Nanoporous NiF$_2$ for energy storage

Yang Yang and James M. Tour

Department of Chemistry, Smalley Institute for Nanoscale Science and Technology, Rice University

http://www.jmtour.com/

yymater@gmail.com and tour@rice.edu
Device fabrication process

(i) plasma treatment  (ii) sputter Cr/Au  (iii) electrodeposit metal layer  (iv) anodization to form porous layer

(v) preparation of solid electrolyte  (vi) supercapacitor device assembly  (vii) ready for testing
Double layer capacitor: 0.29 mF cm$^{-2}$ (3.2 F cm$^{-3}$ or 1.57 F g$^{-1}$), energy density of 0.6 Wh kg$^{-1}$ and power density of 8 kW kg$^{-1}$

Pseudocapacitor: 66 mF cm$^{-2}$ (733 F cm$^{-3}$ or 358 F g$^{-1}$), energy density of 384 Wh kg$^{-1}$ and power density of 112 kW kg$^{-1}$

Proposed charge storage mechanism:

\[
\begin{align*}
\text{NiF}_2 + 2\text{OH}^- & \rightleftharpoons \text{Ni(OH)}_2 + 2\text{F}^- \\
\text{Ni(OH)}_2 + \text{OH}^- & \rightleftharpoons \text{NiOOH} + \text{H}_2\text{O} + e^- 
\end{align*}
\]
Advantages of nanoporous NiF$_2$

1. Wide operation potential window – high energy density

2. Long term stability – reliable performance

3. Li-free, battery-like supercapacitors – works easily

4. Can be used for Ni-Cd and Ni-MH batteries

5. Easy fabrication – only needs a power source

6. Can be grown on any substrates, any shapes, any sizes