



天津工业大学
TIANJIN POLYTECHNIC UNIVERSITY

严谨 严格 求实 求是

纳米多孔金属自氧化制备高性能 膜电容电极

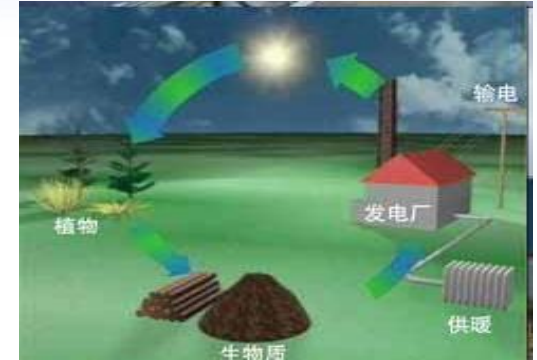
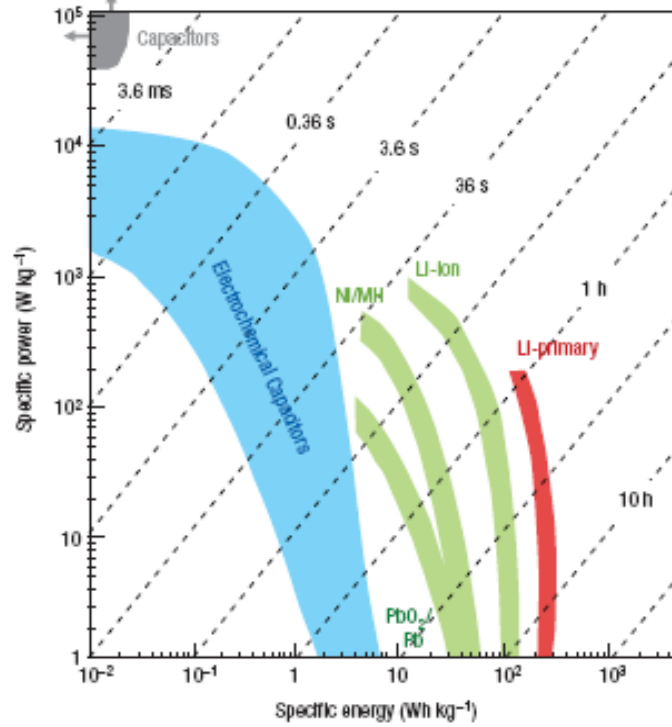
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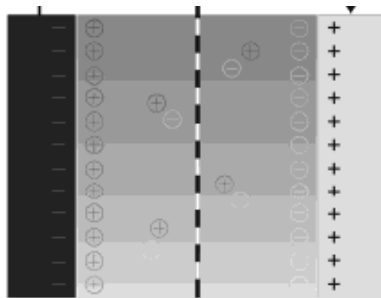
Environment and Energy



