Electronic Supplementary Material (ESI) for Dalton Transactions.

Strongly interfacial interaction $NiCoSe_x$/CG heterostructure with rapid diffusion kinetics as flexible anode for high-rate sodium storage

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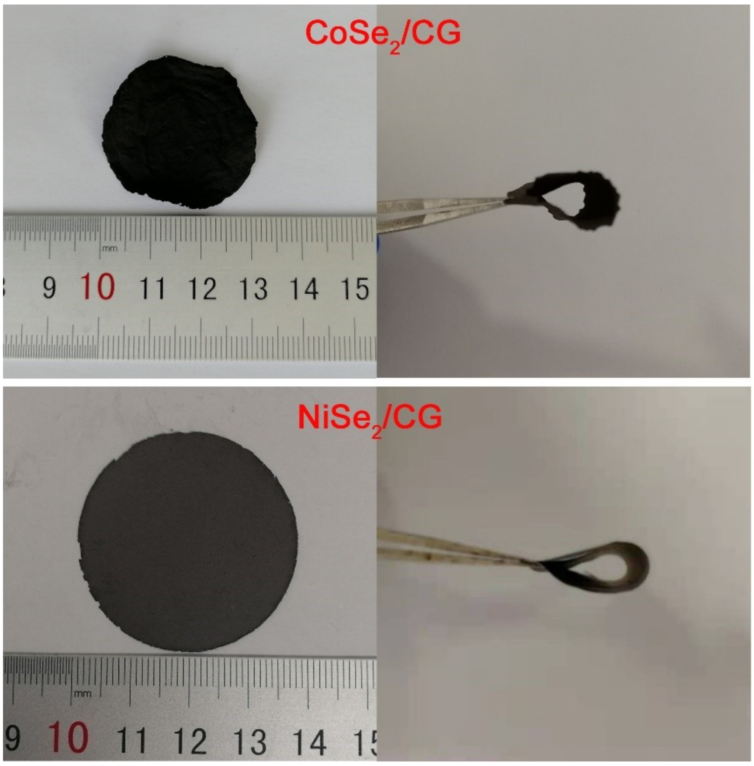


Fig. S1 Photographs of $CoSe_2$/CG and $NiSe_2$/CG in the tiled and curled state.

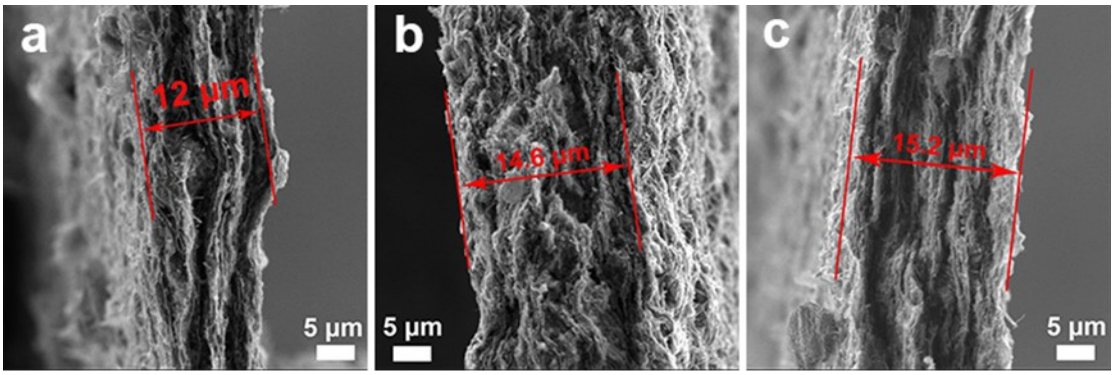


Fig. S2 Cross sectional SEM pictures of $CoSe_2$/CG (a), $NiSe_2$/CG (b) and $NiCoSe_x$/CG (c) films.

Calculation of the relative content of $CoSe_2$ and carbon in $CoSe_2$/CG.

