

The 7th Korea-U.S. Nano Forum

Block Copolymer Based Hybrid Nanostructured Materials As Key Elements In Green Nanotechnology

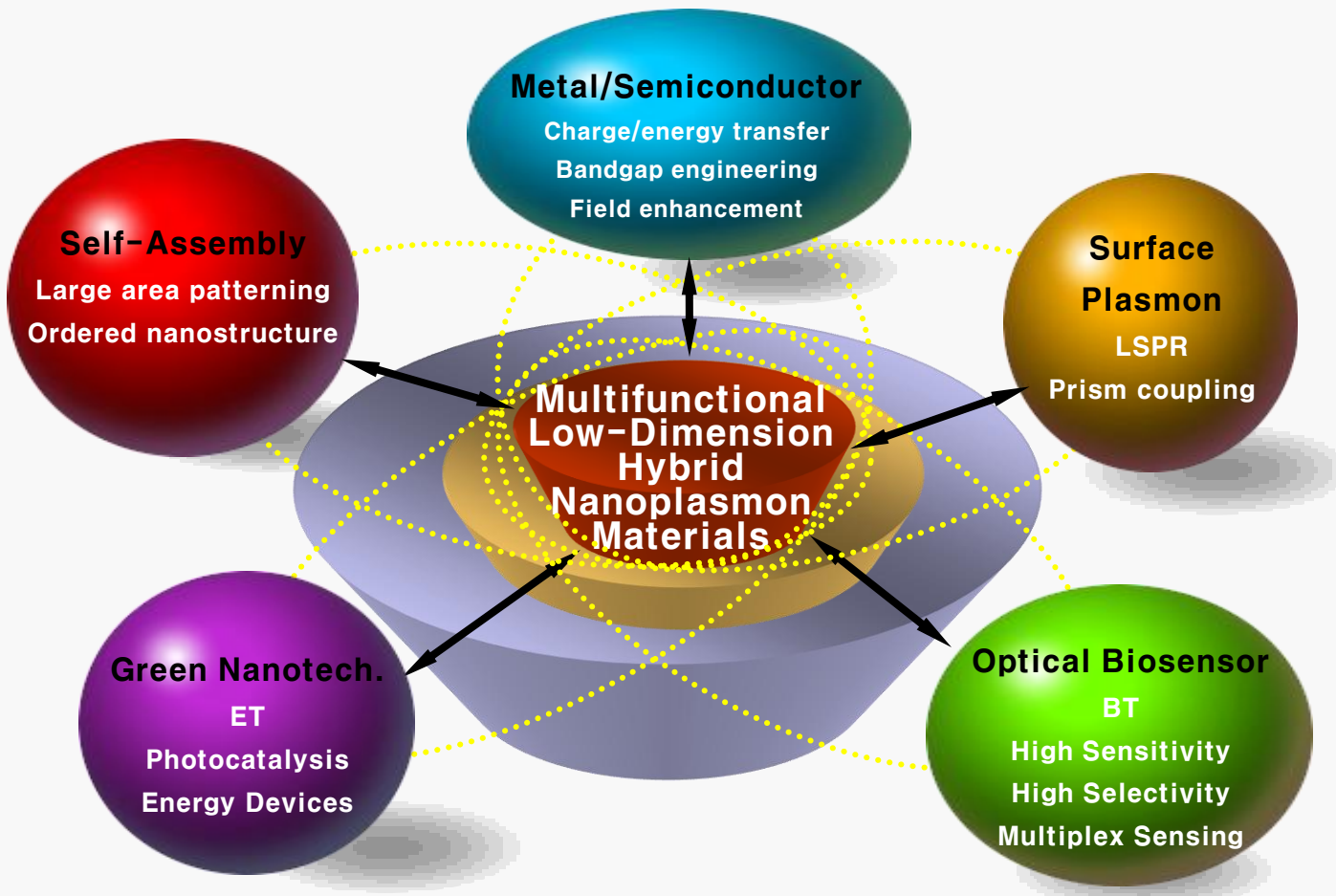


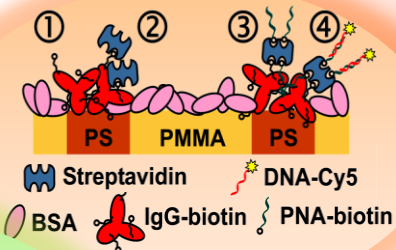
Dong Ha Kim

Department of Chemistry and Nano Science, Ewha Womans University

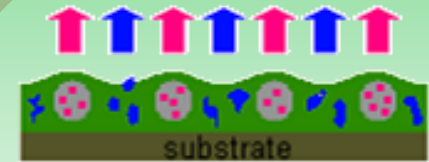
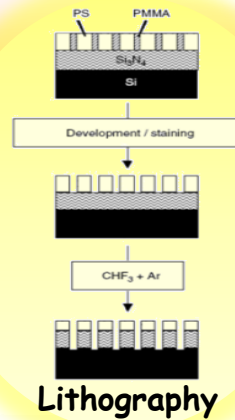
2010. 04. 05

Overview

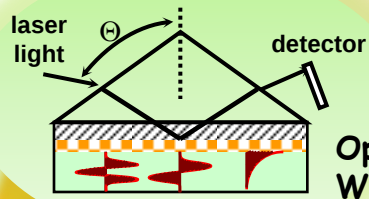




Protein Nanoarray



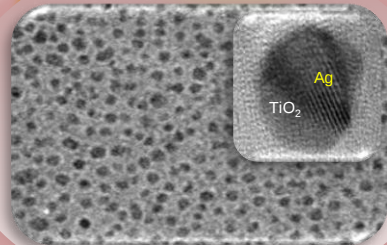
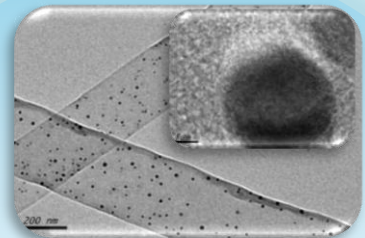
Light Emission