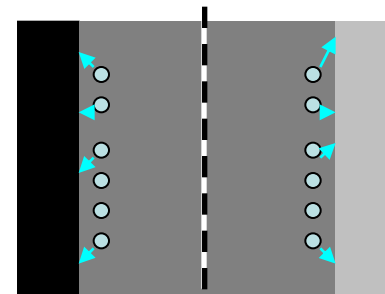
supercapacitor

Electronic double-layer capacitor

Pseudocapacitor



Negative Electrode Electrolyte Separator Positive Electrode



Negative electrode Electrolyte Separator positive electrode

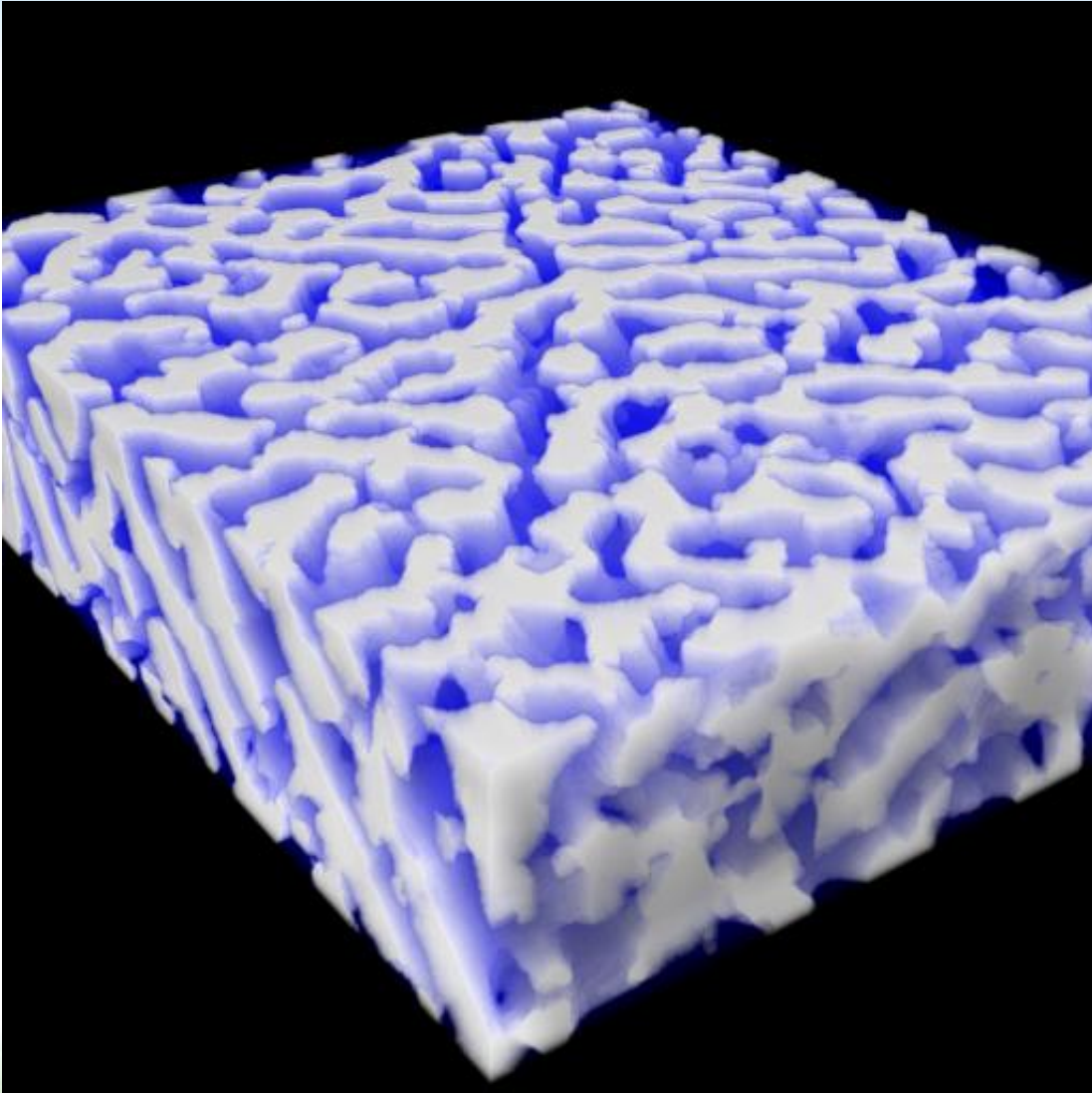
Fast surface redox reaction

Various carbon materials

Metal oxide and conductive polymer

$$E=0.5CV^2$$

New electrodes with high capacitance and operating voltage



Reproducibility

High surface area

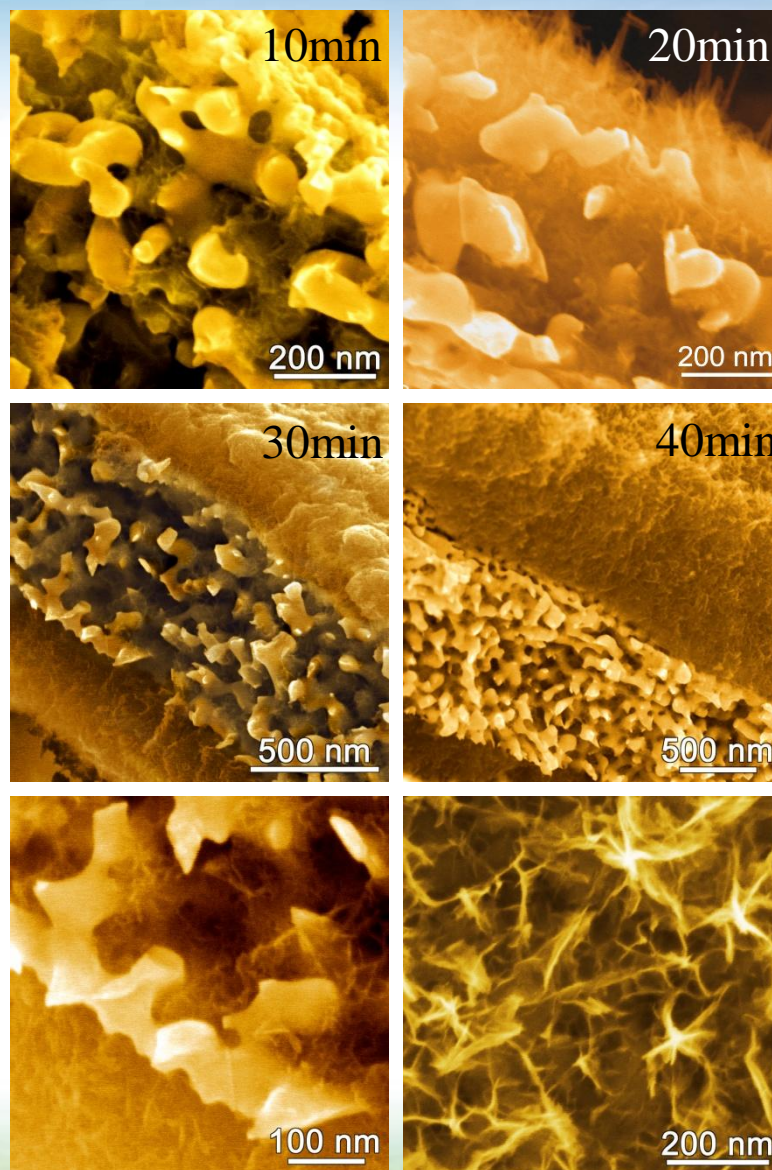
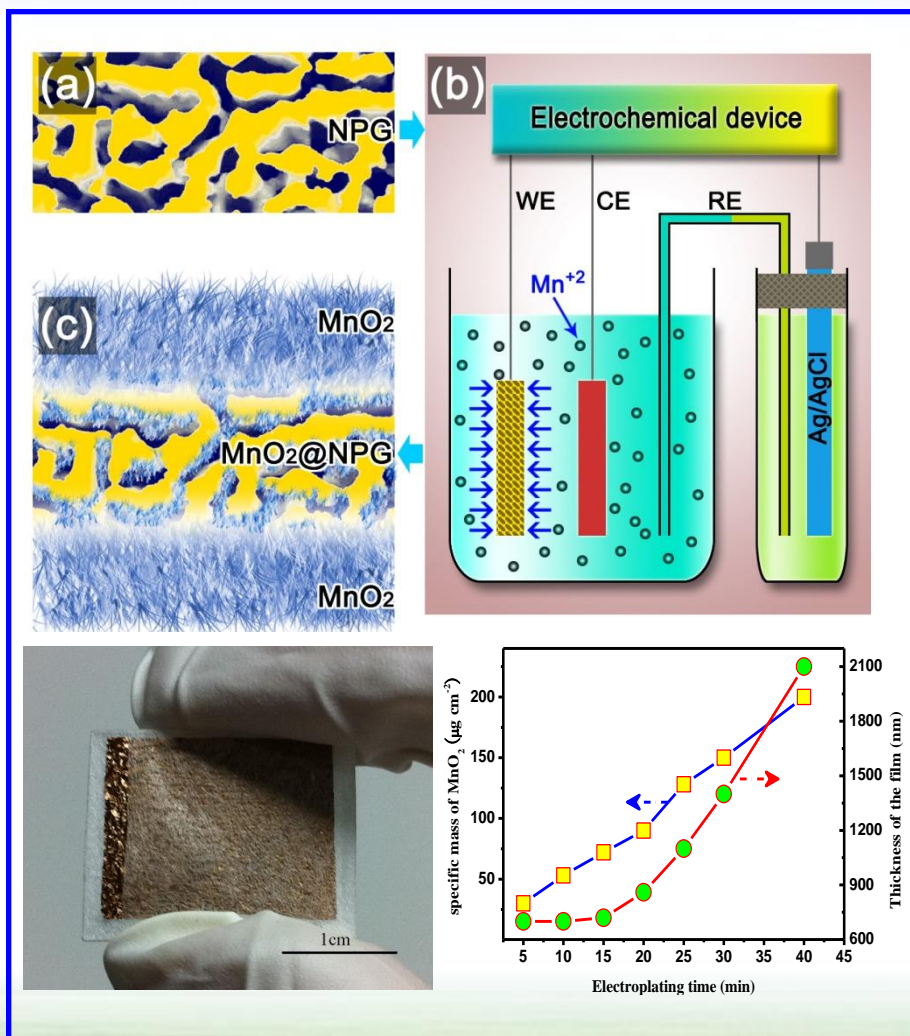
Electronic property

