Electronic Supplementary Material (ESI) for RSC Advances.


# Electronic Supplementary Information

## Silicon nanoparticles grown on reduced graphene oxide surface as high performance anode materials for lithium-ion batteries

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**Table S1**. Comparison of electrochemical performance of graphene-based silicon nanocomposites.

| Material description | Si particle size / Si content | Initial capacity / coulombic efficiency | Cycling performance | Ref. |
|---|---|---|---|---|
| Si nanoparticles grown on rGO surface through sonochemical method, followed by magnesiothermic reduction process without NaCl | ~30 nm / 78 wt.% | 1144 mAh $g^{-1}$ at 50 mA $g^{-1}$ / 68% | No cycling data | 1 |
| Thermally decomposing dead bamboo leaves, followed by magnesiothermic reduction reaction with NaCl as heat scavenger. Carbon coated and embedded in graphene matrix | 5-8 nm / 82.2 wt.% | 2590 mAh $g^{-1}$ at 0.05 C / 87% | 1200 mAh $g^{-1}$ after 100 cycles at 0.2 C | 2 |
| Graphene-silicon hybrids were prepared through hybrid electrostatic assembly between amino-functionalized silica and GO, followed by thermal reduction | <200 nm / 73.9 wt.% | 1328 mAh $g^{-1}$ at 300 mA $g^{-1}$ / 57.3% | 902 mAh $g^{-1}$ after 100 cycles at 300 mA $g^{-1}$ | 3 |
| Self-assembly of positively charged polyelectrolyte functionalized silica and GO, followed by thermal reduction | 40 nm / 80.1 wt.% | 1720 mAh $g^{-1}$ at 100 mA $g^{-1}$ / 58.9% | 1205 mAh $g^{-1}$ after 150 cycles at 100 mA $g^{-1}$ | 4 |
| Freeze-drying an aqueous mixture of GO and silica, followed by thermal reduction | <300 nm / 82.1 wt.% | 1866 mAh $g^{-1}$ at 200 mA $g^{-1}$ / 60.8% | 1153 mAh $g^{-1}$ after 100 cycles at 200 mA $g^{-1}$ | 5 |
| Simple mixing of commercially available silica and graphene | 40 nm / 50 wt.% | 1575 mAh $g^{-1}$ at 100 mA $g^{-1}$ / 73% | 1168 mAh $g^{-1}$ after 30 cycles at 100 mA $g^{-1}$ | 6 |
| Cross-linking reaction between polyacrylamide and GO to prepare 3D framework and Si embedded in it | 100 nm / 79 wt.% | 1881 mAh $g^{-1}$ at 1.2 A $g^{-1}$ / 67.9% | 1610 mAh $g^{-1}$ after 200 cycles at 1.2 A $g^{-1}$ | 7 |
| Covalent immobilization of silicon nanoparticles and GO, followed by thermal reduction step | 50 - 100 nm / 93.6 wt.% | 973 mAh $g^{-1}$ at 150 mA $g^{-1}$ / 75% | 1203 mAh $g^{-1}$ after 50 cycles at 0.2 C | 8 |
| Wrapping of micro-sized Si/C composite by graphene nanosheets | 2 µm / 70 wt.% | 1834 mAh $g^{-1}$ at 50 mA $g^{-1}$ / 64% | 1100 mAh $g^{-1}$ after 100 cycles at 50 mA $g^{-1}$ | 9 |
| Growth of ultra-small silica nanoparticles on GO surface followed by magnesiothermic reduction reaction with NaCl | <10 nm / 76 wt.% | 1902 mAh $g^{-1}$ at 100 mA $g^{-1}$ / 64.5% | 1165 mAh $g^{-1}$ after 100 cycles at 2.1 A $g^{-1}$ | This work |