Optical Waveguide

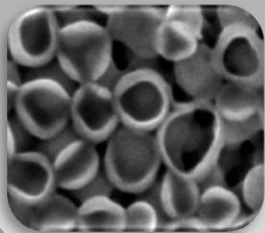


Hybrid Carbon Nanotube

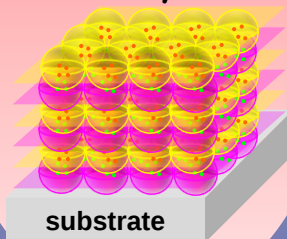


Hybrid Metal/Semiconductor

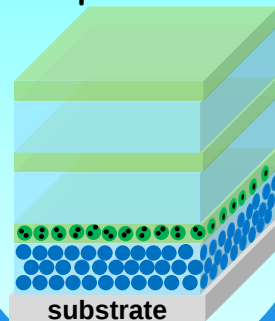
TiO₂ Nanobowl



Functional Multilayer



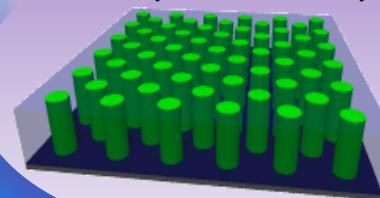
Photonic Band Gap Material



ZnO Nanoring

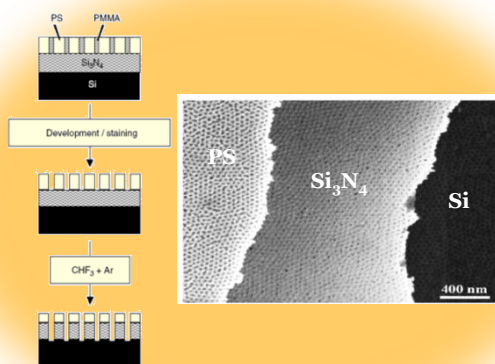


2D Nanoparticle Array

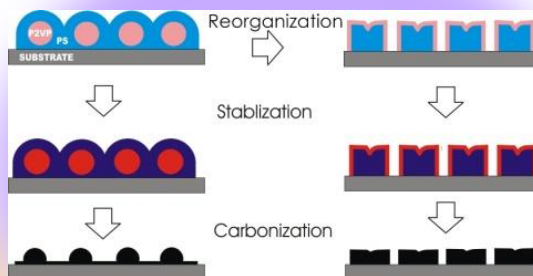


Nanostructured Carbons

Lithography

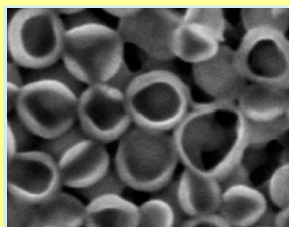


Nano Lett. **2007**, 7, 1516
Nanotechnology **2006**, 17, 2122



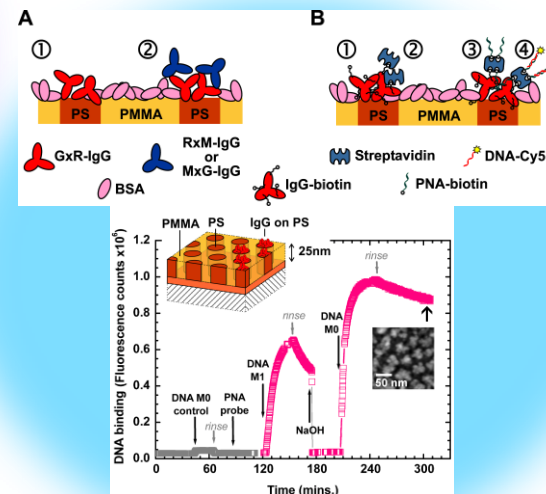
Nano Lett. **2008**, 8, 3993
J. Mater. Chem., submitted

Nanostructured TiO₂ (ZnO)



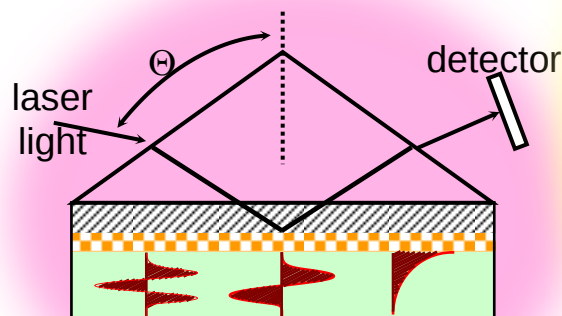
J. Mater. Chem. **2010**, 20, 677
J. Mater. Chem. **2009**, 19, 7245
Chem. Commun. **2009**, 1091-1093
Chem. Mater. **2008**, 20, 6041
Chem. Mater. **2008**, 20, 1200
Soft Matter **2008**, 4, 515
Macromol. Rapid Commun. **2008**, 28, 2055
ChemPhysChem **2006**, 7, 370
Adv. Funct. Mater. **2005**, 15, 1160
Langmuir, **2005**, 21, 5212
Macromol. Rapid Commun. **2005**, 26, 1173
Nano Lett. **2004**, 4, 1841

Protein Nanoarray



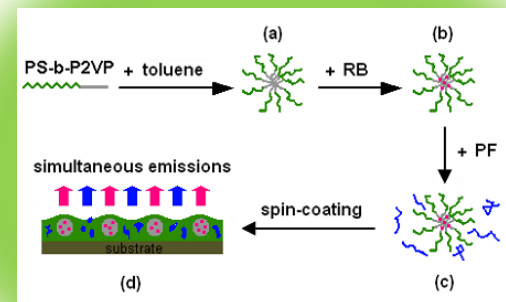
Adv. Funct. Mater. **2008**, 18, 3148
Biomacromolecules **2009**, 10, 1061

