RPGR 2017 SINGAPORE

RECENT PROGRESS IN GRAPHENE & 2D MATERIALS RESEARCH

Flexible electrode technology based on chemically-modified graphene nanosheets

2017. 9.22

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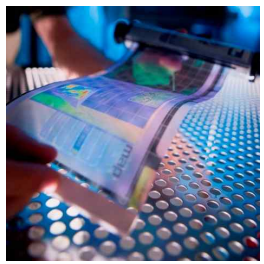
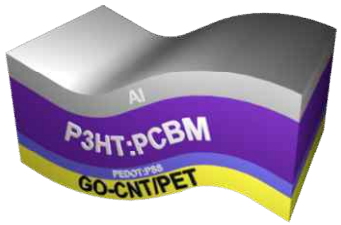
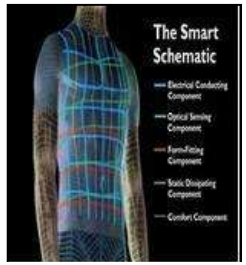
Outline

- Research works at KERI
- Exfoliation of graphite oxide
- Dispersion of reduced graphene oxide
- How to make high quality or highly porous graphene from graphite oxide (unpublished)
- Summary

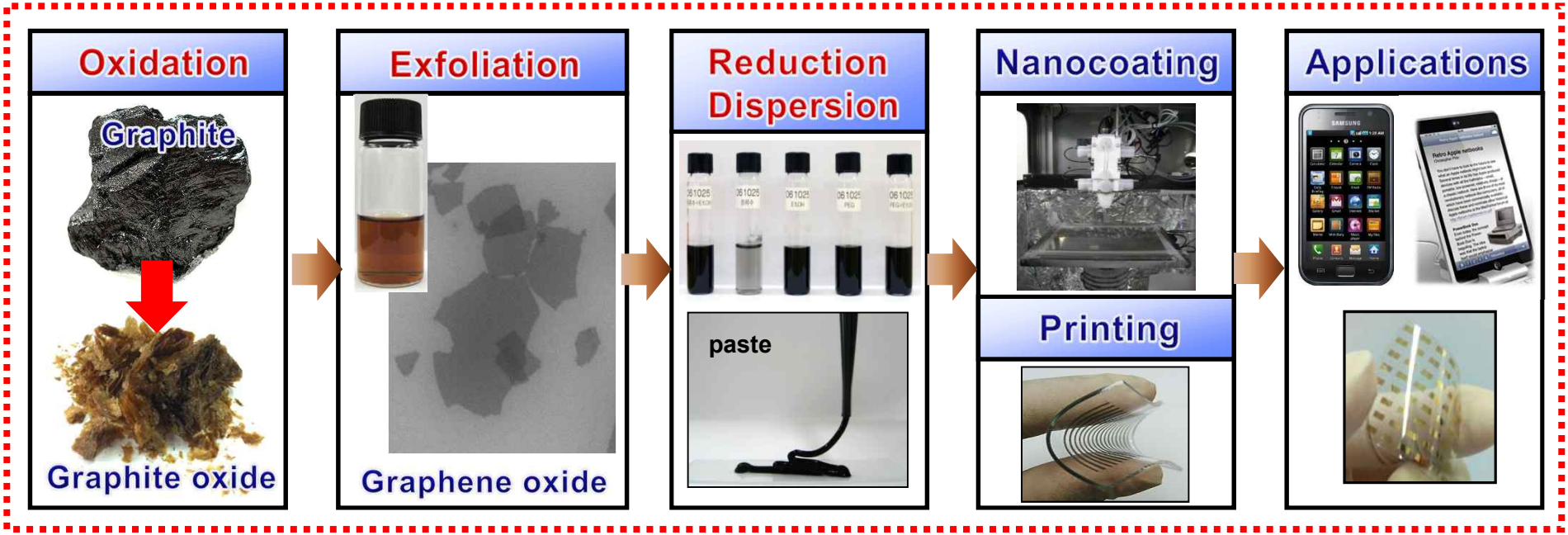







