Selenium vacancies enriched the performance of supercapacitor with excellent cyclic stability via simple chemical bath deposition method

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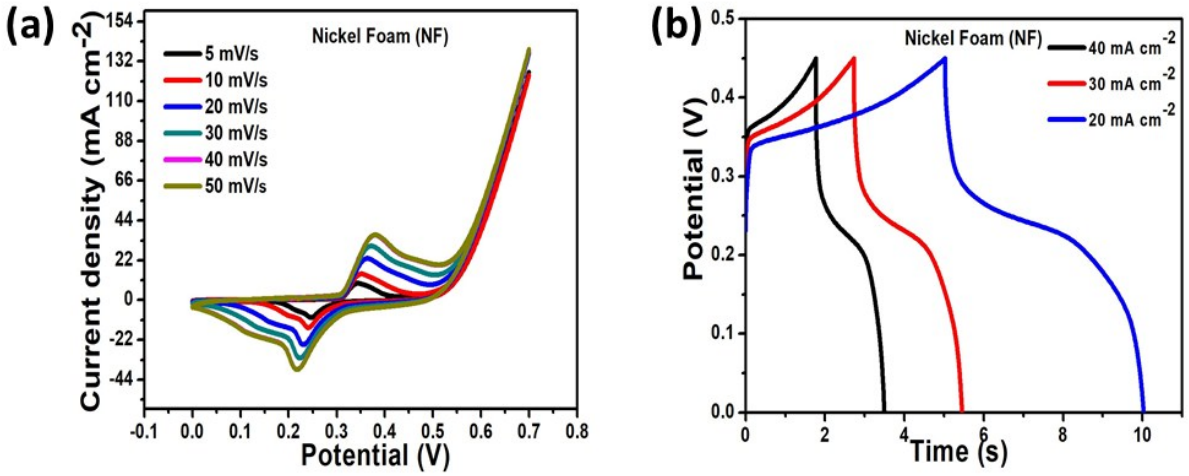

Fig S1. (a) CV curves, (b) GCD curves of the nickel foam (NF) at different scanning rates and discharge current densities in 1 M KOH solution.

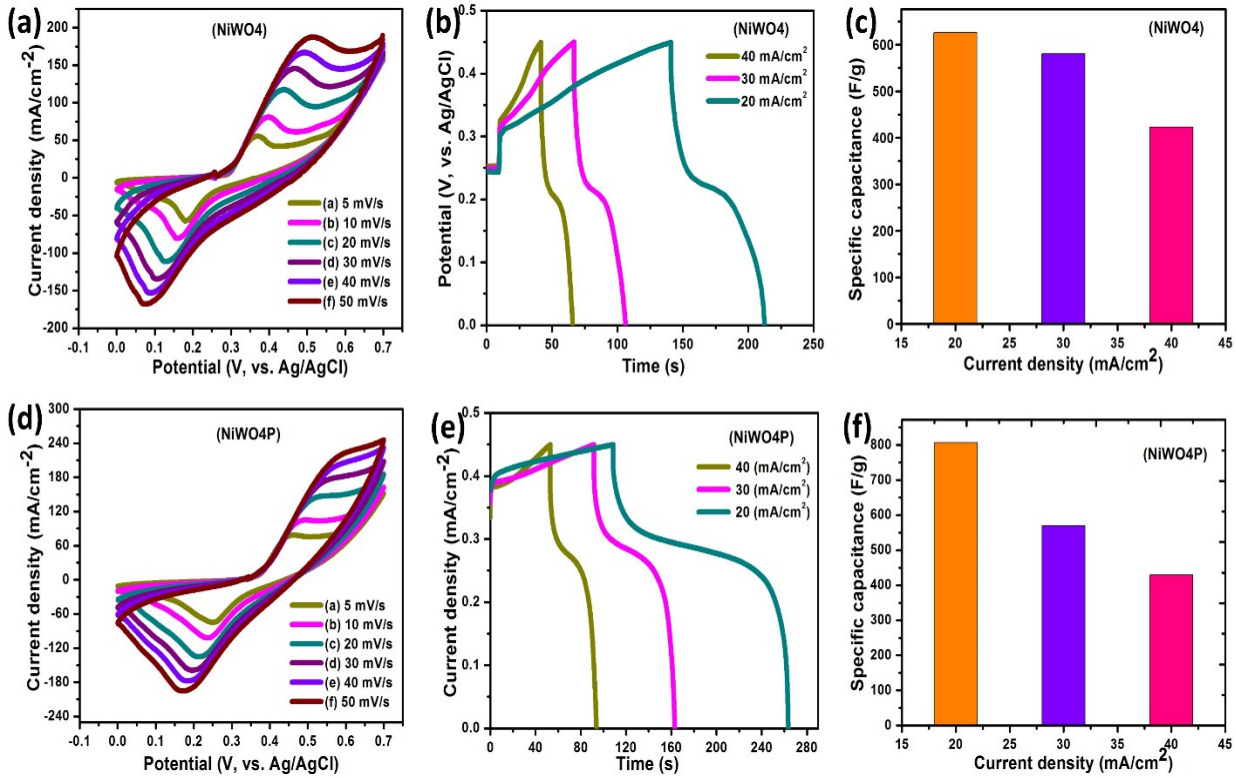

Fig S1. (a-c) CV curves, GCD curves of the $NiWO_4$ electrode at different scanning rates and discharge current densities in 1 M KOH solution, calculated specific capacity values from the GCD curves plotted as a function of discharge current density for the $NiWO_4$. (d-f) CV curves, GCD curves of the $NiWO_4P$ electrode tested at various scan rates and discharge current densities, estimated specific capacitance values as a function of discharge current density for the corresponding sample.