SPR Sensing



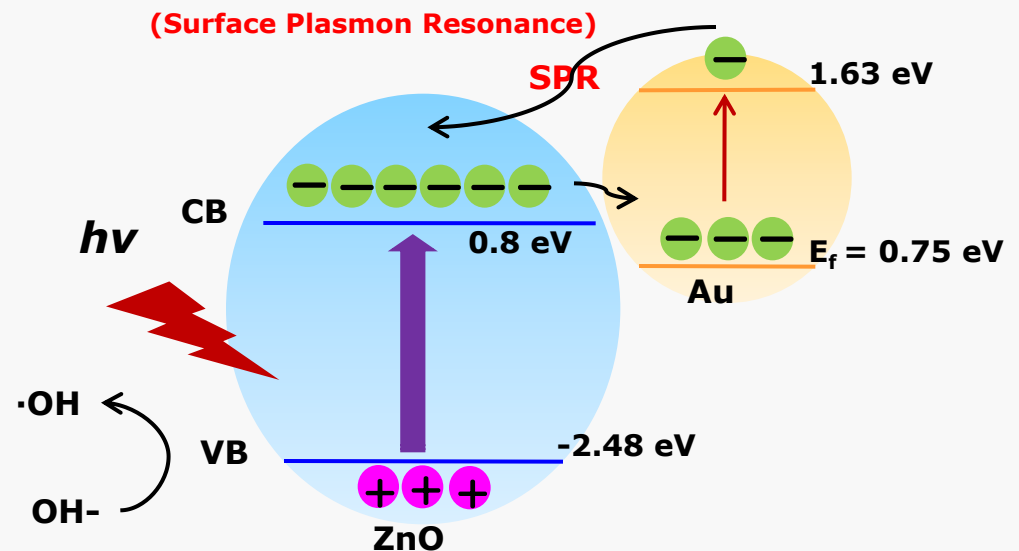
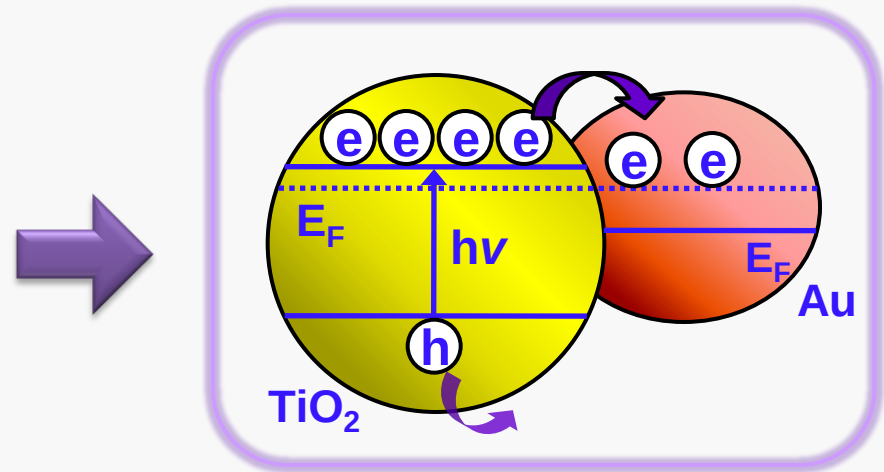
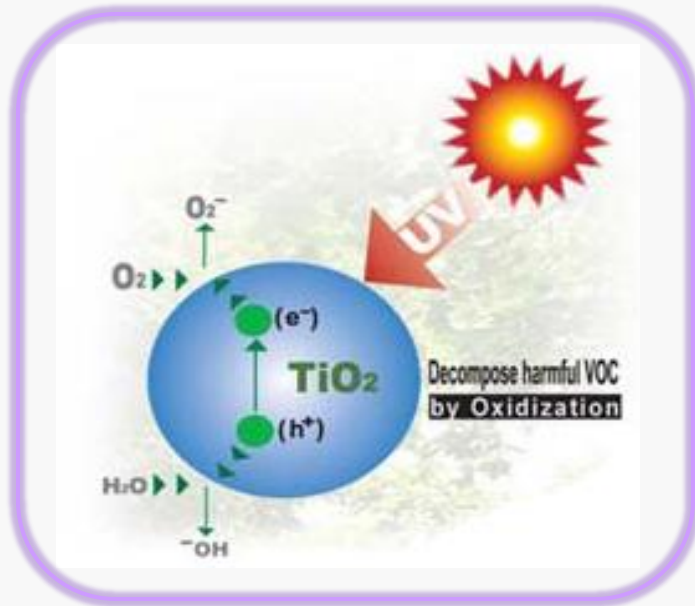
Nano Lett. **2009**, 9, 2384
J. Mater. Chem. **2009**, 19, 2006
Adv. Mater **2005**, 17, 2442
J. Phys. Chem. B **2006**, 110, 15381
Macromol. Res. **2007**, 15, 211