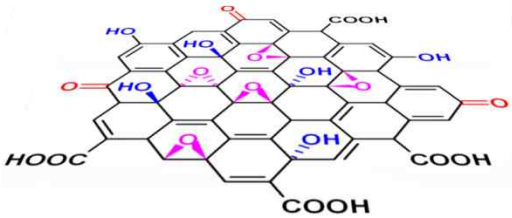
Chemically-modified Graphene

KERI



- Defect control
- size
- Oxidation level

- Functional groups
- Defect level
- Number of layer
- Graphene size



- Reduction level
- Defect level
- Number of layer
- Graphene size
- Dispersion

- Nanostructures
- Assembly
- Interfacial energy
- Wettability
- Doping
- Transmittance
- Conductivity
- Stability

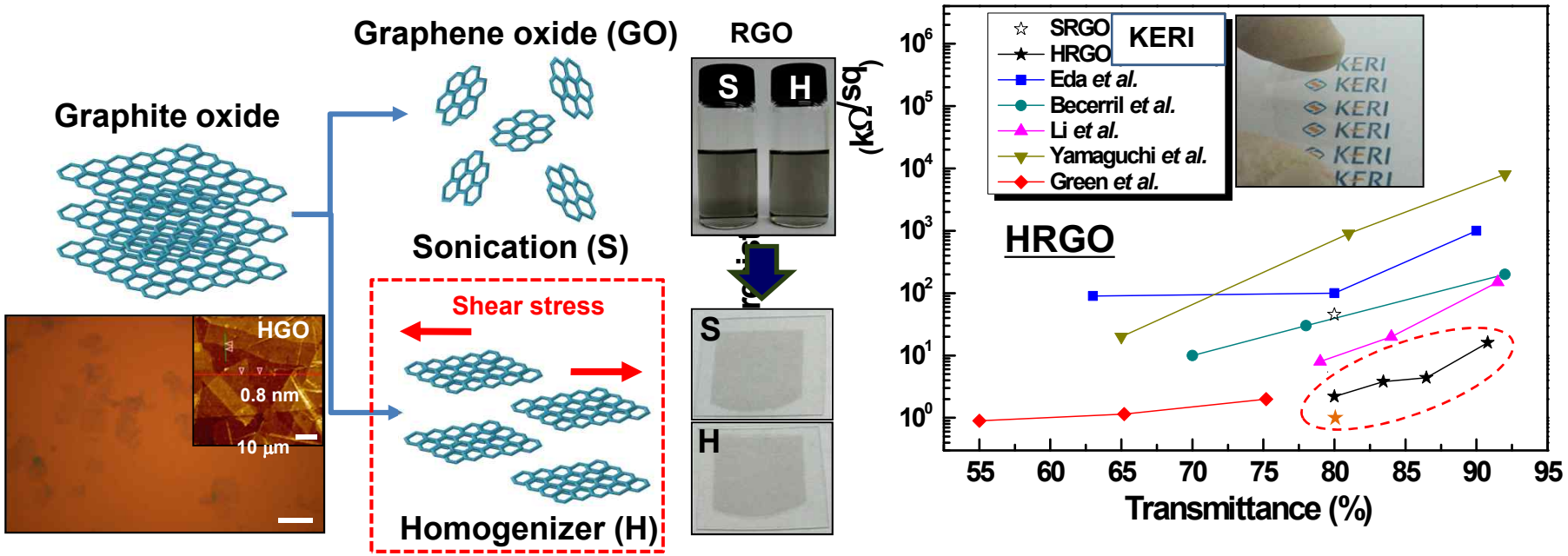
- Touch panel
- Solar cell
- OLED
- Energy storage
- EMI coating
- Thermal

There are many issues in each step we have to solve for commercialization.