Self-support

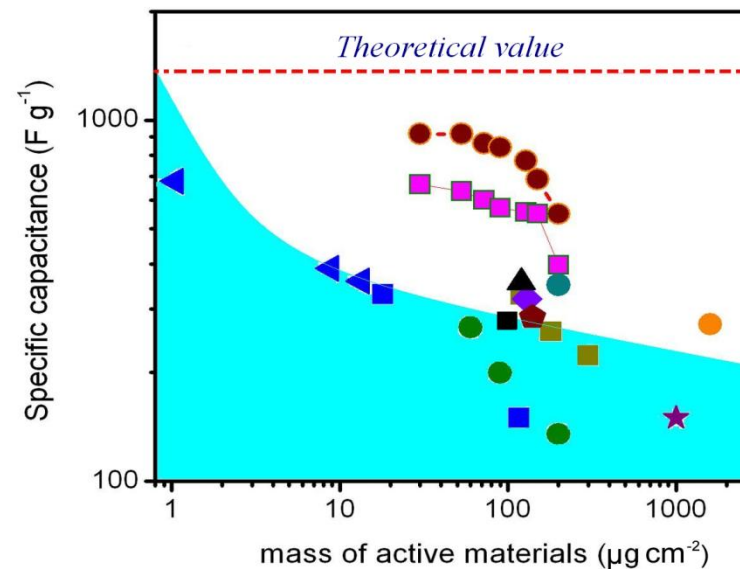
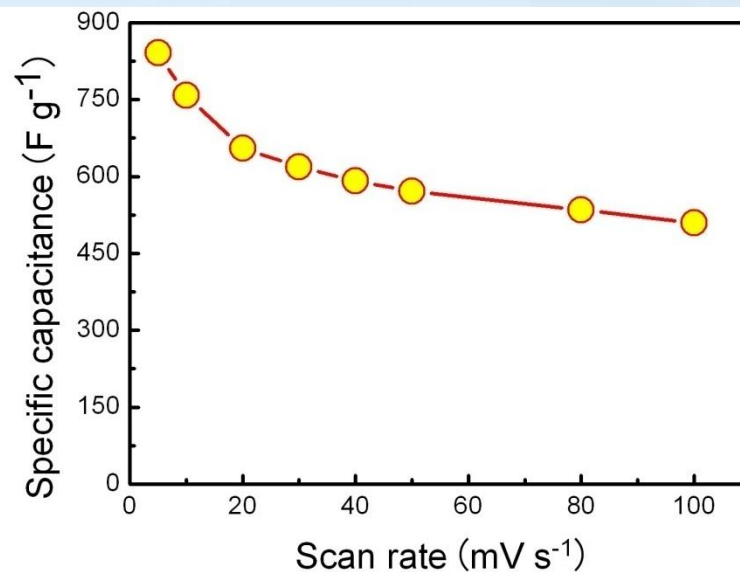
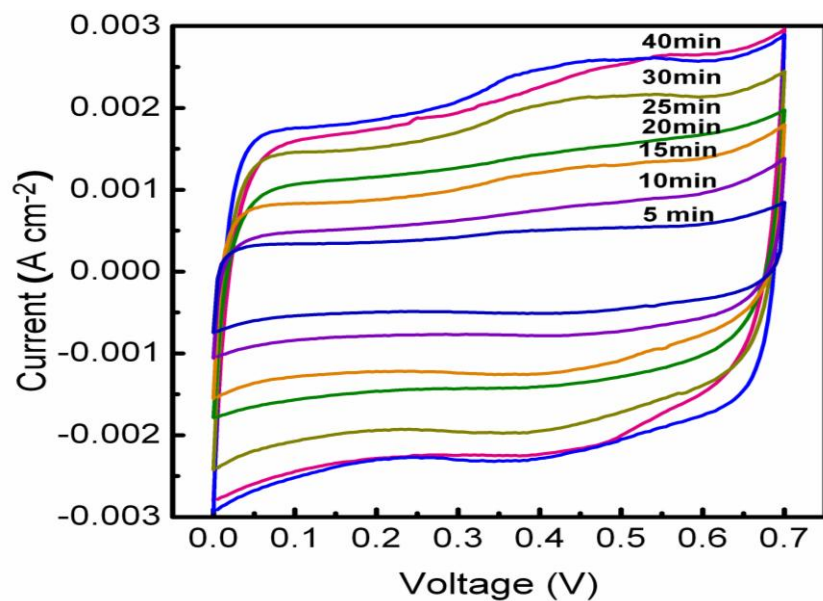
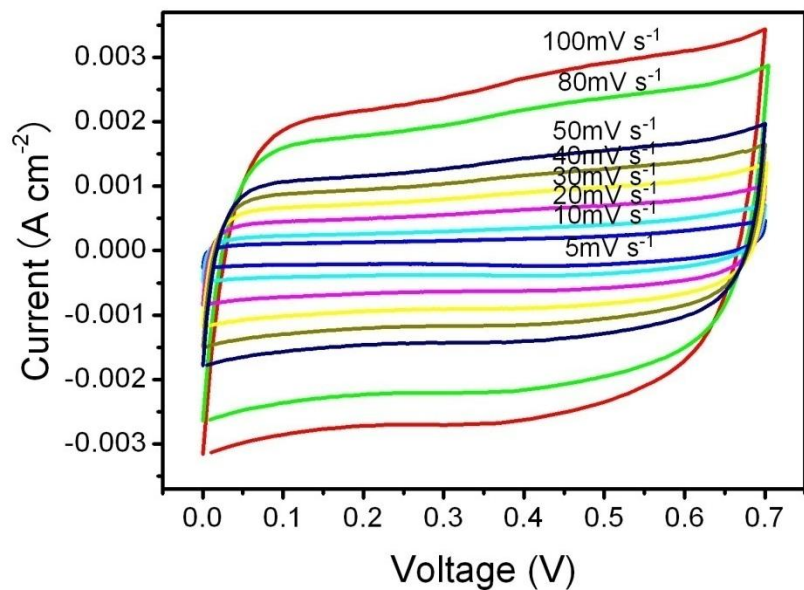
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MnO₂/NPG/MnO₂ sandwich electrodes