Light Emission

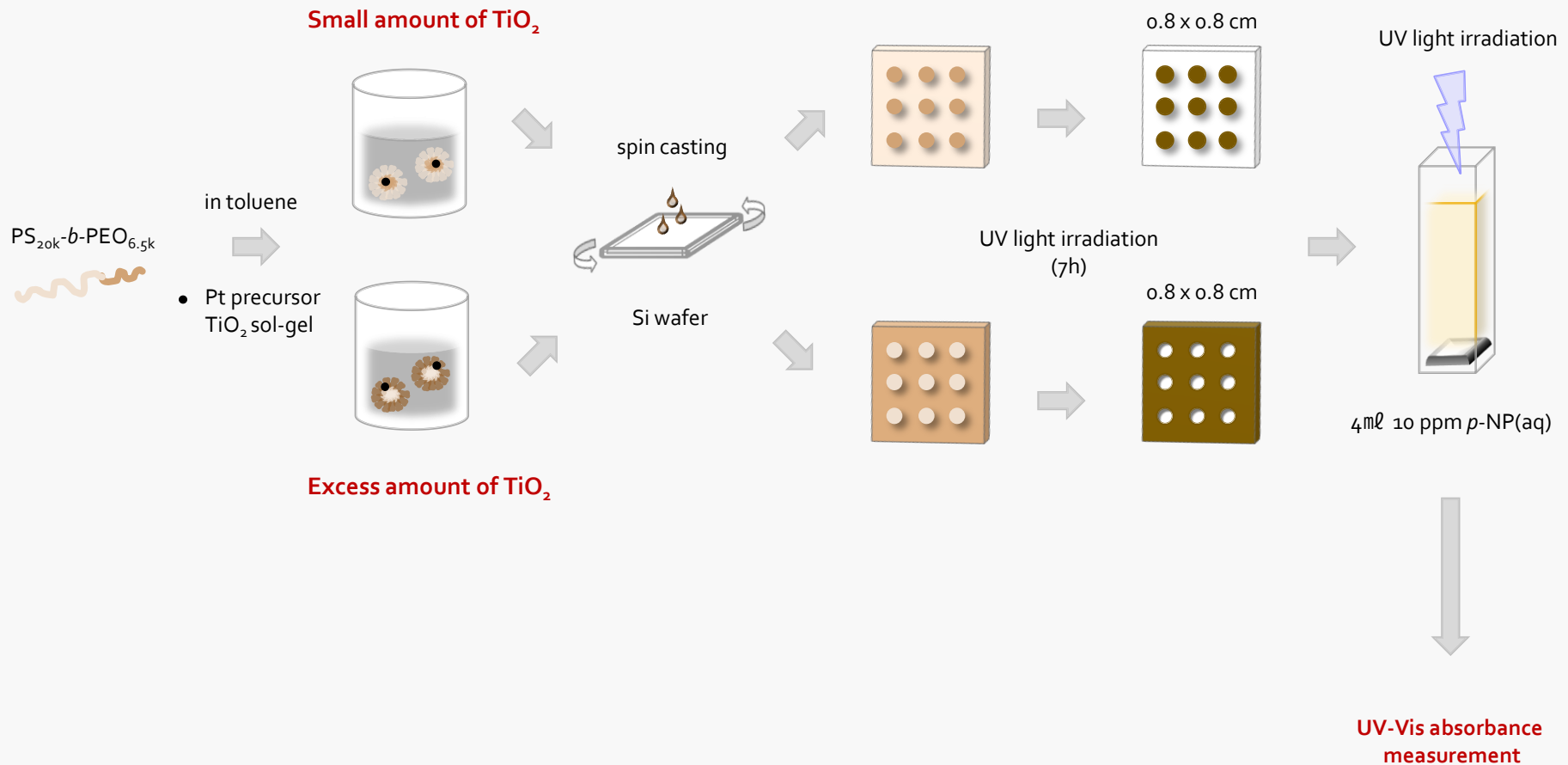


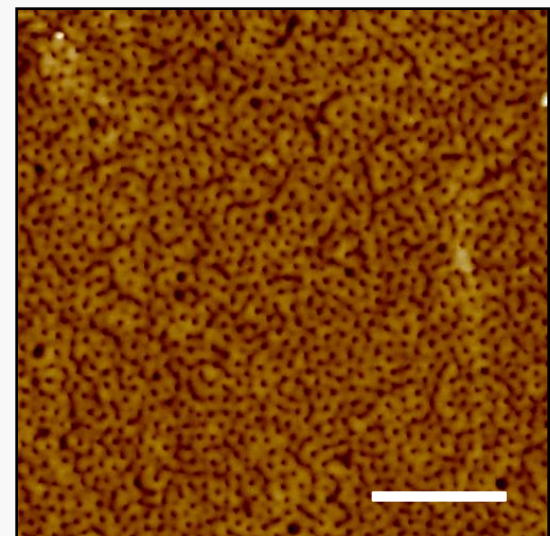
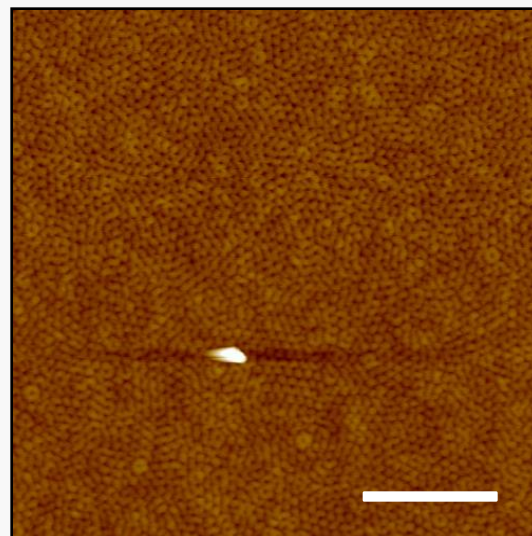
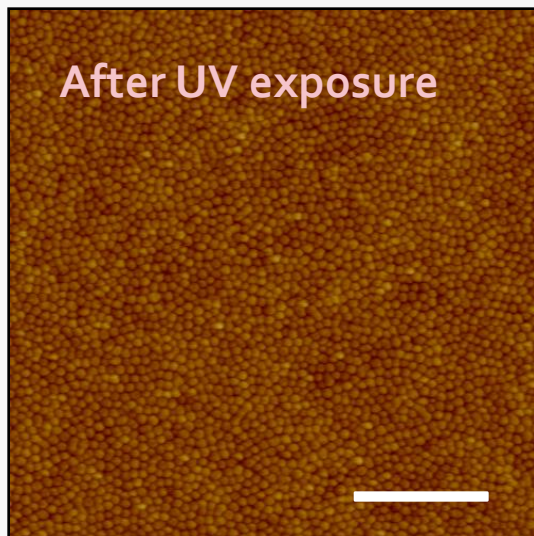
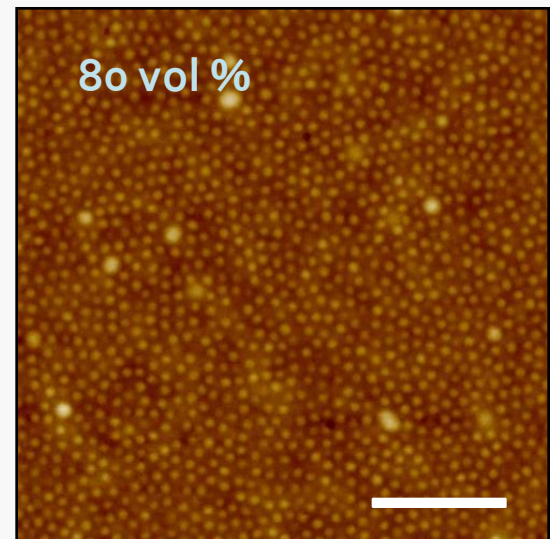
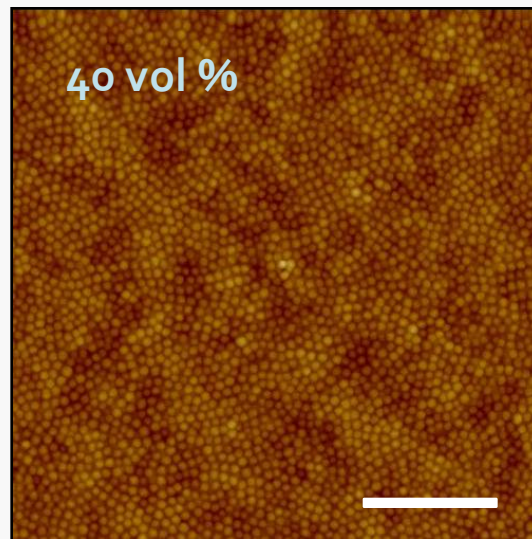
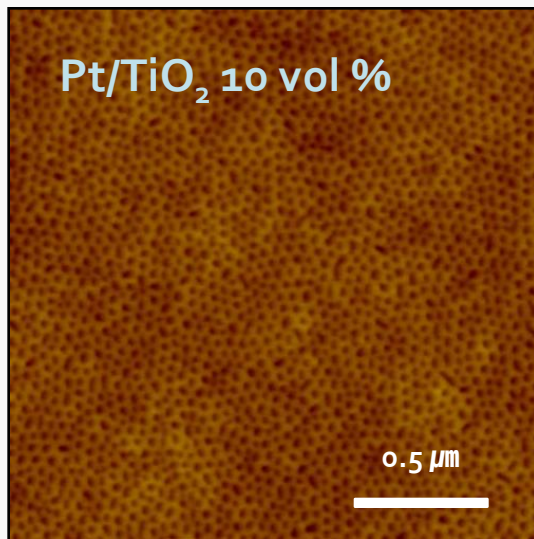
Appl. Phys. Lett. **2008**, 93, 183303
Chem. Mater. **2008**, 20, 6041