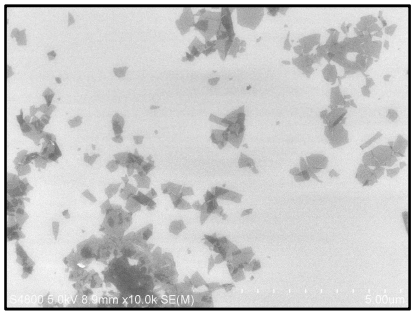
1) Effective exfoliation of graphite oxides

KERI

Jeong *et al. ACS Nano* 5, 870-878 (2011)

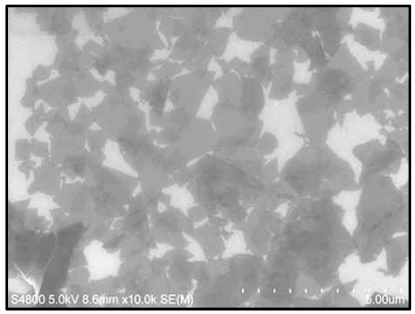


SRGO



Larger **structural defects** on the basal plane

HRGO
(less defect formation)

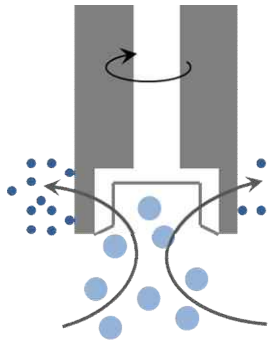


Ordered six-fold rings on the basal plane

Sonication

Acoustic cavitation

Homogenizer



Shear force + cavitation

SCIENTIFIC REPORTS

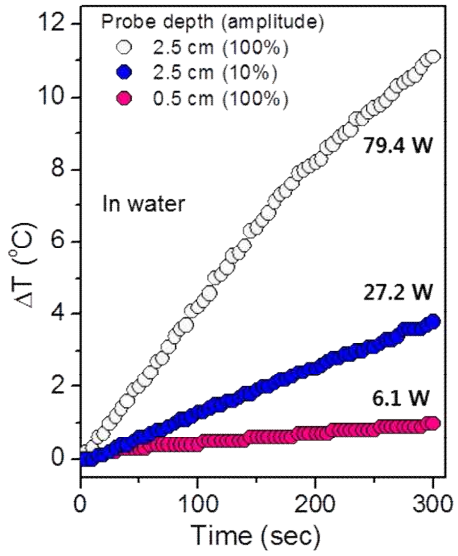
Han et al. ***Sci. Rep. 4, 5133*** (2014)

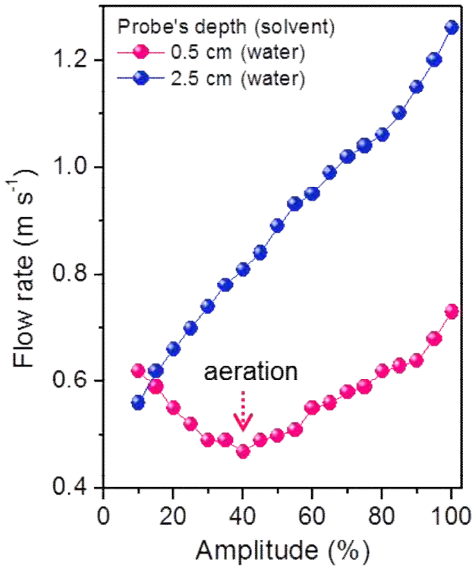
Extremely Efficient Liquid Exfoliation and Dispersion of Layered Materials by Unusual Acoustic Cavitation