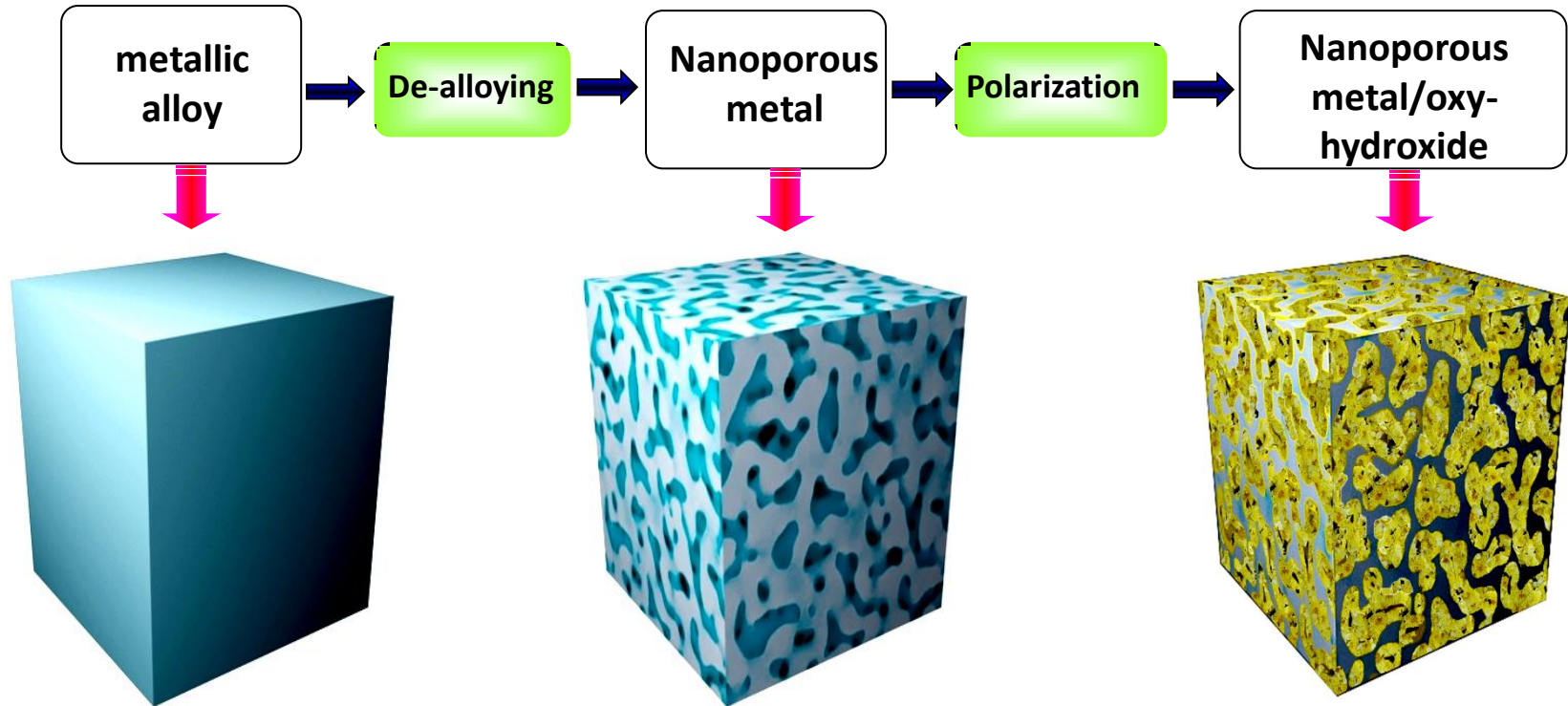
Experimental



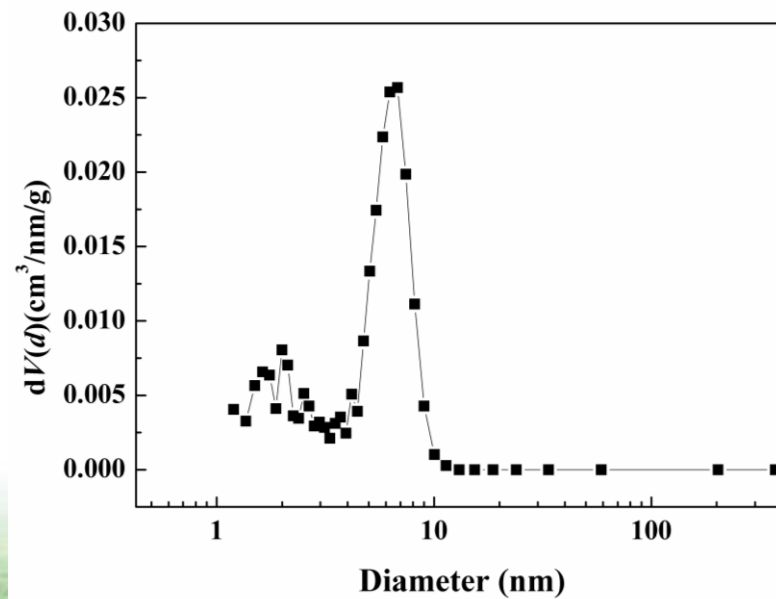
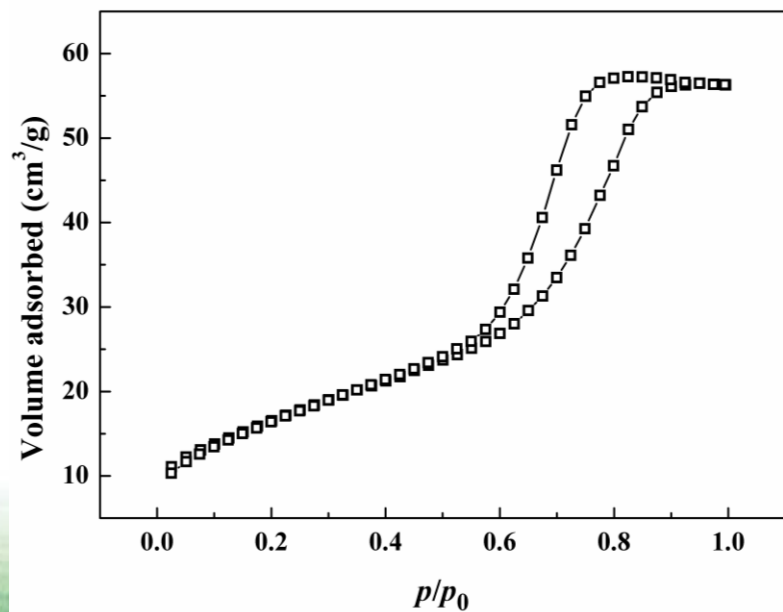
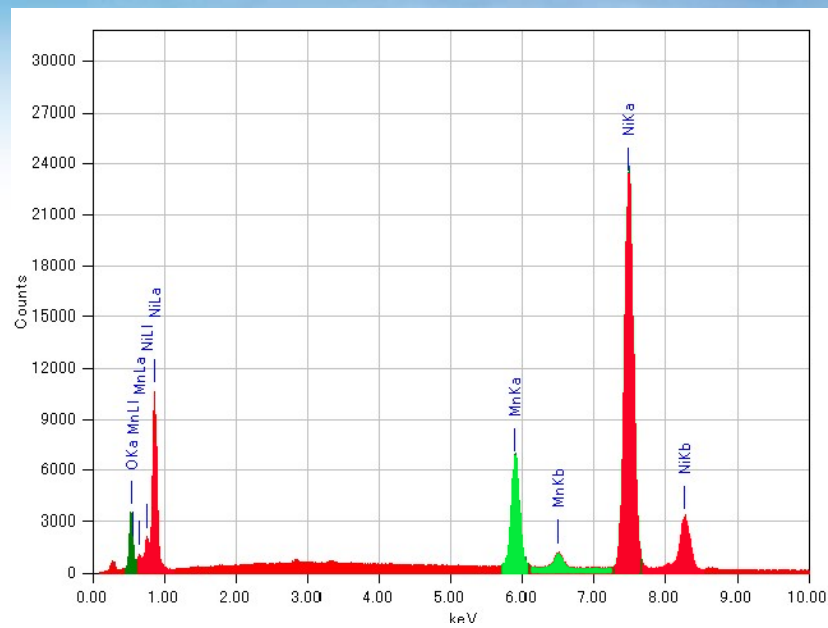
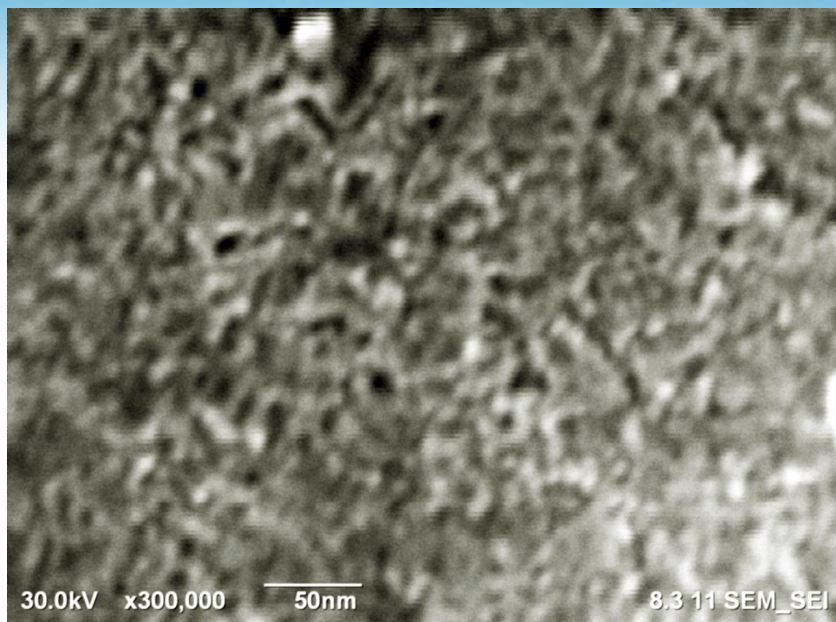
Electrochemical property