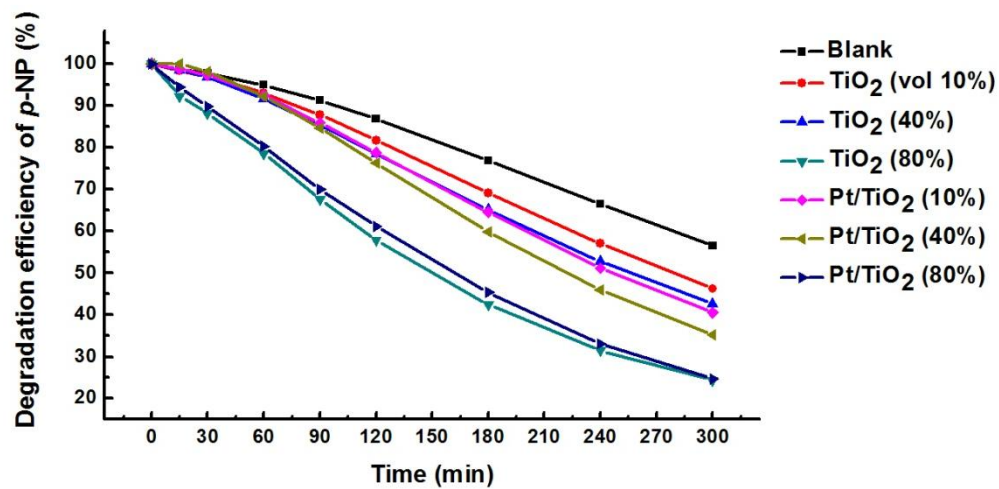
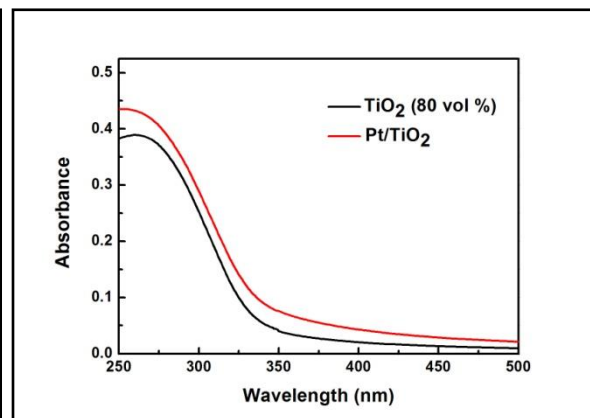
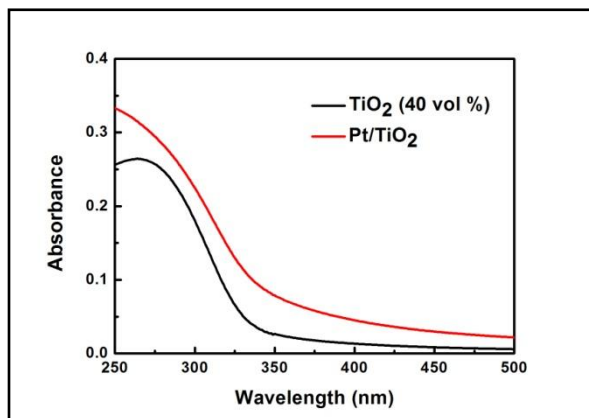
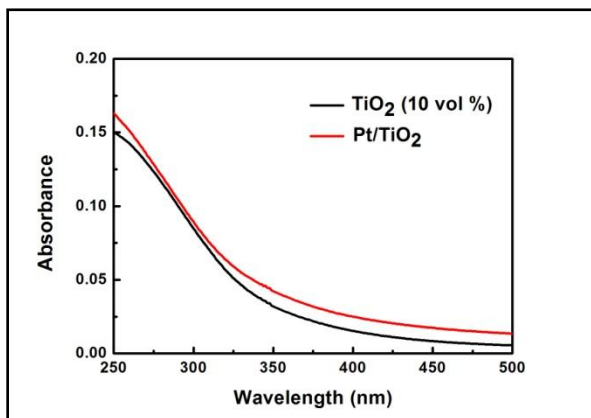
Photocatalyst



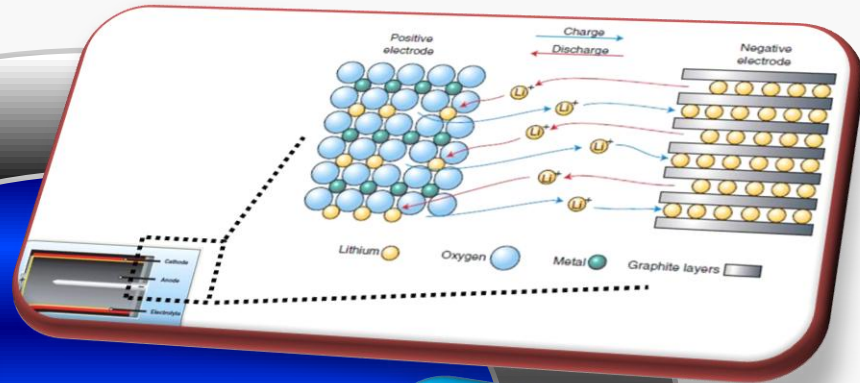
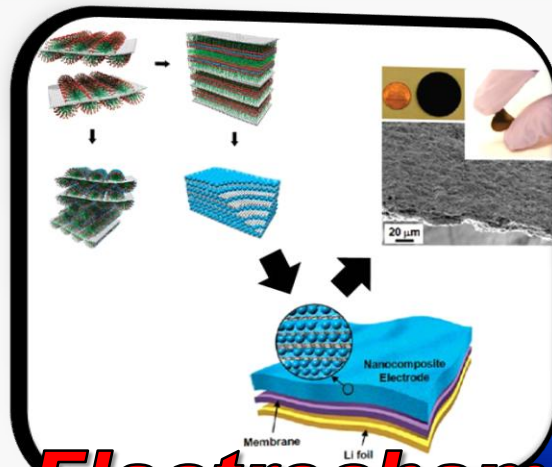
Pt/TiO₂ Nanohybrids



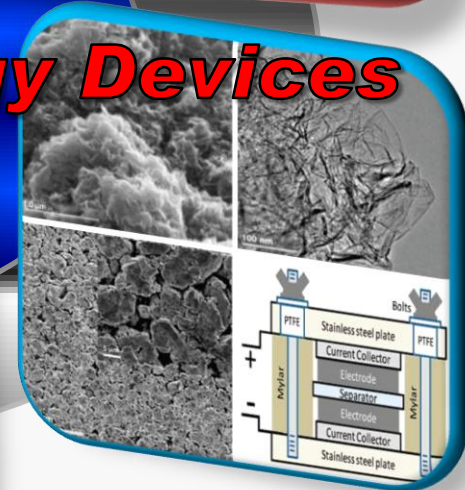
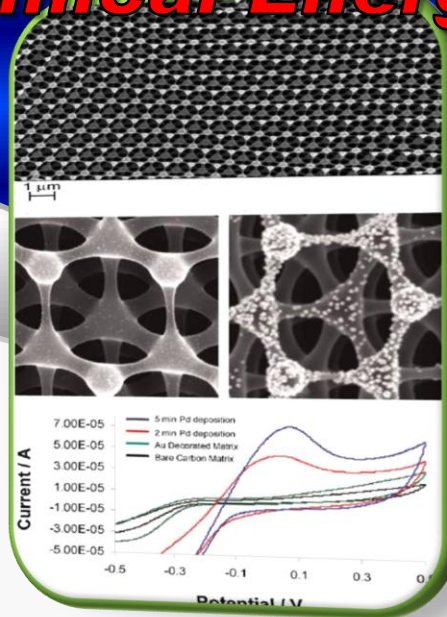
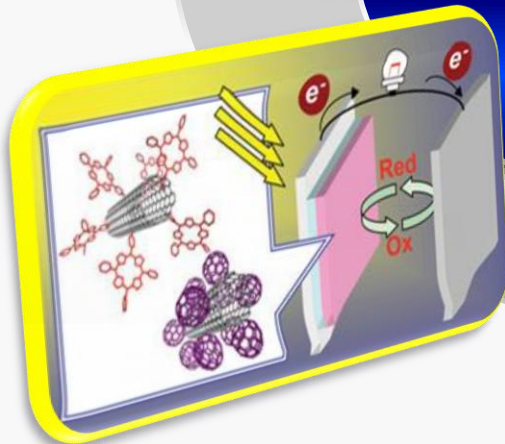