As shown in Figure 1c, the weight loss of $CoSe_2$/CG is 77.8 wt%. After heating to 500 ^{o}C in the air, the final product is Co_3O_4. According to the reaction equation (1), the weight loss from pure $CoSe_2$ to Co_3O_4 is 63.0 wt%. The weight reduction of composite is consisted of two parts: weight loss of the variation from $CoSe_2$ to Co_3O_4 and the weight loss of carbon oxidation, which can be illustrated as the equation (2):

$$3CoSe_2 + 8O_2 \rightarrow Co_3O_4 + 6SeO_2\uparrow \quad (1)$$

$$W \times 63.0\% + 100\% - W = 77.8\% \quad (2)$$

W represents the loading content of $CoSe_2$, and the loading content of carbon is (100%-W). Thus, the content of $CoSe_2$ in $CoSe_2$/CG can be calculated as 60.0 wt%.

Calculation of the relative content of $NiSe_2$ and carbon in $NiSe_2$/CG.

As shown in Figure 1c, the weight loss of $NiSe_2$/CG is 91.0 wt%. After heating to 500 ^{o}C in the air, the final product is Ni_2O_3. According to the reaction equation (1), the weight loss from pure $NiSe_2$ to Ni_2O_3 is 61.7 wt%. The weight reduction of composite is consisted of two parts: weight loss of the variation from $NiSe_2$ to Ni_2O_3 and the weight loss of carbon oxidation, which can be illustrated as the equation (2):

$$4NiSe_2 + 11O_2 \rightarrow 2Ni_2O_3 + 8SeO_2\uparrow \quad (3)$$

$$W \times 61.7\% + 100\% - W = 91.0\% \quad (4)$$

W represents the loading content of $NiSe_2$, and the loading content of carbon is (100%-W). Thus, the content of $NiSe_2$ in $NiSe_2$/CG can be calculated as 23.5 wt%.

Calculation of the relative content of $CoSe_2$, $NiSe_2$ and carbon in $NiCoSe_x$/CG.

As shown in Figure 1c, the weight loss of $NiCoSe_x$/CG is 84.1 wt%. The weight reduction of composite is consisted of three parts: weight loss of the variation from $CoSe_2$ to Co_3O_4, $NiSe_2$ to Ni_2O_3 and the weight loss of carbon oxidation.

W represents the loading content of $CoSe_2$. Because the ratio of cobalt to nickel in the raw material is controlled to be 1:1, the loading content of $NiSe_2$ is also W, and the loading content of carbon is (100%-2W). Thus, according to the equation (5), it can be calculated that the content of $CoSe_2$ in $NiCoSe_x$/CG is 21.1 wt%, the content of $NiSe_2$ in $NiCoSe_x$/CG is 21.1 wt%.

$$W \times 63.0\% + W \times 61.7\% + 100\% - W = 84.1\% \quad (5)$$

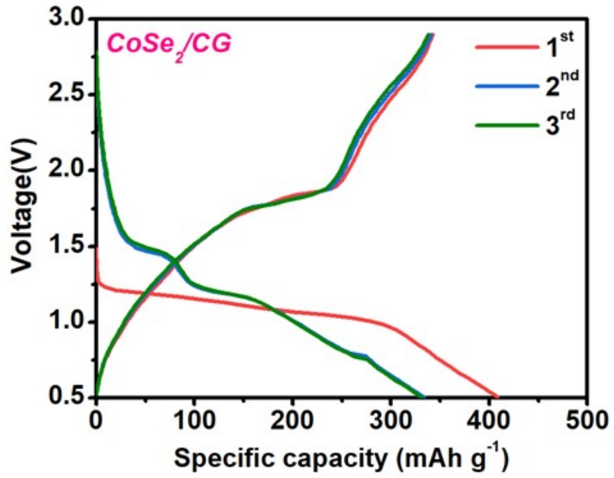


Fig. S3 Initial three discharge/charge voltage curves at 0.1 A g^{-1} of $CoSe_2$/CG.