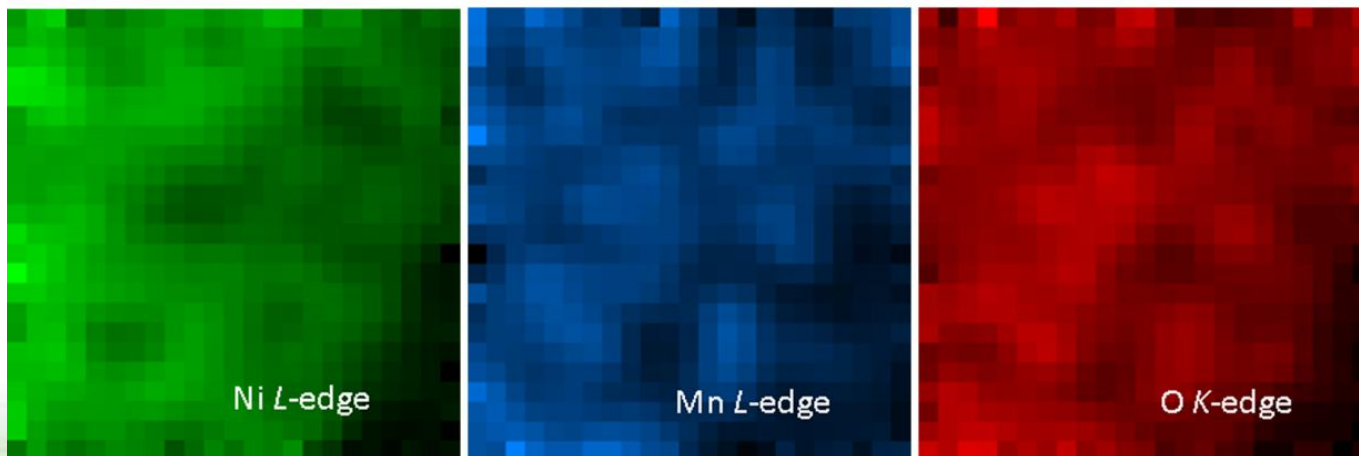
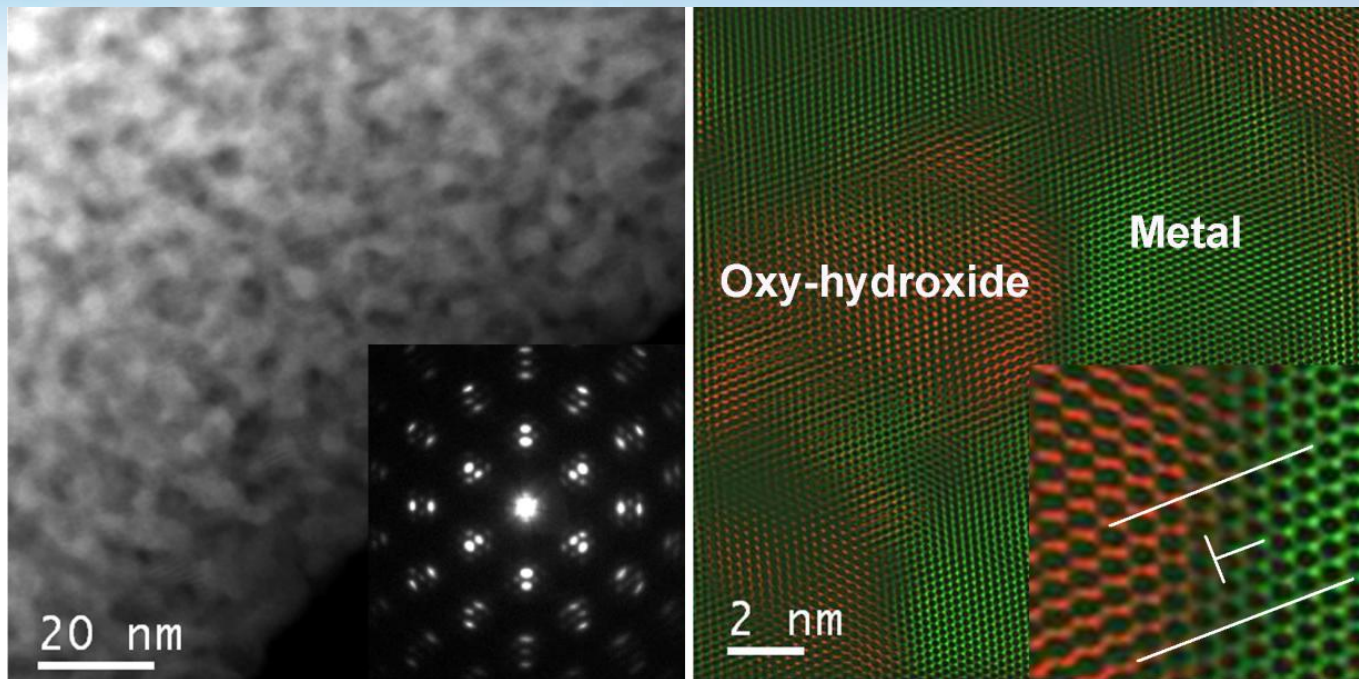


