Supporting information

Advanced asymmetric supercapacitors based on $Ni_3(PO_4)_2$@GO and Fe_2O_3@GO electrodes with high specific capacitance and high energy density

Jia-Jia Li [a], Mao-Cheng Liu [a, b, *], Ling-Bin Kong [b*], Dan Wang [b], Yu-Mei Hu [b], Wei Han [b], and Long Kang [b]

[a] *State Key Laboratory of Gansu Advanced Non-ferrous Metal Materials, Lanzhou University of Technology, Lanzhou 730050, PR China*

[b] *School of Materials Science and Engineering, Lanzhou University of Technology, Lanzhou 730050, PR China*

* Corresponding author. Tel.: +86-931-2976579; fax: +86-931-2976578. E-mail address: liumc@lut.cn; konglb@lut.cn

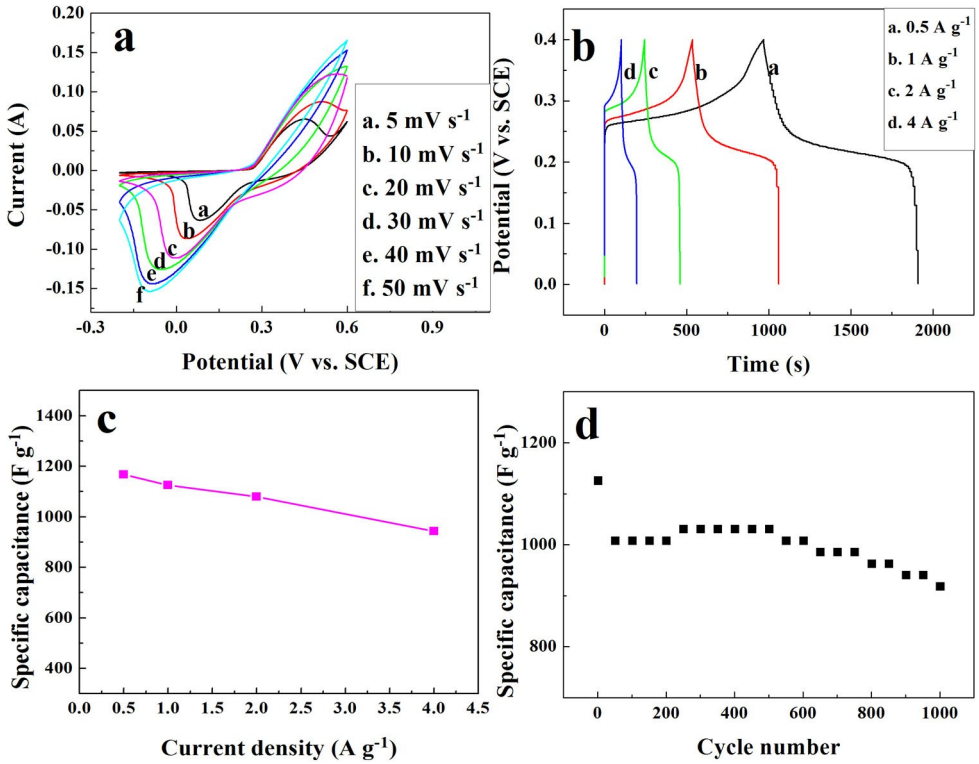

Fig. S1 Electrochemical characterizations of $Ni_3(PO_4)_2$. (a) CV curves at different scan rates. (b) Charge/discharge curves. (c) Specific capacitance at controlled current densities. (d) Cycle-life of $Ni_3(PO_4)_2$ at a current density of 1 A g^{-1}.

Figure S1a shows the CV curves of $Ni_3(PO_4)_2$ at different scan rates. For each curve, a pair of redox peaks can be observed, suggesting that the measured capacitance is mainly based on the redox mechanism. Figure S1b shows the galvanostatic charge-discharge curves of $Ni_3P_2O_8$. The specific capacitance is 1167, 1125, 1080.5, and 943 F g^{-1} at a current density of 0.5, 1, 2, and 4 A g^{-1}, respectively. As can be seen from Figure S1c, the specific capacitance is retained 80% as the current density increase from 0.5 to 4 A g^{-1}. The cycling performance of the composite is recorded as shown in Figure S1d. After 1000 times of continuous cycling at a current of 8 A g^{-1}, 78% of the initial capacitance was retained.

