvothermal | | 0.02 - 1.6 | 3052 | | 1095 | 48 | 106 |
| Coil-like | Si | 100 | Solvothermal | | 0.02 - 1.6 | 3550 | | | | 106 |

$Q_{d1}$ = 1$^{st}$ delithiation capacity; $Q_{irr1}$ = irreversible capacity loss in the 1$^{st}$ cycle; $Q_{r,N}$ = reversible capacity in the N$^{th}$ cycle; d Si = diameter of nanoparticle.

**Table ESI-7** Nanoparticles—Composite

| Morphology | Composition | Si (wt%) | Method | d Si (nm) | Potential (V) | $Q_{d1}$ (mAh/g) | $C_{irr1}$ (mAh/g) | $Q_{r,N}$ (mAh/g) | N Cycles | Reference |
|---|---|---|---|---|---|---|---|---|---|---|
| Nanocrystalline Si/ Graphite | Si - graphite | 10 atom % | Milling | ~ 40 | | 700 | | 380 | 20 | 68 |
| Nanocrystalline Si/ Graphite | Si - graphite | 20 atom % | Milling | ~ 10 | | 1040 | | 800 | 20 | 68 |
| Nanocrystalline Si/ $Ni/Ni_2Si$/graphite | Si - graphite - nickel stearate | 20 | Milling, thermal decomposition | | 0.001 - 1.5 | 680 | 260 | 495 | 30 | 79 |
| Silicon/Cellulose/ Carbon Black | Si - cellulose - carbon black (SE2) | 50 | Mixing, heat treatment | | 0 - 1.5 | 2560 ($2^{nd}$ cycle) | | 1800 | 50 | 85 |
| Silicon/Cellulose/ Carbon Black | Si - cellulose - carbon black (Super P) | 50 | Mixing, heat treatment | | 0 - 1.5 | 2820 ($2^{nd}$ cycle) | | 1300 | 50 | 85 |
| Nanocrystalline Si/ Nanocrystalline Ag | Si - $AgNO_3$ | 80 | Milling, electroless deposition | < 100 | 0.02 - 1.5 | 2347 | 382 | 1150 | 15 | 86 |
| Nanocrystalline Si/ Nanocrystalline Ag | Si - $AgNO_3$ | 64.1 | Milling, electroless deposition | | 0.01 - 1.2 | 700 | 250 | 620 | 30 | 87 |
| Si Nanoparticles/ Amorphous C | Si - carbon black | | Laser ablation, manual grinding | ~ 78 | 0 - 0.8 | 2780 | | 1300 | 22 | 89 |
| Si nanoparticles/ Graphite | $SiH_4$ - graphite | 20 | Pyrolysis | ~ 50 | 0.005 - 1.0 | 1350 | 350 | 900 | 115 | 92 |

$Q_{d1}$ = $1^{st}$ delithiation capacity; $Q_{irr1}$ = irreversible capacity loss in the $1^{st}$ cycle; $Q_{r,N}$ = reversible capacity in the $N^{th}$ cycle; d Si = diameter of Si in nanoparticle.

**Table ESI-7 (continued)** Nanoparticles—Composite

| Morphology | Composition | Si (wt%) | Method | d Si (nm) | Potential (V) | $Q_{d1}$ (mAh/g) | $C_{irr1}$ (mAh/g) | $Q_{r,N}$ (mAh/g) | N Cycles | Reference |
|---|---|---|---|---|---|---|---|---|---|---|
| Nanocrystalline Si/NiSi | Si - Ni | 49 | Milling | 40 | 0.001 - 1.2 | 1135 | 115 | 530 | 50 | 93 |
| Si Nanoparticles/TiC | Si - Li-Ti-O sol | 65 | Sol-gel synthesis with Si nanoparticles | 30 - 50 | 0.02 - 3 | 1250 | 790 | 1240 | 80 | 94 |
| Silicon-Tin alloy/Carbon | Si - Sn - C | 89 | Chemical reduction | 10 | 0 - 1.2 | 2032 | 500 | 1971 | 60 | 96 |
| Microcrystalline Si/ Microcrystalline SnSb | Si - SnSb | | Carbothermal reduction | 5 - 10 μm | 0.01 - 1.5 | 970 | 205 | 905 | 10 | 104 |
| Si particles/CNTs | Si - CNTs | | Electroless deposition, chemical vapor deposition | | 0.0 - 2.0 | 1675 | | 1245 | 12 | 105 |
| Silicon/Graphite/Single-walled Nanotubes | Si - SWNTs - graphite | 35 | Milling, heat treatment | | 0.02 - 1.2 | 960 | 922 | 865 | 30 | 107 |
| Silicon/Graphite/ SWNTs | Si - SWNTs - graphite | 45 | Milling, heat treatment | | 0.02 - 1.2 | 1121 | 751 | 922 | 30 | 107 |
| Silicon/Graphite/ SWNTs | Si - SWNTs - graphite | 45 | Milling, functionalization, heat treatment | | 0.02 - 1.2 | 1130 | 655 | 1066 | 30 | 107 |
| Silicon/Graphite | Si - graphite | 15.5 | Chemical grafting of silicon to graphite | 50 | 0.01 - 1 | 1503 | 644 | 540 | 50 | 112 |
| Silicon/Graphite | Si - graphite | 9 | Chemical modification, mixing | 50 | 0.01 - 1 | 1049 | 494 | 303 | 50 | 112 |