Carbon-based Electrodes

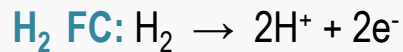


Electrochemical Energy Devices



Electrodes in Fuel Cell

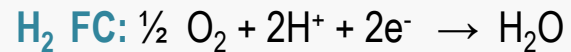
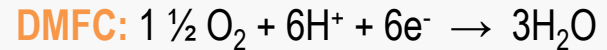
Anode: Fuel oxidation reaction



Pt (+Ru) Nanocatalysts in Carbon (+TiO₂) Matrix

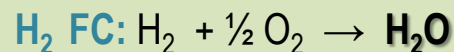
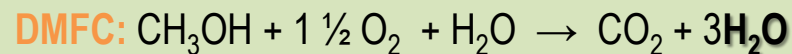


Cathode: Oxygen reduction reaction



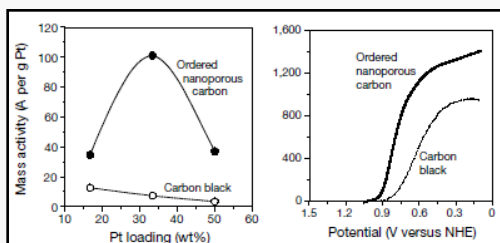
Pt (+Pd, Ni, Co) Nanocatalysts in Carbon (+TiO₂) Matrix

Overall reaction



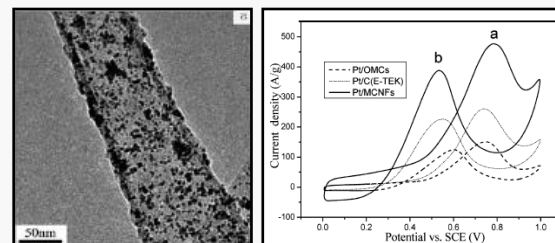
Pt/C or Pd/C Hybrids in Electrocatalysis

High dispersion of Pt on porous carbon gives rise to promising electrocatalytic activity for O_2 reduction, which could prove to be relevant for fuel-cell technologies.



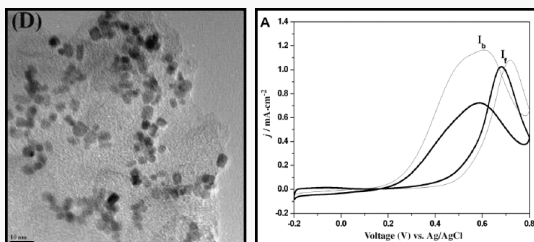
S. H. Joo, *Nature* 2001, 412, 169

1-D carbon nanofiber loaded with Pt nanoparticles had high electrocatalytic methanol oxidation reaction due to its high mass transport and electron transport.



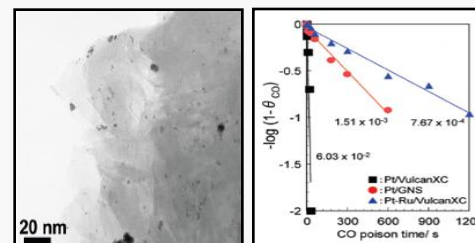
G. Zhao, *J. Phys. Chem. C* 2008, 112, 1028

The Pt nanocube/carbon catalyst with dominant {100} faces showed lower onset potential and higher current density for methanol electrooxidation than the polycrystalline Pt nanocatalyst.

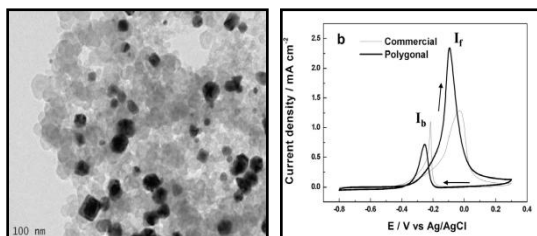


S.-B. Han, *Electrochem. Commun.* 2008, 10, 1044

Graphene nanosheets were expected as a new carbon support material modifying catalytic properties of Pt fuel cell catalysts.

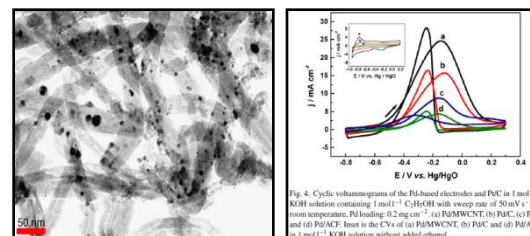


For methanol electrooxidation, the polygonal Pd/C shows improved current-density and less accumulation of residues. The polygonal Pd/C exhibits an excellent stability in comparison with commercial Pd/C.



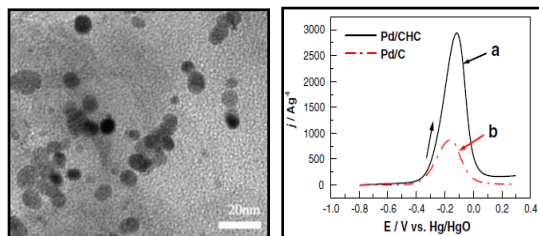
Y. W. Lee, *Electrochem. Commun.* 2009, 11, 1968

Pd/MWCNT (> Pd/C > Pd/ACF) electrocatalyst showed the highest activity for ethanol oxidation in alkaline media. The results indicated that the support would significantly influence the catalytic activities.



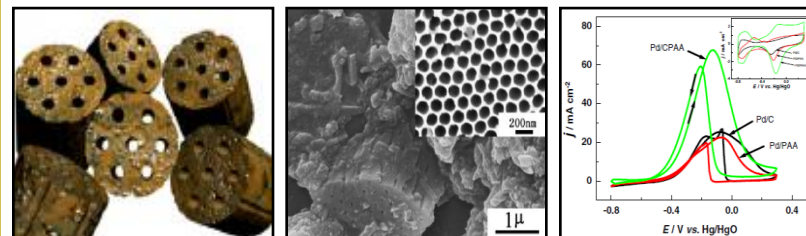
H.T. Zheng, *J. Power Sources* 2006, 163, 371

The Pd/coin-like hollow carbon (CHC) electrocatalyst gave a enhanced performance for MeOH oxidation because the micrometer sized CHCs significantly reduced the liquid sealing effect.