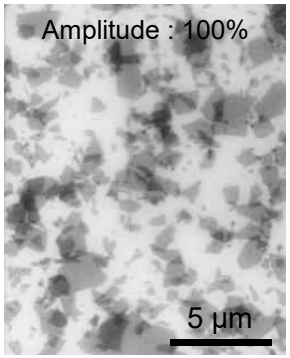
Depth=2.5 cm

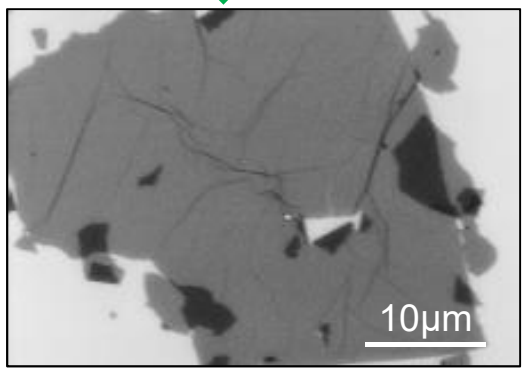
Depth=0.5 cm

Less energetic and high shearing process

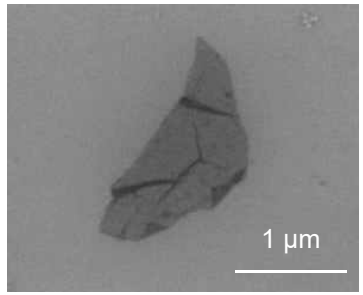








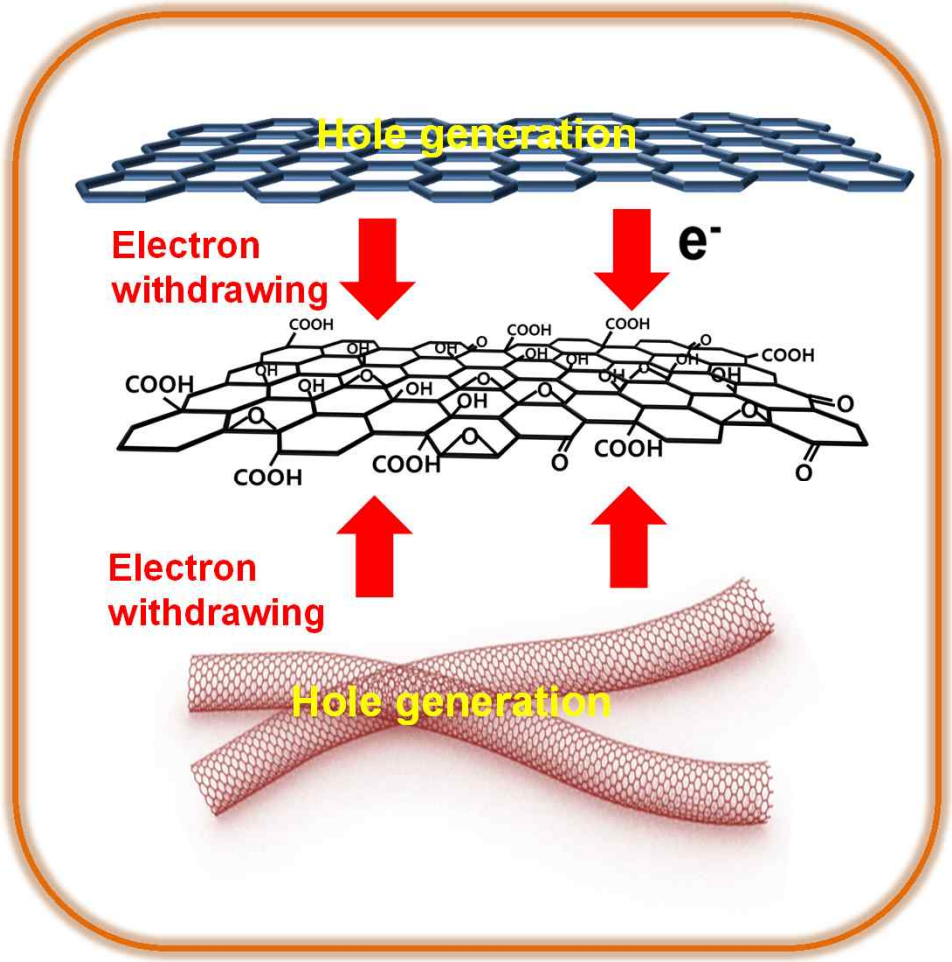
Graphene oxide



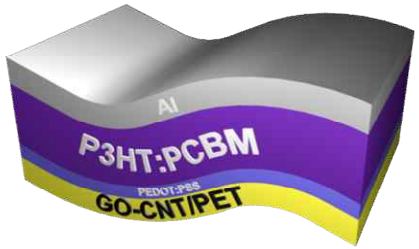
High concentration of MoS_2 solution

Applications of atomically thin graphene oxide

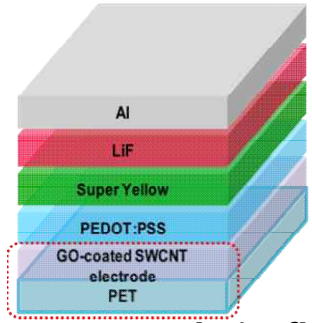
Transparent graphene oxide nanosheets as a stable p-type dopant of conducting nanocarbon materials

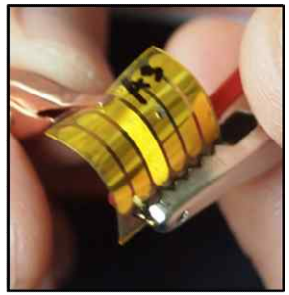