$Q_{d1}$ = 1st delithiation capacity; $Q_{irr1}$ = irreversible capacity loss in the 1st cycle; $Q_{r,N}$ = reversible capacity in the Nth cycle; d Si = diameter of Si in nanoparticle.

**Table ESI-7 (continued)** Nanoparticles—Composite

| Morphology | Composition | Si (wt%) | Method | d Si (nm) | Potential (V) | $Q_{d1}$ (mAh/g) | $C_{irr1}$ (mAh/g) | $Q_{r,N}$ (mAh/g) | N Cycles | Reference |
|---|---|---|---|---|---|---|---|---|---|---|
| Nanocrystalline Si/Disordered C | Si - sucrose | 71 | Milling, pyrolysis | 59 | 0.02 - 1.2 | 842 | 420 | 587 | 20 | 69 |
| Nanocrystalline Si/Disordered C | Si - sucrose | 76 | Milling, pyrolysis | | 0.02 - 1.2 | 815 | | 485 | 20 | 69 |
| Nanocrystalline Si/Disordered C | Si - sucrose | 90 | Milling, pyrolysis | | 0.02 - 1.2 | 738 | | 195 | 20 | 69 |
| Nanocrystalline Si/Disordered C | Si - polyvinyl alcohol | 71 | Milling, pyrolysis | 17 | 0.02 - 1.2 | 935 | 230 | 755 | 20 | 69 |
| Nanocrystalline Si/Disordered C | Si - polyvinyl alcohol | 80 | Milling, pyrolysis | | 0.02 - 1.2 | 904 | | 650 | 20 | 69 |
| Nanocrystalline Si/Disordered C | Si - polyvinyl alcohol | 93 | Milling, pyrolysis | | 0.02 - 1.2 | 738 | | 267 | 20 | 69 |
| Si nanoparticles/Amorphous C | Si - polypyrrole | 50 | Milling | 300 - 3000 | 0.02 - 1.2 | 1100 | | 765 | 10 | 70 |
| Si nanoparticles/Amorphous C | Si - polypyrrole | 90 | Milling | 300 - 3000 | 0.02 - 1.2 | 1800 | | 600 | 10 | 70 |
| Nanocrystalline Si/Amorphous C | Si - citric acid | 44 | Spray pyrolysis | < 100 nm | 0.02 - 1.20 | 1857 | 743 | 1489 | 20 | 71 |
| Nanocrystalline Si/Amorphous $SiO_x$-Amorphous C | SiO - furfuryl alcohol - graphite | | Milling, pyrolysis | 5 to 10 | 0.01 - 1.5 | 700 | | 640 | 200 | 72 |
| Nanocrystalline Si/Amorphous C | Si - graphite - resin | 24 | Milling | 25 | 0.02 - 1.2 | 599 | 281 | 640 | 30 | 73 |
| Nanocrystalline Si/Amorphous C | Si - poly(vinyl) chloride | 44 | Pyrolysis | 7 | 0 - 2 | 985 | 170 | 840 | 20 | 74 |
| Nanocrystalline Si/Amorphous C | Si - poly(vinyl) chloride | 44 | Pyrolysis | > 100 | 0 - 2 | 1200 | 175 | 600 | 20 | 74 |
| Nanocrystalline Si/Graphite/LiCl | $SiCl_4$ - $LiC_6$ | 9.3 | Chemical reduction | 42 | 0.005 - 3 | 608 | 125 | 525 | 10 | 75 |
| Nanocrystalline Si/LiCl | $SiCl_4$ - Li | 9.1 | Milling | 10 to 30 | 0.005 - 3 | 533 | 185 | 370 | 10 | 75 |
| Si nanoparticles/Amorphous C | Si - PVdF | | Pyrolysis | ~ 60 | 0.02 - 1.5 | 1495 | | 970 | 16 | 76 |
| Si nanoparticles/Amorphous C | Si - PVC | | Pyrolysis | ~ 60 | 0.02 - 1.5 | 1825 | | 1150 | 16 | 76 |
| Si nanoparticles/Amorphous C | Si - CPE | | Pyrolysis | ~ 60 | 0.02 - 1.5 | 1930 | | 1215 | 16 | 76 |
| Nanocrystalline Si/Amorphous C | Si - PVdF | | Milling, pyrolysis | 60 | 0.02 - 1.5 | 745 | | 600 | 50 | 76 |

$Q_{d1}$ = 1st delithiation capacity; $Q_{irr1}$ = irreversible capacity loss in the 1st cycle; $Q_{r,N}$ = reversible capacity in the Nth cycle; d Si = diameter of Si in nanoparticle.