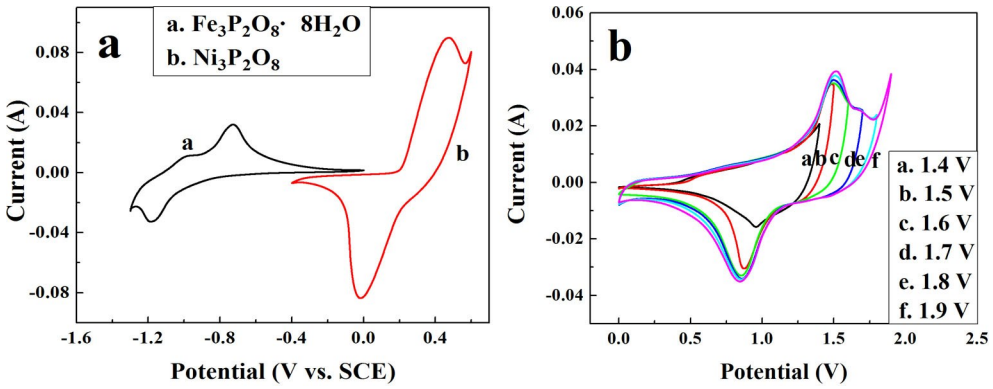

Fig. S2 (a) CV of Fe_2O_3@GO and $Ni_3(PO_4)_2$@GO electrodes recorded at 10 mV s^{-1}. (b) CV of the Fe_2O_3@GO//$Ni_3(PO_4)_2$@GO asymmetric supercapacitor with different operation voltage windows at 10 mV s^{-1}.

Fig. S2a shows the CV curves, Fe_2O_3@GO and $Ni_3(PO_4)_2$@GO electrodes at a scan rate of 10 mV s^{-1} in 2 M aqueous KOH solution, are used to confirm the appropriate operation voltage window (OVW). The potential windows of the Fe_2O_3@GO and $Ni_3(PO_4)_2$@GO electrodes are -1.3 to 0 and -0.4 to 0.6 V, respectively. The total cell voltage can be expressed as the sum of the potential range for the Fe_2O_3@GO and $Ni_3(PO_4)_2$@GO electrodes. In a fully oxidized state, the $Ni_3(PO_4)_2$@GO gives about 0.6 V, while the Fe_2O_3@GO electrode gives about 1.3 V in a fully reduced state. It is possible to conclude that the cell potential can reach 1.9 V in 2 M aqueous KOH solution for the Fe_2O_3@GO and $Ni_3(PO_4)_2$@GO based asymmetric supercapacitor. However, owning to the phenomenon of oxygen evolution when operation voltage window (OVW) is greater than 1.8 V, so the charge/discharge curve can only work within the scope of 0 to 1.8 V. CV curves with various potential windows were used to evaluate the applicable operation voltage window (OVW) of the asymmetric supercapacitor, as shown in Fig. S2b. When OVW is located at 1.4 V, a triangular CV curve implies an incomplete pseudocapacitive

response from the hybrid supercapacitor. By increasing the OVW to 1.6 V, oxidation and reduction humps appear in the CV curves, showing the pseudocapacitive properties. Further increasing OVW to 1.9 V, some distinct redox peaks arise in these CV curves, indicating deeper redox reactions on the surface of positive $Ni_3(PO_4)_2$@GO and negative Fe_2O_3@GO electrodes. The result indicates that the electrochemical capacitance performance of the asymmetric supercapacitor based on Fe_2O_3@GO and $Ni_3(PO_4)_2$@GO show the maximum SC within certain potential window 0 ~ 1.8 V. When the hybrid supercapacitor works within the potential range, it can reach a safe performance of both electrodes during long cycling.