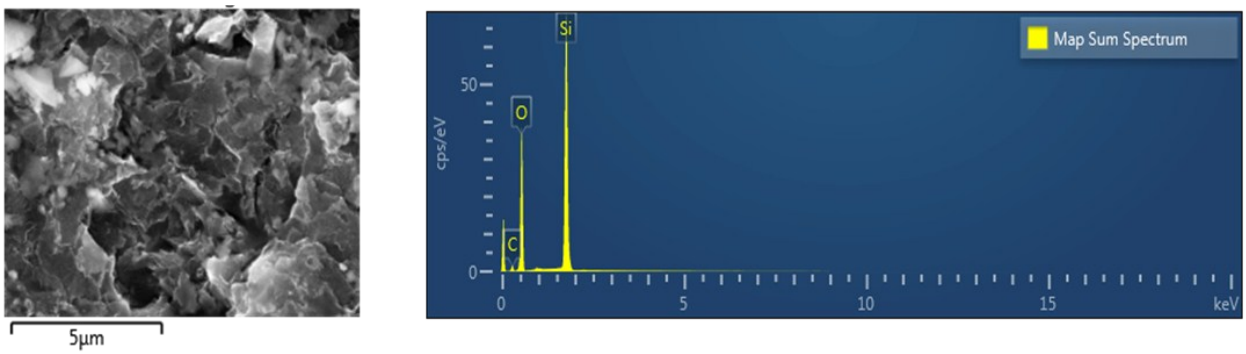


**Fig. S1.** SEM image and corresponding EDS spectrum of GO-$SiO_2$ sample.

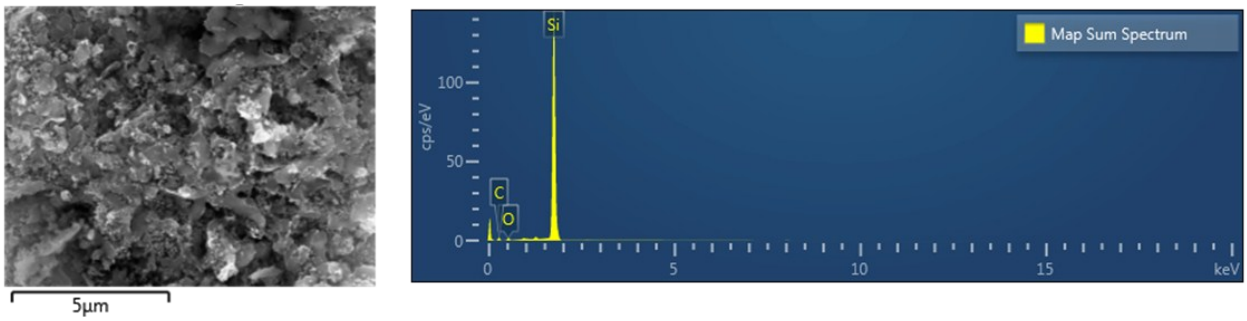


**Fig. S2.** SEM image and corresponding EDS spectrum of rGO-$Si_{NaCl}$ sample.

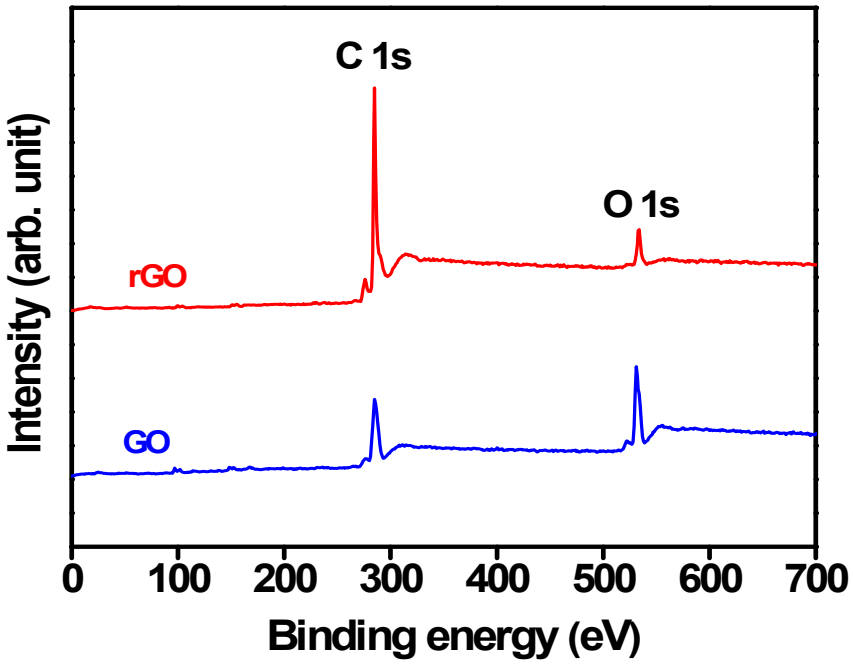


**Fig. S3.** XPS survey spectra of GO and rGO (prepared using the same reduction procedure in the absence of silica nanoparticles on GO surface).