**Table ESI-7 (continued)** Nanoparticles—Composite

| Morphology | Composition | Si (wt%) | Method | d Si (nm) | Potential (V) | $Q_{d1}$ (mAh/g) | $C_{irr1}$ (mAh/g) | $Q_{r,N}$ (mAh/g) | N Cycles | Reference |
|---|---|---|---|---|---|---|---|---|---|---|
| Si nanoparticles/Graphite | Si - graphite | 33 | Milling | 100-2000 | 0.001 - 1.5 | 1091 | 402 | 770 | 50 | 77 |
| Si nanoparticles/ Graphite/Polymer | Si - graphite - polymer microspheres (5%) | 33 | Milling | 100-2000 | 0.001 - 1.5 | 1060 | 369 | 830 | 50 | 77 |
| Si nanoparticles/ Graphite/Polymer | Si - graphite - polymer microspheres (10%) | 33 | Milling | 100-2000 | 0.001 - 1.5 | 1065 | 318 | 885 | 50 | 77 |
| Crystalline Si/Amorphous C | Si - benzene | 73 | Milling, pyrolysis | 3000 - 5000 | 0.05 - 1.2 | 950 | 50 | 750 | 70 | 78 |
| Si nanoparticles/Amorphous C | Partially oxidized Si - pitch | 10 | Milling, pyrolysis | 22 | 0.01 - 2 | 465 | 115 | 360 | 10 | 80 |
| Si nanoparticles/Amorphous C | Si - pitch | 10 | Milling, pyrolysis | 22 | 0.01 - 2 | 460 | 105 | 335 | 15 | 80 |
| Si nanoparticles/Amorphous C | Si - pitch | 15 | Milling, pyrolysis | 22 | 0.01 - 2 | 576 | 120 | 400 | 15 | 80 |
| Crystalline Si/Amorphous C | Si - citric acid | | Milling, pyrolysis, annealing | 1000 - 2000 | 0.02 - 1.50 | 1570 | | 627 | 30 | 81 |
| Nanocrystalline Si/Amorphous C | Si - glucose | 74 | Milling, hydrothermal coating | 50 - 80 | 0 - 1.5 | 824 | 1001 | 800 | 30 | 82 |
| Nanocrystalline Si/Amorphous C | Si - graphite - polypropylene | < 10 | Mixing | 60 | 0.005 - 1 | 750 | 165 | 325 | 14 | 83 |
| Nanocrystalline Si/Amorphous C | Si - graphite | 10 | Mixing, pyrolysis | 60 | 0.005 - 1 | 750 | 102 | 575 | 14 | 83 |
| Nanocrystalline Si/Cu/Amorphous C | Si - resorcinol-formaldehyde | 31.5 | Milling, pyrolysis | | 0.0 - 2.0 | 910 | 290 | 683 | 20 | 84 |
| Nanocrystalline Si/Amorphous C | Si - Cu - resorcinol-formaldehyde | | Milling, pyrolysis | | 0.0 - 2.0 | 518 | 152 | 487 | 20 | 84 |
| Nanocrystalline Si/Amorphous C | Si - benzene | 73 | Milling, pyrolysis | ~ 3000 | 0 - 1.2 | 980 | | 1000 | 55 | 90 |
| Nanocrystalline Si/Amorphous C | Si - citric acid | 73 | Spray pyrolysis | < 100 | 0.02 - 1.2 | 1830 | 1220 | 275 | 100 | 95 |
| Nanocrystalline Si/Amorphous C | Si - citric acid | 44 | Spray pyrolysis | < 100 | 0.02 - 1.2 | 1857 | 743 | 1120 | 100 | 95 |
| Nanocrystalline Si/Amorphous C | Si - citric acid | 15 | Spray pyrolysis | < 100 | 0.02 - 1.2 | 427 | 663 | 125 | 100 | 95 |
| Nanocrystalline Si/Amorphous C | Butyl-capped Si | 90 | Chemical reduction | 5 | 0 - 1.5 | 1257 | 365 | 1055 | 30 | 96 |
| Nanocrystalline Si/Amorphous $SiO_x$-Amorphous C | Si - $SiO_x$ - resorcinol-formaldehyde | 23 | Pyrolysis | 30 - 50 | 0 - 2 | 930 | 800 | 330 | 20 | 97 |

$Q_{d1}$ = 1st delithiation capacity; $Q_{irr1}$ = irreversible capacity loss in the 1st cycle; $Q_{r,N}$ = reversible capacity in the Nth cycle; d Si = diameter of Si in nanoparticle.