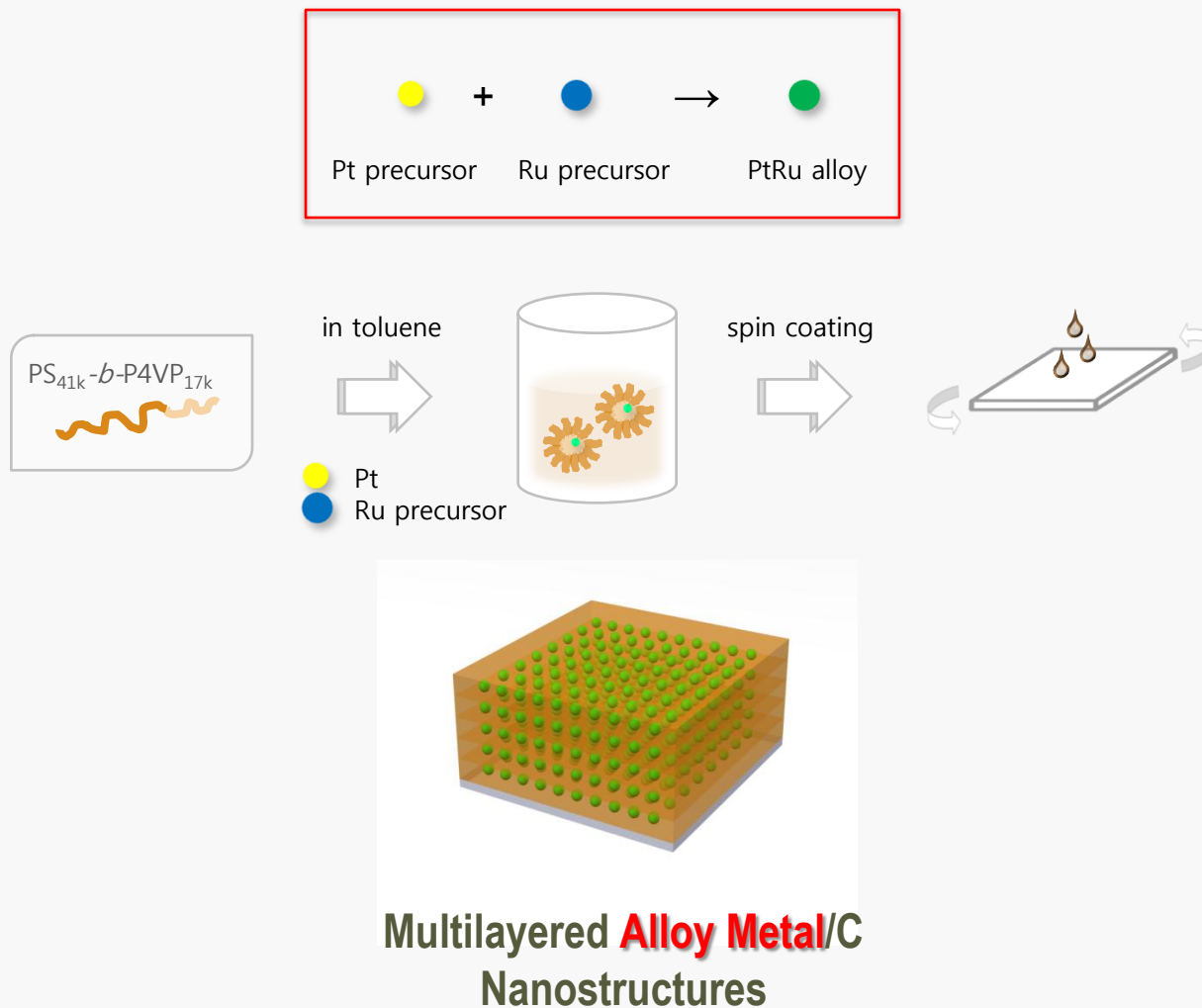
D. Yuan, *Electrochem. Commun.* 2007, 9, 2473

The activities of alcohol oxidation on Pd on carbonized pulverized PAA electro-catalyst are higher than that on Pd/C. Electrodes prepared by Pd/CPAA showed a porous structure, resulting in a high active surface area.