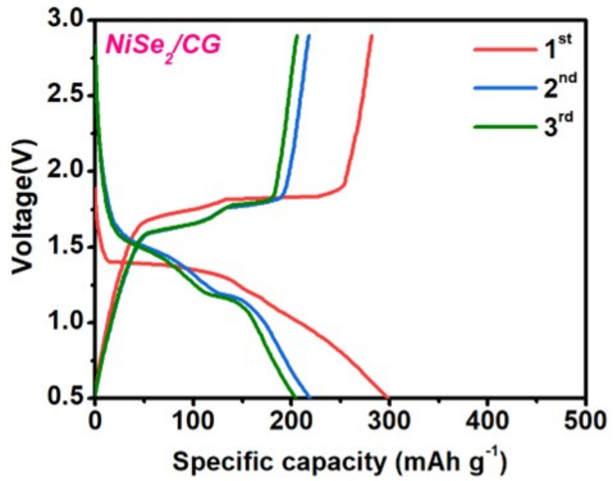


Fig. S4 Initial three discharge/charge voltage curves of $NiSe_2$/CG at 0.1 A g^{-1}.

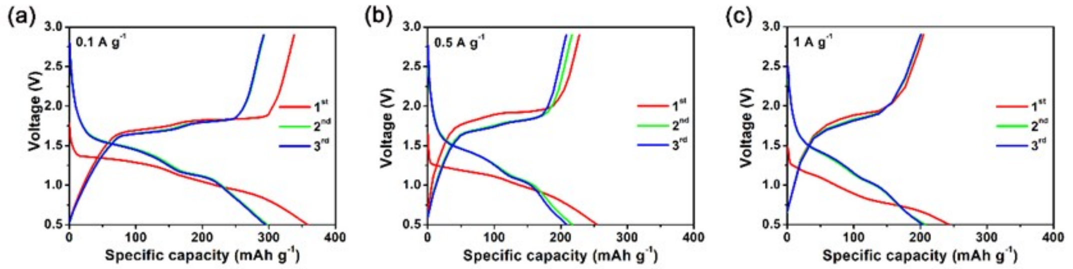


Fig. S5 The initial three discharge/charge curves of $NiCoSe_x$/CG at different current densities.

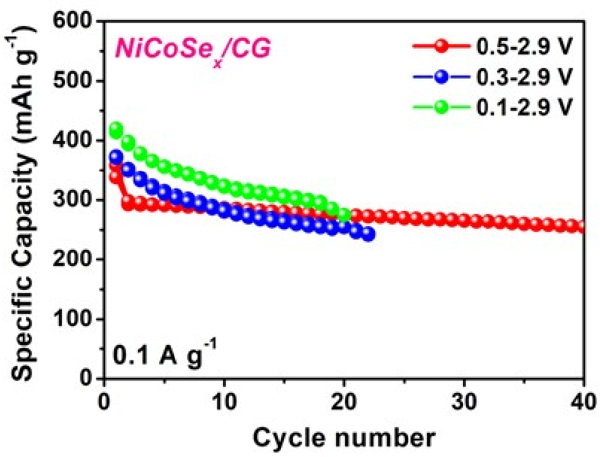


Fig. S6 Cyclic performance of $NiCoSe_x$/CG at different voltage ranges.

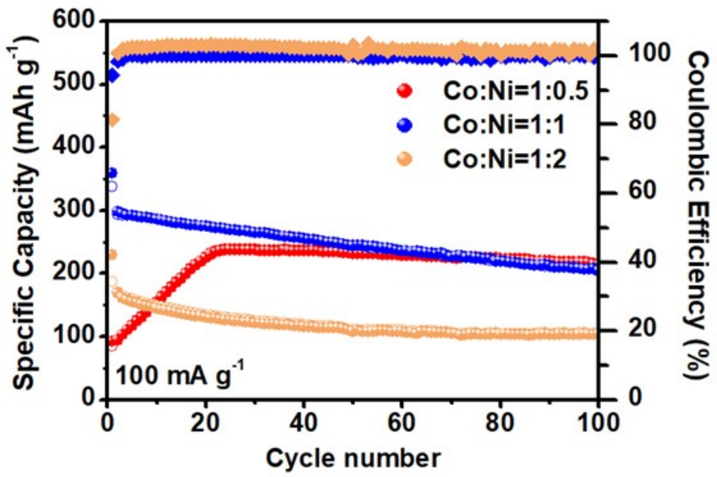


Fig. S7 Cyclic performance of $NiCoSe_x$/CG with different cobalt to nickel at 0.1 A g^{-1}.