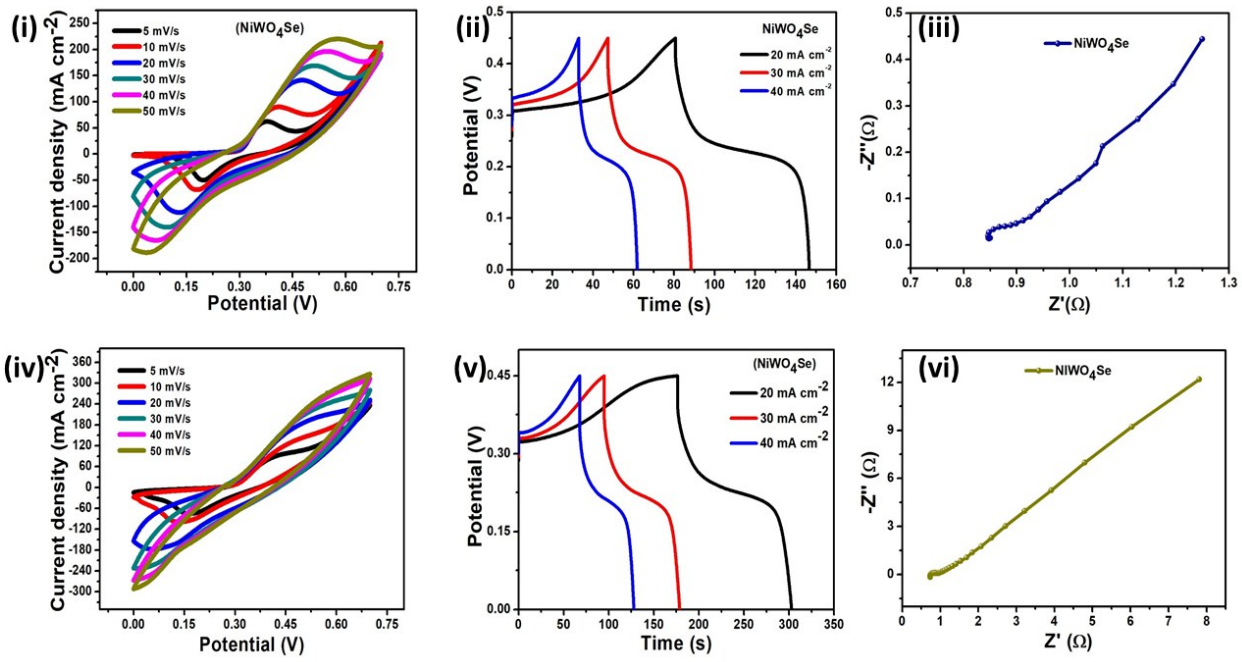

Fig. S2. CV, GCD, and EIS of $NiWO_4Se$ at different reaction times in 1 M KOH solution: (i-iii)1h, and (iv-vi) 4h.

The electrochemical properties of $NiWO_4Se$ were further examined by a series of experiments at different deposition times in 1 M KOH solution. Fig. S2 shows the CV, GCD, and EIS images of the samples collected at 1h, and 4h, respectively. A pair of redox peaks can be clearly observed in each CV curve (Fig. S2), indicating that the capacitance is mainly based on the Faradaic redox mechanism. For the deposition of 1h, the $NiWO_4Se$ electrode delivers a specific capacitance of 649.45, 606.05, and 568.47 F g -1 at a current density of 20, 30, and 40 mA cm^{-2}, respectively. Similarly, when the deposition time 4h, the capacitance can be calculated to be 763.64, 762.12, and 730.69 F g -1 at different current densities 20 to 40 mA cm^{-2}. Therefore, the deposition time 7h electrode exhibits superior supercapacitive performance than 1h and 4h deposition. The electrochemical performance of $NiWO_4Se$ electrodes was further confirmed by electrochemical impedance spectroscopy (EIS). Fig. S2 (iii, and vi) displays Nyquist plots of the $NiWO_4Se$ at 1h, and 4h in the frequency range of 0.01 Hz to 100 kHz. From the EIS plots, the $NiWO_4Se$

deposition time 7h shows a more vertical line in the lower frequency region, see-through the lower diffusion resistance. Moreover, the charge transfer resistance of $NiWO_4Se$ (7h) electrode is observed to be lower than that of the 1h, and 4h, which may be due to the nanoball structure with additional pathways for electron transport. The good conductivity and ion diffusion are beneficial to the outstanding electrochemical performance of $NiWO_4Se$.

Table 1. Comparative electrochemical performance of $NiWO_4Se$ nanoball structures with previously reported metal chalcogenide materials in the aqueous alkaline electrolyte solution

Electrode	**Electrolyte**	**Specific capacitance (F g^{-1})**	**Ref**
$CoWO_4$	2 M KOH	764.4	1
$NiWO_4$	2 M KOH	797.8	1
$NiWO_4$-$CoWO_4$	2 M KOH	196.7	2
$CoWO_4$@$NiWO_4$	1 M KOH	746	3
$Co3O_4$/$CoWO_4$	6 M KOH	336.4	4
$NiWO_4$	1 M KOH	765.7	5
$NiWO_4$	2 M KOH	574	6
$CoWO_4$	1 M KOH	403	7
rGO- $CoWO_4$	2 M KOH	159	8
$NiWO_4Se$	**1 M KOH**	**1115.05**	**This work**

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