Han *et al*. **Nanoscale (2012)**
Lee *et al*. **J. Mater. Chem. *(2012)***
Yu *et al*. ***ACS AMI (2014)***
Kim *et al*. **Adv. Mater. (2014)**

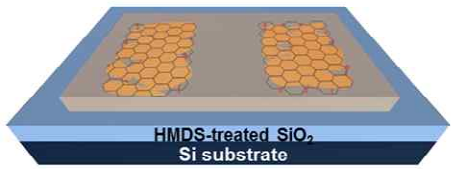


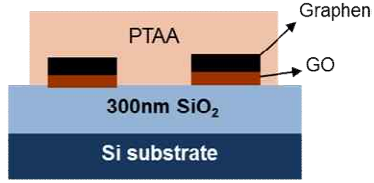
Anode in flexible OPV





Anode in flexible PLED





S/D in OTFT

2) Dispersion of nanocarbon materials

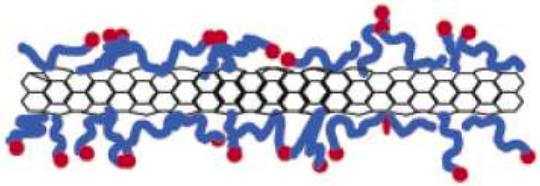
Colloidal dispersion

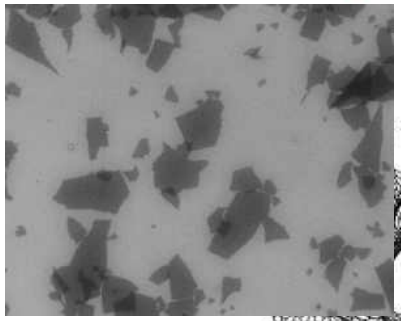
- Surfactant
- Polymeric dispersant
- Defective surface
- High functionalization
- Small size