**Table ESI-7 (continued)** Nanoparticles—Composite

| Morphology | Composition | Si (wt%) | Method | d Si (nm) | Potential (V) | $Q_{d1}$ (mAh/g) | $C_{irr1}$ (mAh/g) | $Q_{r,N}$ (mAh/g) | N Cycles | Reference |
|---|---|---|---|---|---|---|---|---|---|---|
| Nanocrystalline Si/Amorphous $SiO_x$ | Si - $SiO_x$ | 88 | Pyrolysis | 30 - 50 | 0 - 2 | 1480 | | 330 | 20 | 97 |
| Nanocrystalline Si//graphite/amorphous C | Si-graphite-phenyl-formaldehyde resin | | Pyrolysis, milling | | 0.01 - 1.5 | 700 | 275 | 550 | 40 | 98 |
| Nanocrystalline Si//graphite/amorphous C | Si-phenyl-formaldehyde resin | | Pyrolysis, milling | | 0.01 - 1.5 | 875 | 325 | 310 | 40 | 98 |
| Nano Si/Amorphous C | Si - polypyrrole | 46.6 | Mixing, pyrolysis | 40 | 0.02 - 1.2 | 841 | | 250 | 100 | 99 |
| Nanocrystalline Si/Carbon black/Amorhpous carbon | Si - carbon black - propylene | ~ 50 | Chemical vapor deposition, pyrolysis | 10 - 30 | 0 - 1.1 | 1590 | | 1530 | 100 | 100 |
| Amorphous Si and pregraphitic C | Si - $(CH_3)_2Cl_2Si$ | 5.9 atom % | Chemical vapor deposition/pyrolysis | | | 600 | 120 | 478 | 34 | 101 |
| Amorphous Si and pregraphitic C | Si - $(CH_3)_2Cl_2Si$ | 11 atom % | Chemical vapor deposition/pyrolysis | | | 640 | 160 | 493 | 34 | 101 |
| Si/Amorphous C | Si - poly(vinyl) chloride | 19.4 | Pyrolysis | < 100 | 0.02 - 1.5 | 605 | 170 | 500 | 30 | 102 |
| Si/Amorphous C | Si - poly(vinyl) chloride - graphite | 19.6 | Pyrolysis | < 100 | 0.02 - 1.5 | 730 | 150 | 670 | 30 | 102 |
| Si/Amorphous C | Si - petroleum pitch - graphite | 20.8 | Pyrolysis | < 100 | 0.02 - 1.5 | 640 | | 325 | 27 | 102 |
| Nanocrystalline Si/ Amorphous C | Si - phenol formaldehyde - graphite | 13 | Pyrolysis | < 100 | 0.02 - 1.5 | 500 | 200 | 440 | 40 | 103 |
| Nanocrystalline Si/ Amorphous C | Si - phenol formaldehyde - graphite | | Pyrolysis | < 100 | 0.02 - 1.5 | 550 | | 515 | 40 | 103 |
| Nanocrystalline Si/ Amorphous C | Butyl-capped Si gel | 88 | Hard templating, pyrolysis | 40 - 100 | 0 - 1.2 | 2820 | 318 | 2780 | 100 | 110 |
| Nanocrystalline Si/ Amorphous C | Butyl-capped Si gel | 88 | Hard templating, pyrolysis | 40 - 100 | 0 - 1.2 | 2670 | | 2440 | 100 | 110 |
| Carbon inverse-opals/Amorphous silicon | Sucrose - Disilane | | Hard templating, chemical vapor deposition | | 0.05 - 2 | 2406 | 973 | 2132 | 145 | 111 |
| Nanocrystalline Si/ Amorphous C | Si – PVdF | 95.7 | Pyrolysis/ hand milling | < 100 | 0.02 - 1.5 | 1329 | 1057 | 1290 | 30 | 113 |
| Nanocrystalline Si/ Amorphous C | Si - acetylene | 94 | Pyrolysis | 10 | 0 - 1.5 | 3535 | 437 | 3394 | 40 | 114 |

$Q_{d1}$ = 1st delithiation capacity; $Q_{irr1}$ = irreversible capacity loss in the 1st cycle; $Q_{r,N}$ = reversible capacity in the Nth cycle; d Si = diameter of nanowire or nanotube.