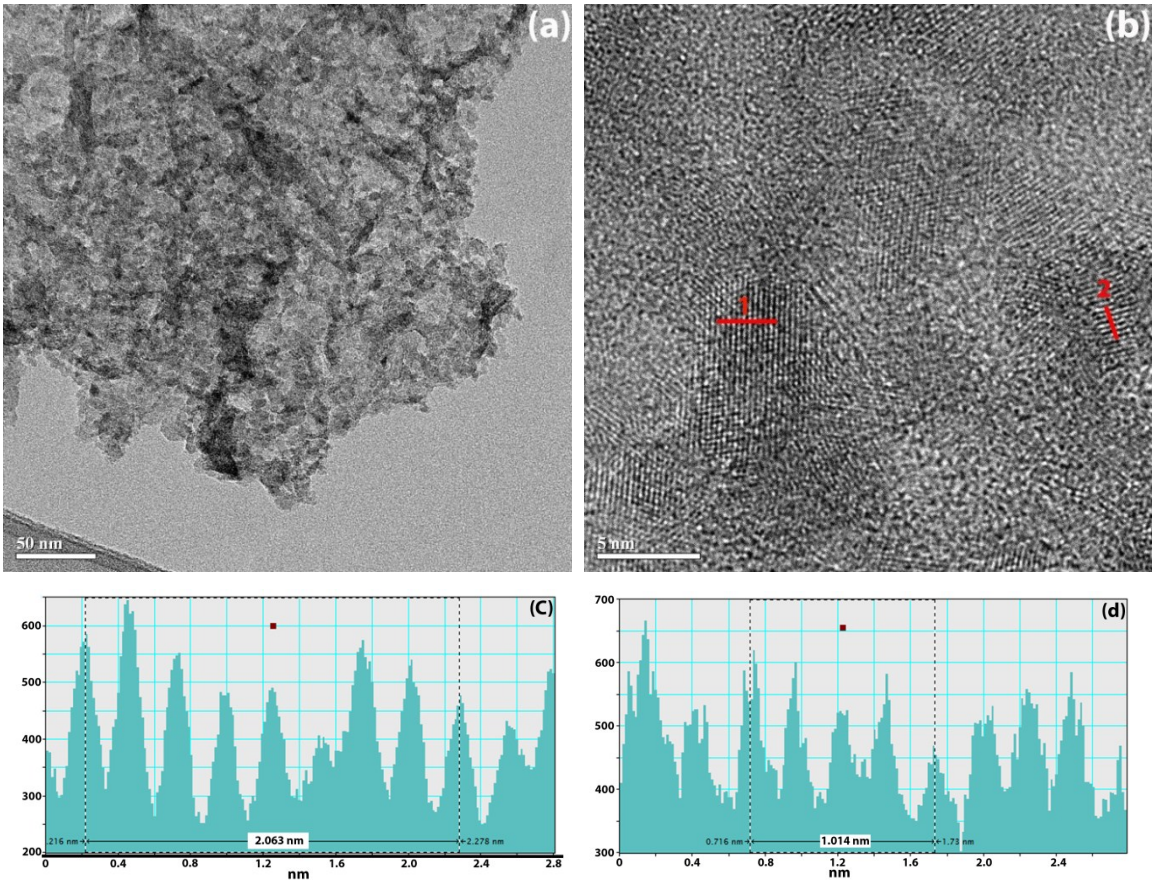


**Fig. S4.** (a) TEM and (b) HRTEM images of the rGO-Si sample showing the silicon particles attached to the rGO nanosheet synthesized using magnesiothermic reduction reaction without NaCl as a heat scavenger. This results in larger particle size due to aggregation of nanoparticles during the magnesiothermic reduction step. (c) and (d) show the line profiles of the area marked as 1 and 2, respectively in (b). The HRTEM image and the corresponding line profiles confirm the presence of crystalline silicon carbide impurity phase in the hybrid.