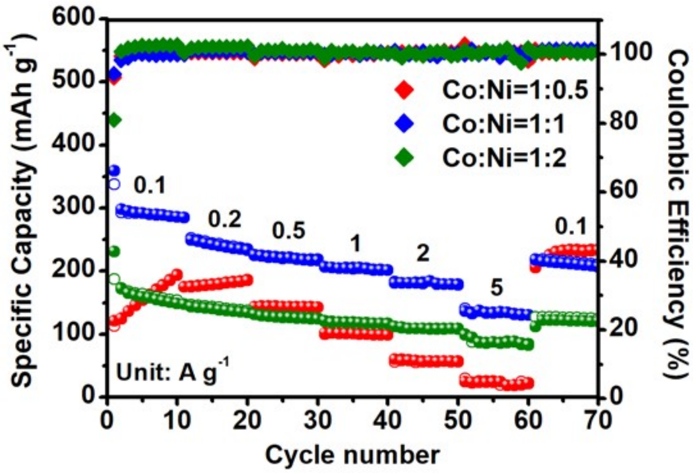
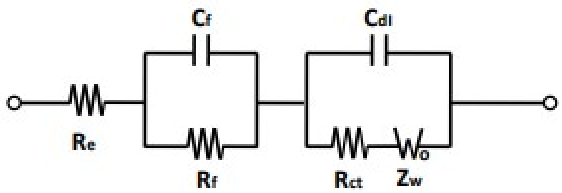


Fig. S8 Rate performance of $NiCoSe_x$/CG with different cobalt to nickel at various current density from 0.1 to 5 A g^{-1}.

Table S1. Randles equivalent circuit and the dynamical parameters of the $CoSe_2$/CG, $NiSe_2$/CG and $NiCoSe_x$/CG after three cycles at 100 mA/g.



	R_e/Ω	R_f/Ω	R_{ct}/Ω
$CoSe_2$/CG	13.4	58.5	43.5
$NiSe_2$/CG	11.8	27.0	29.2
$NiCoSe_x$/CG	11.6	13.9	11.1

Table S2. A comparison of this work with previously reported performances of flexible anode materials for SIBs.

Samples	Initial reversible	Capacity retention	Rate capability	Capacity retention	Ref.

	capacity/mAh $\cdot g^{-1}$	at a low current density	$mAh\cdot g^{-1}$	$mA\cdot g^{-1}$	at a high current density	
Bi_4Se_3/Bi_2O_2Se-CNTs-rGO	345.6	68.1% at 0.1 A/g after 100 cycles	345.6 235.3 155 120.5 101.5 85.4	0.1 0.2 0.5 1 2 5	84% at 1 A/g after 1000 cycles	[1]
P-doped carbon cloth	186	88% at 0.2 A/g after 600 cycles	242.7 215.5 186.8 152.7 123.1 87	0.05 0.1 0.2 0.5 1 2	null	[2]
Crumpled graphene	190	null	183 150 120 100 80	0.1 0.2 0.5 1 2	89% at 1 A/g after 500 cycles	[3]
graphene stacks	145	83% at 0.3 A/g after 1000 cycles	163 143 120 100 82 52	0.1 0.3 0.5 1 2 5	null	[4]
Ni-CNTs	101	91% at 05 A/g after 1800 cycles	110 82 78 72 67	0.1 0.2 0.5 1 2	null	[5]
Bismuth Selenide /Graphene	695	33.4% at 0.05 A/g after 50 cycles	400 210 160 70 30 20	0.05 0.1 0.2 0.5 1 2	null	[6]
$NiCoSe_x$/CG	338	61% at 0.1 A/g after 100 cycles	338 285 225 206 183 140	0.1 0.2 0.5 1 2 5	66% at 2 A/g after 1000 cycles	This work

References

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