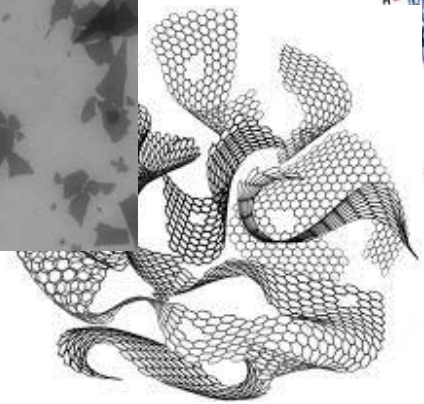
Trade-off

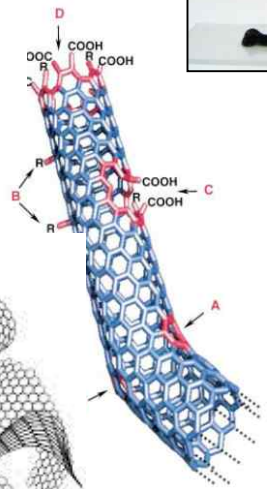
Electrical conductivity

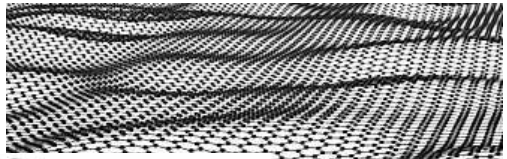
- Dispersant-free
- Less defective surface
- Low functionalization
- Orientation (flatness)
- Long CNT
- Large-sized graphene
- Thin layer
- Chemical compatibility

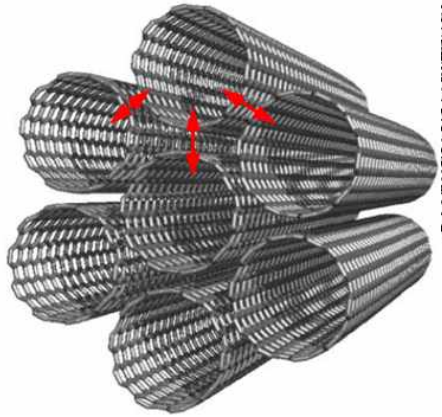


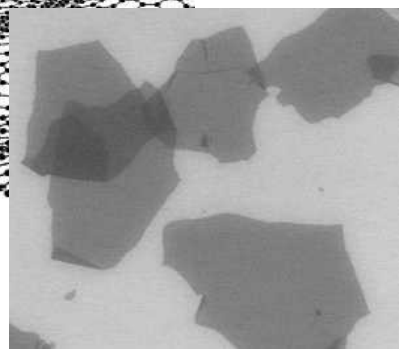






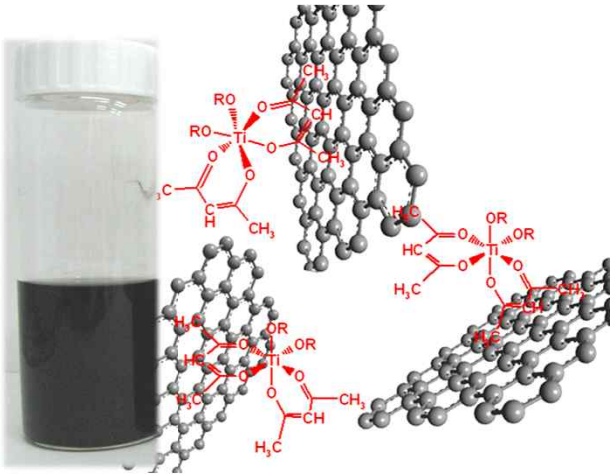


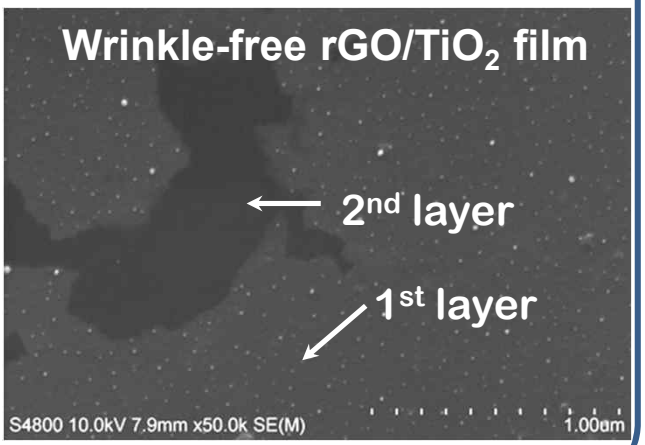




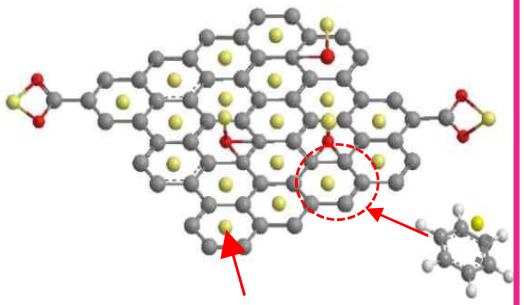
Colloidal dispersion of graphene nanosheets