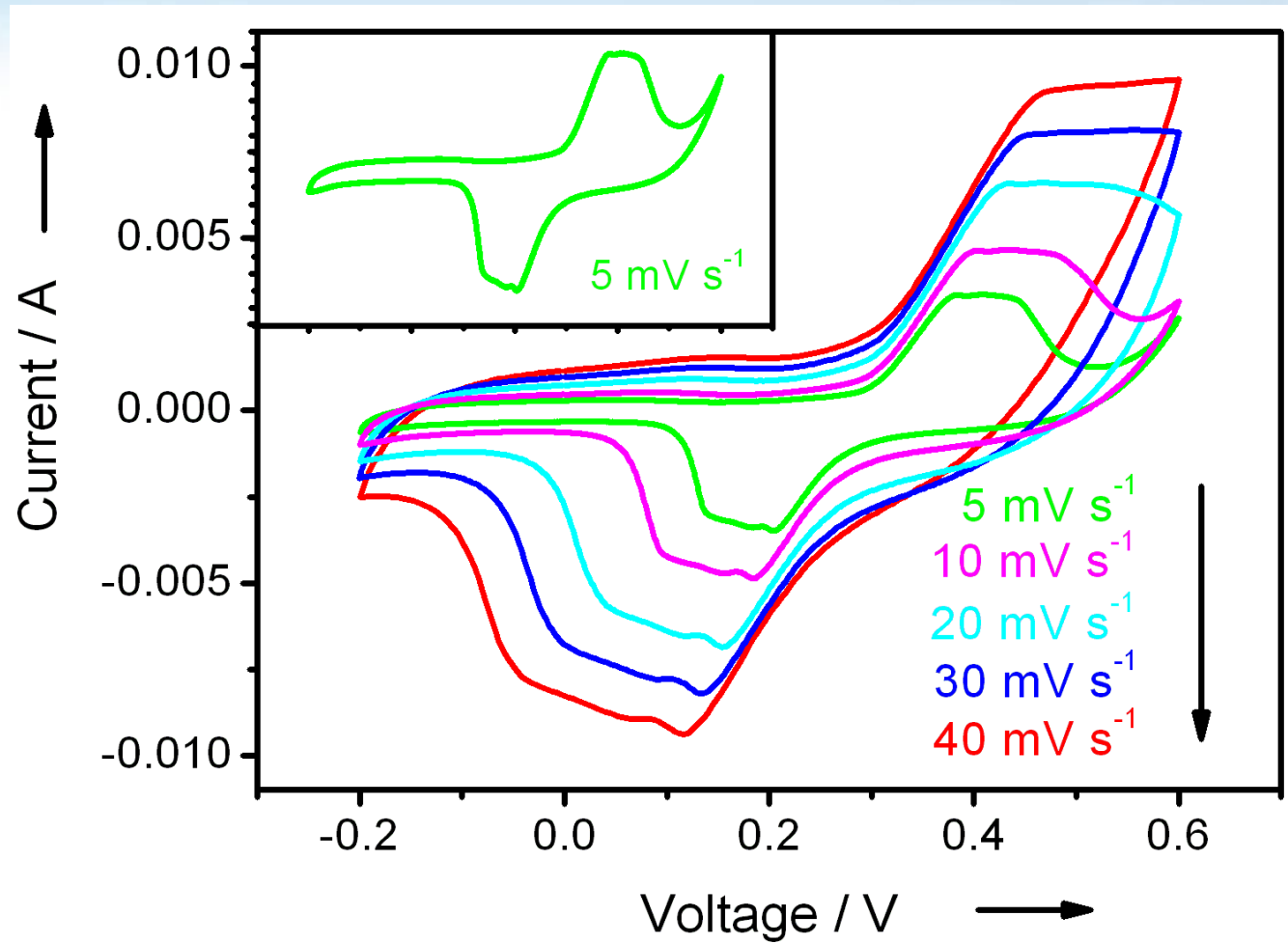
Self-grown oxide/nanoporous metal

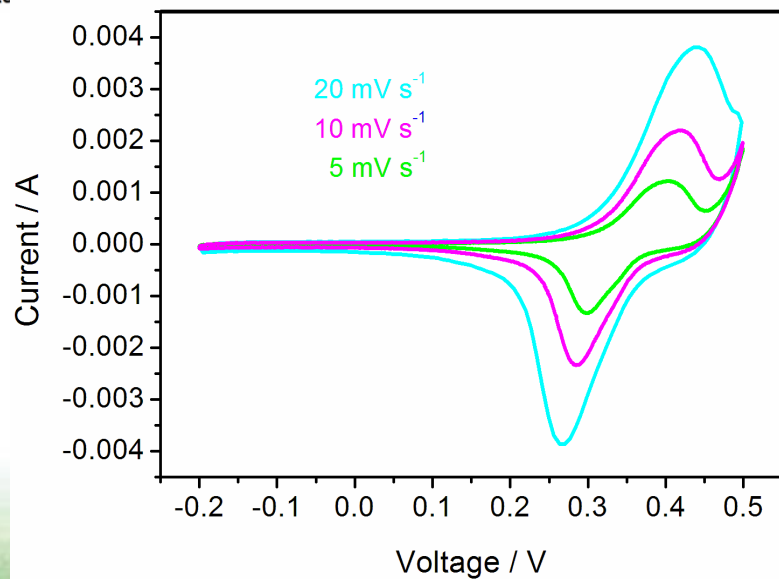
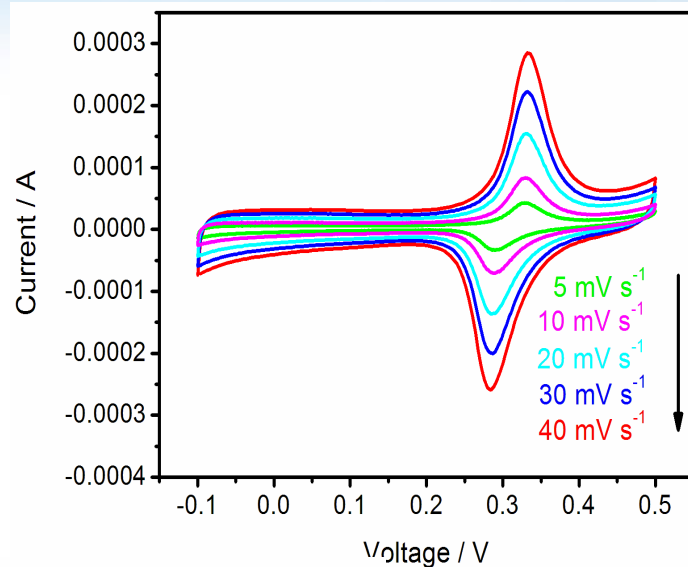
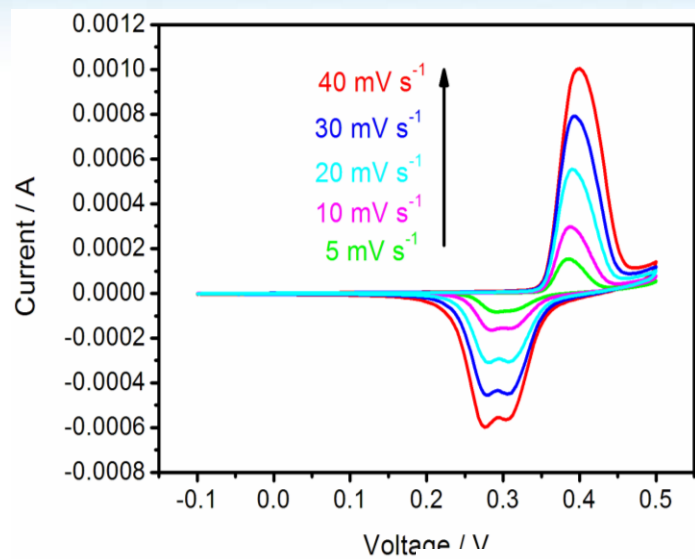


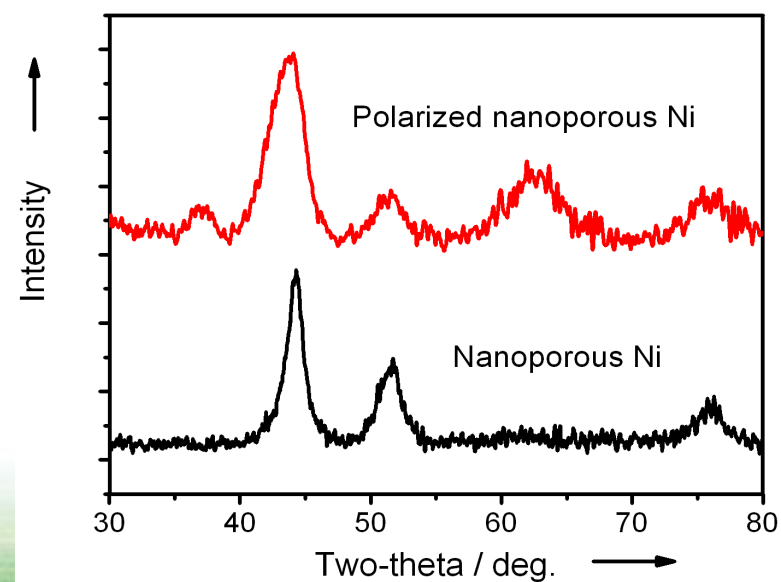
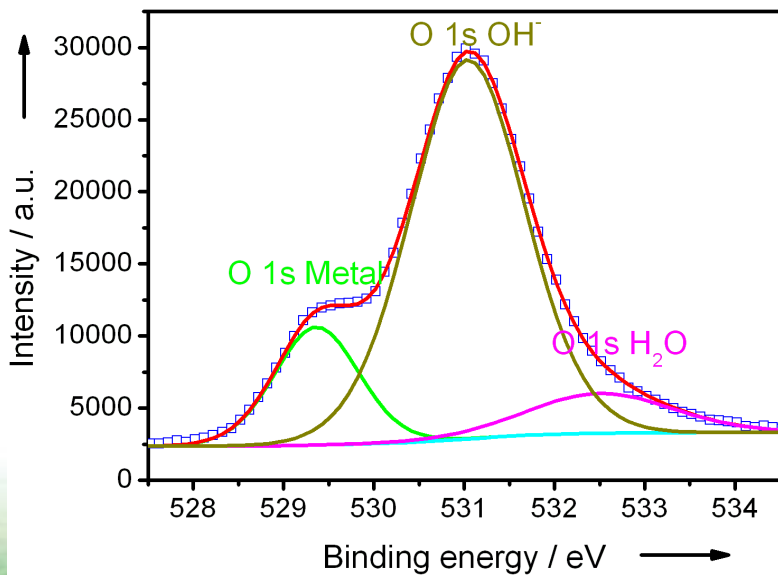
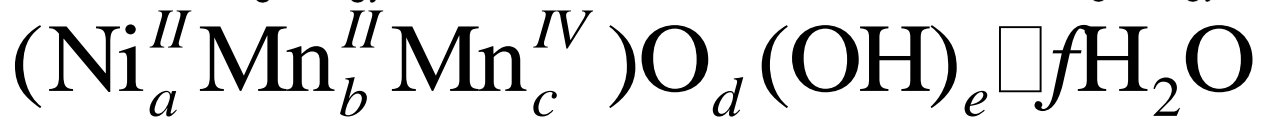
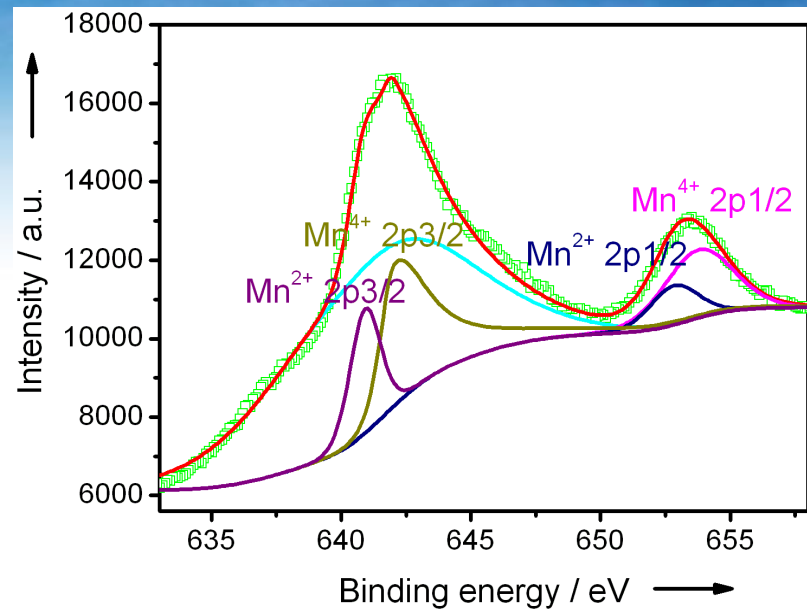
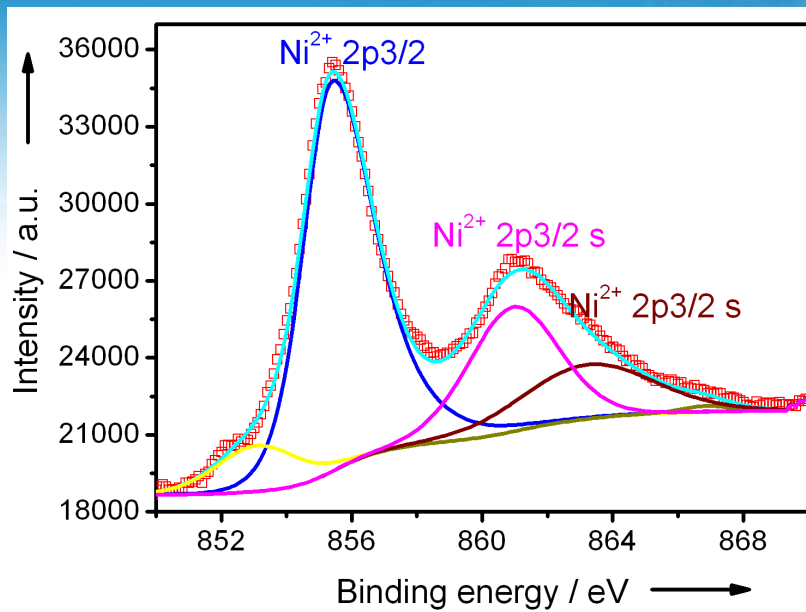
Ni-Mn system