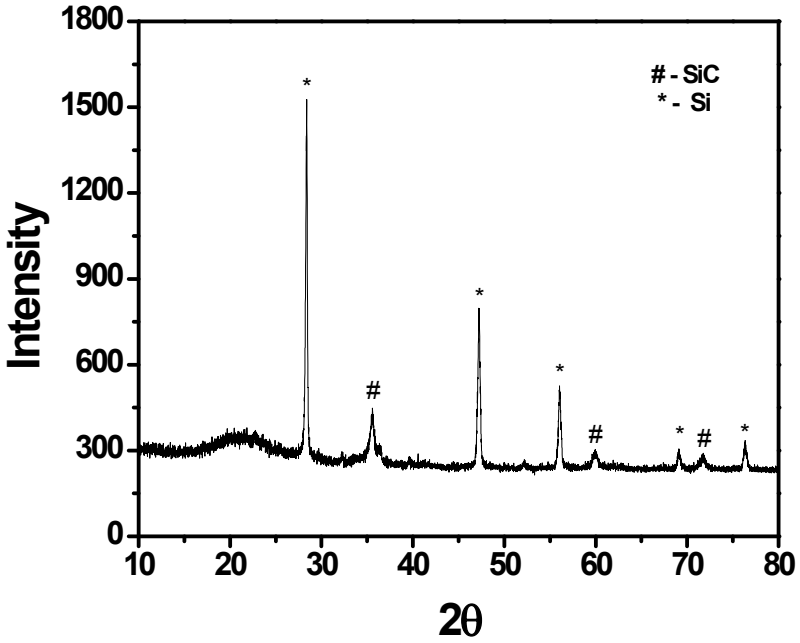


**Fig. S5.** XRD pattern of the rGO-Si sample prepared using similar synthetic procedure except NaCl was not used as a heat scavenger in the magnesiothermic reduction step. Excessive local heat produced by the exothermic reaction of magnesium metal enabled the reaction of silicon and carbon in rGO to form a silicon carbide phase.

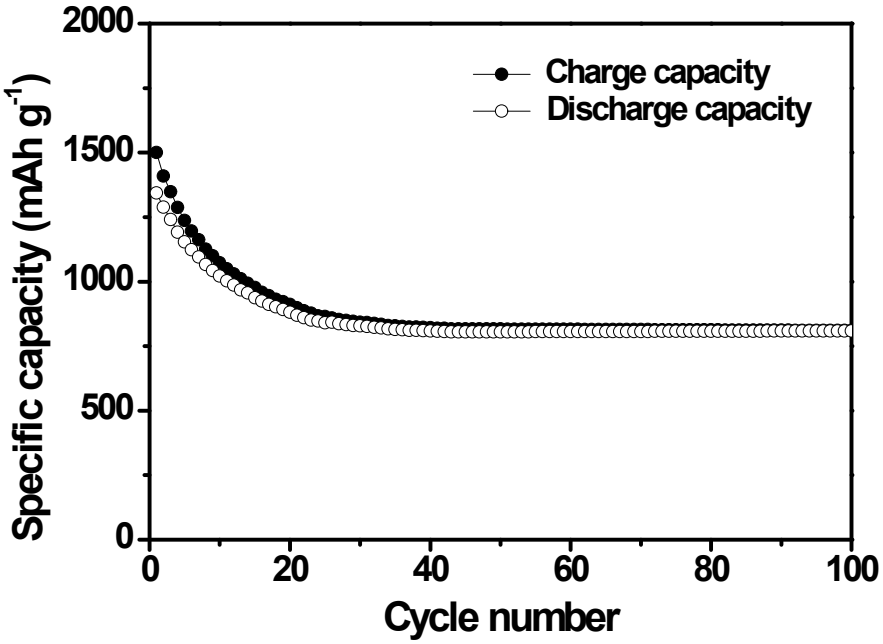


**Fig. S6.** Cycling performance of rGO-Si electrode prepared without using NaCl as a heat scavenger. The cycling performance was inferior to the rGO-$Si_{NaCl}$ electrode prepared with NaCl.

**References**


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