Z. Wang, *Electrochem. Commun.* 2006, 8, 1764

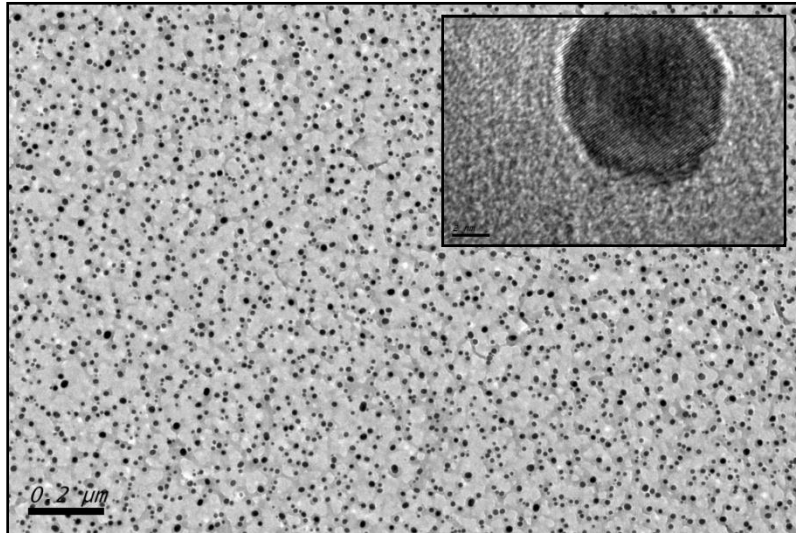
Scheme to Pt-Ru/C Nano-Architectures



Pt/C

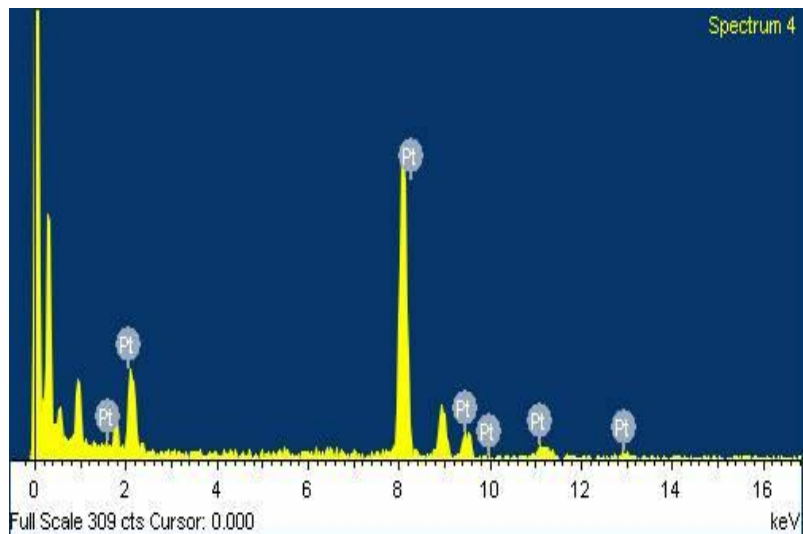
1 layered

500 nm

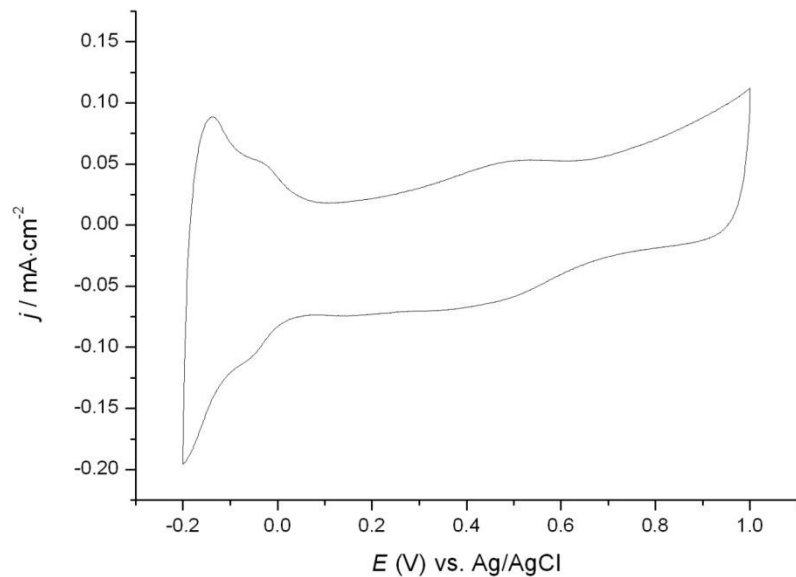
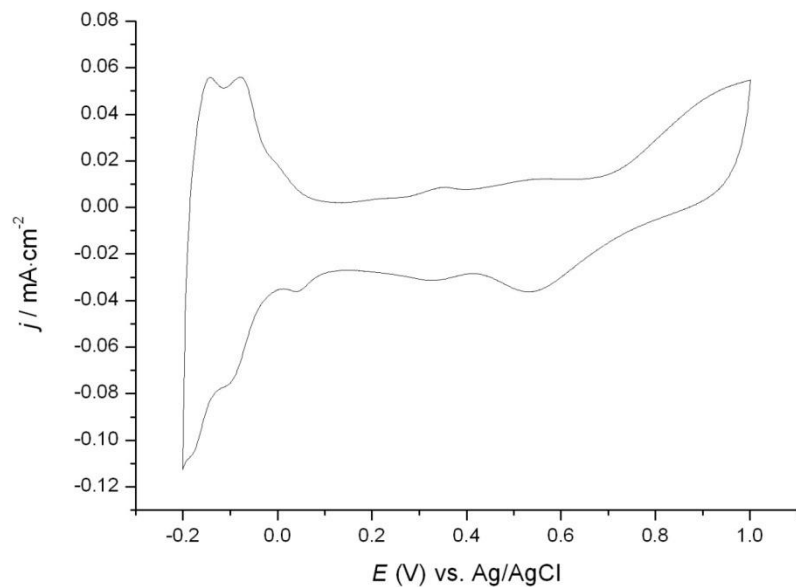


5 layered

500 nm

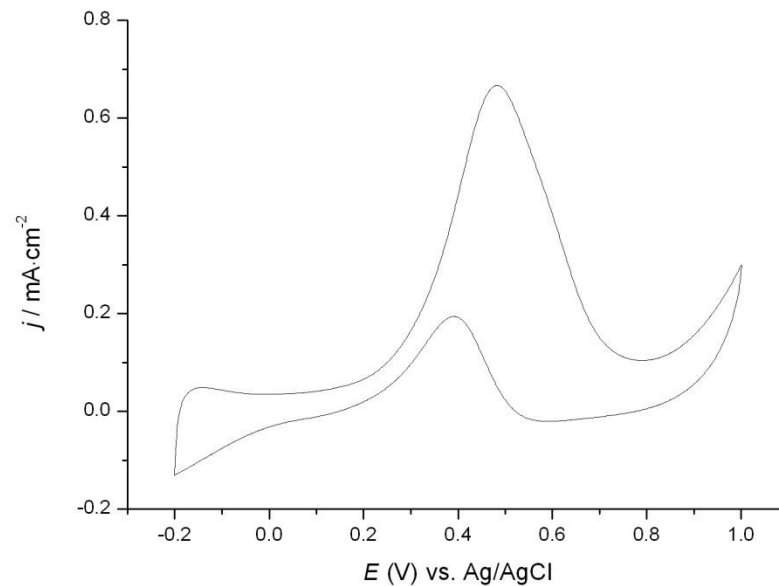
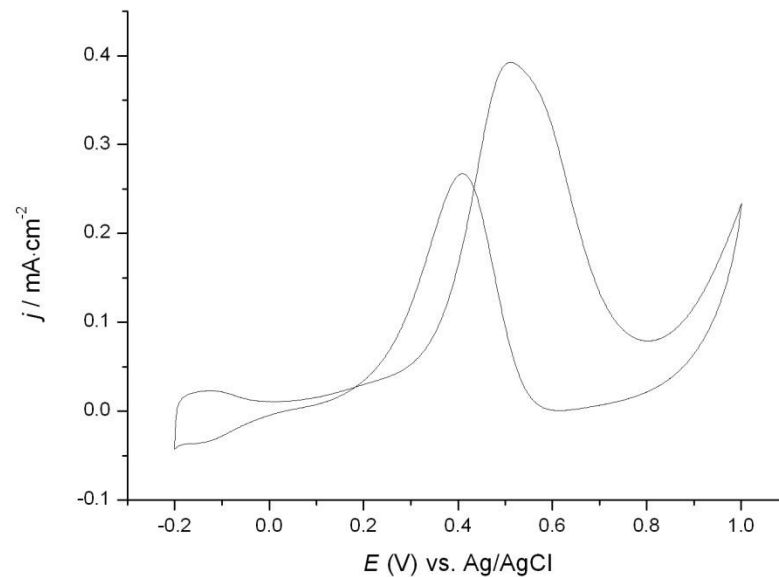


5 layered **Pt**/C in HClO_4



5 layered **Pt-Ru**/C in HClO_4

5 layered **Pt**/C in HClO_4 + **MeOH**



5 layered **Pt-Ru**/C in HClO_4 + **MeOH**

Summary

What have been done:

- Block copolymer self-assembly for tailored hybrid nanostructures
- Direct carbonization route to hybrid carbon nanostructures
- Metal/TiO₂ or Carbon/TiO₂ as visible light active photocatalysts
- Pt-Ru/C based electrocatalyst for fuel cell anodes

Further discussions:

- Candidates for cathode?
- Universal paradigm for the design of elements in energy devices

Acknowledgements

◆ Collaborators

Dr. Dinakaran Kannaiyan, *Postdoctoral Researcher*

Saji Thomas Kochuveedu, Yoon Hee Jang, *Ph.D. Candidate*

Min-Ah Cha, Yu Jin Jang, Jieun Lee, Ji Yong Lee, Juyon Lee, *M.S. Candidate*



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Polymer Nanohybrid Materials Lab

<http://nano.ewha.ac.kr/~polykim>