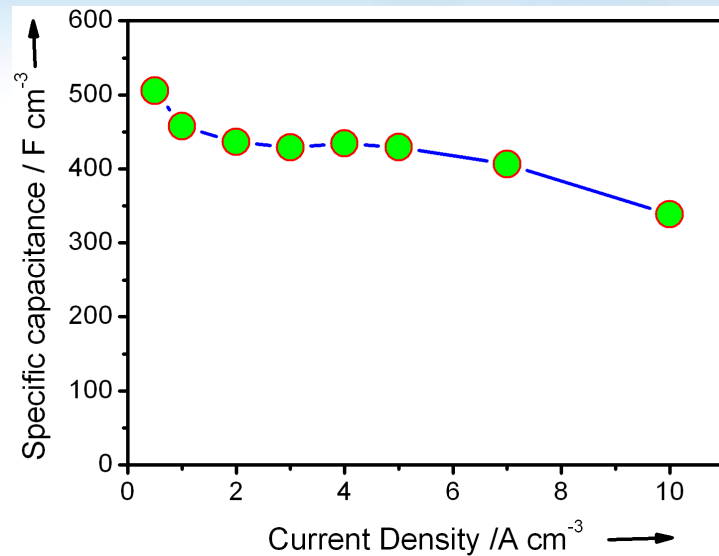
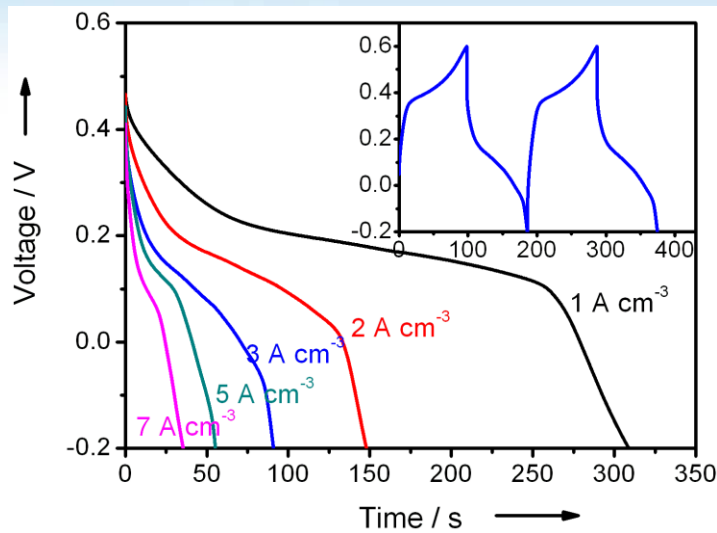




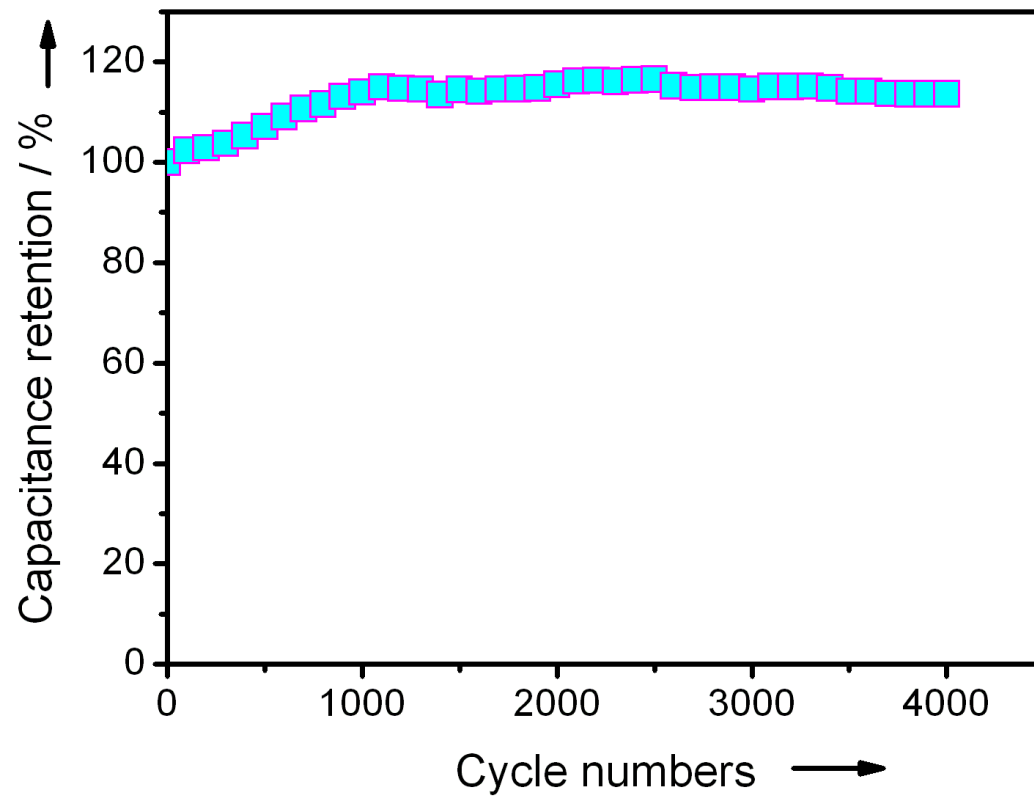




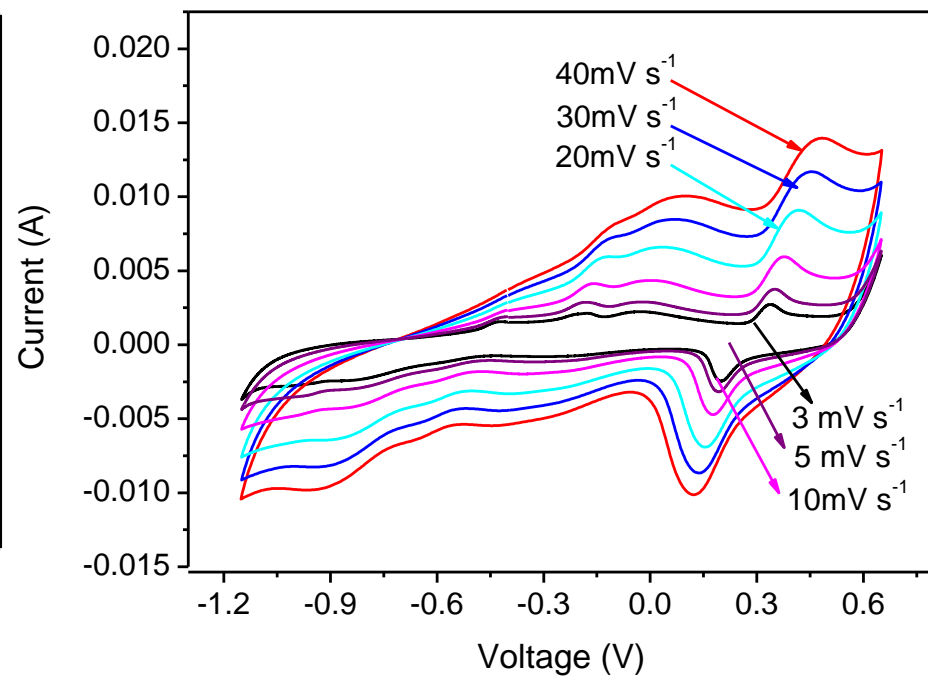
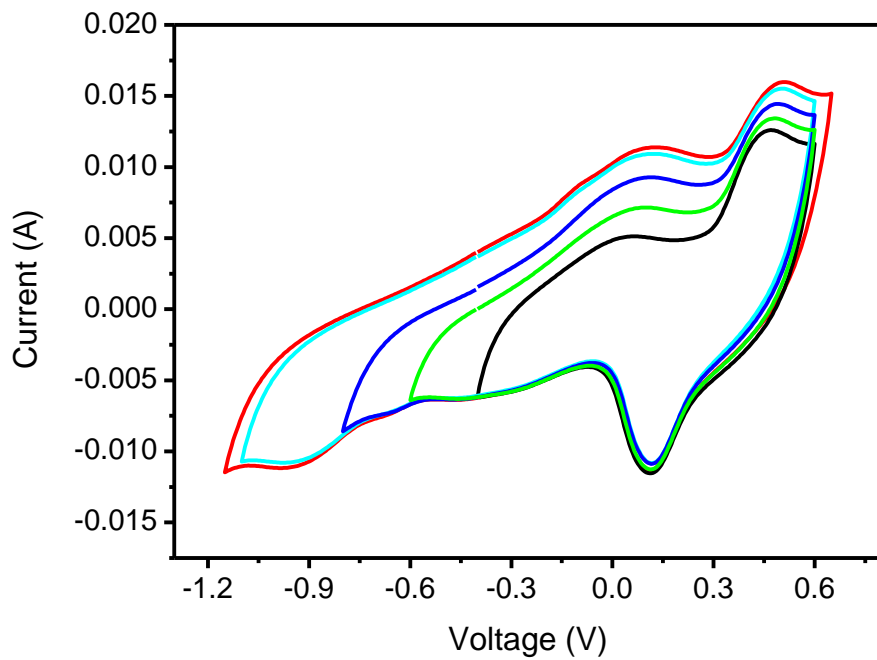


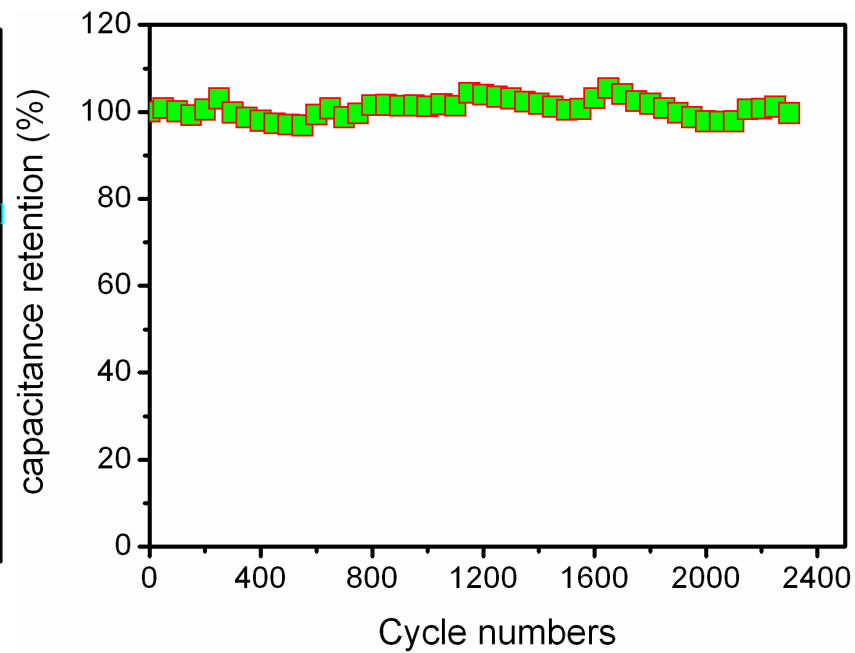
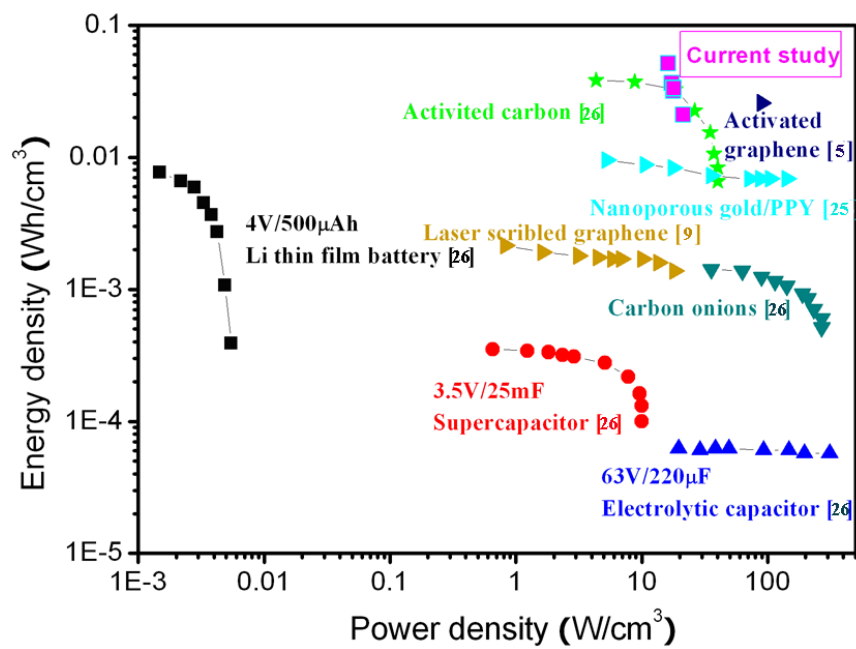


electrode	Specific capacitance [F cm ⁻³]	referenc e
Carbide-derived carbon powder	55-80	[18]
Carbide-derived carbon film	60-160 (thickness of 2-120 um)	[19]
Activated graphene oxide	60	[20]
MnO ₂ /carbon nanoform	90	[21]
NiCo ₂ O ₄ /carbon aerogel	110	[22]
Oxy-hydroxide@nanoporous metal	505	Current study



Electrochemical property





结论

- 通过多元混价结构设计，有望突破已有氧化物电极材料的限制，制备出新一代高性能赝电容电极材料。
- 结合其工艺简单、成本低，纳米多孔金属/多元混价氧化物复合电极具有极高的商用价值，有望成为未来超级电容器电极的最佳选择之一。

致谢

国家自然科学基金

天津市自然科学基金

天津市千人计划

请各位专家同行批评指正！