TiO_2 precursor (ACS Nano 2011)



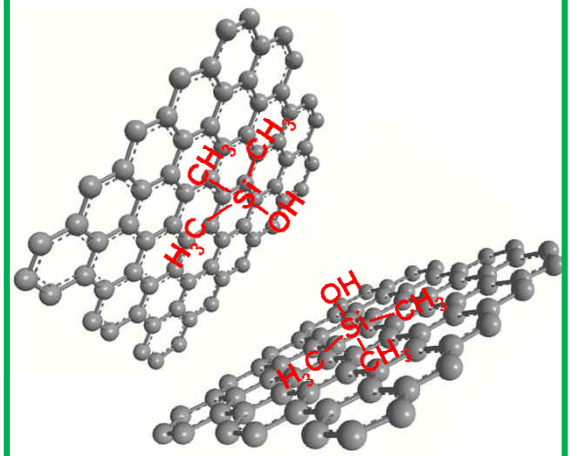


Cation-π interaction (Adv. Func. Mater. 2012)



cation

Silanol (J. Mater. Chem. 2012)



Alcohol-based dispersion

Limitation: Concentration < 1 g/L

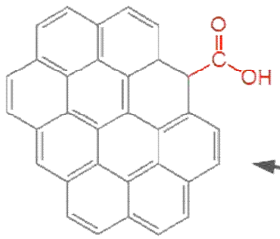
nature COMMUNICATIONS

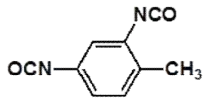
Dispersant-free conducting paste (2013)

DOI: 10.1038/ncomms3491

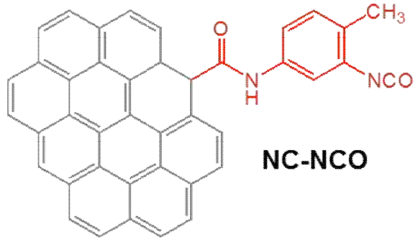
CNT
Graphene
CNF
.
.
.

NC-COOH

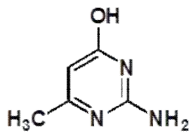




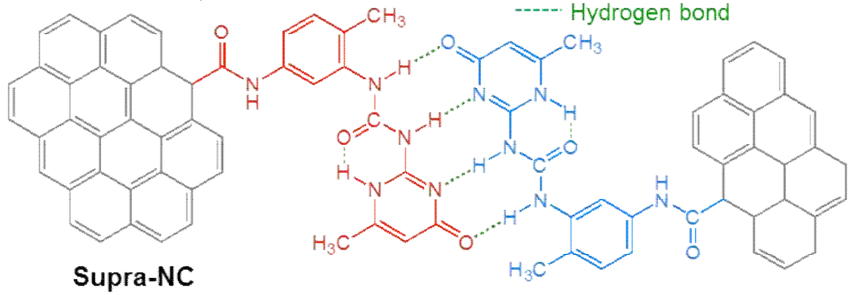
(50°C, 24hr)



NC-NCO

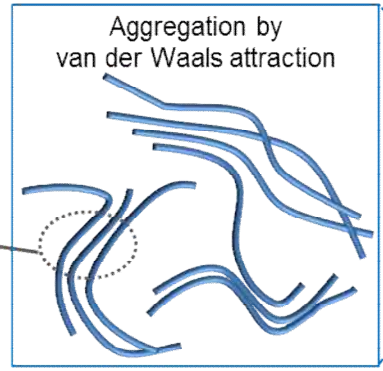


(100°C, 20hr)

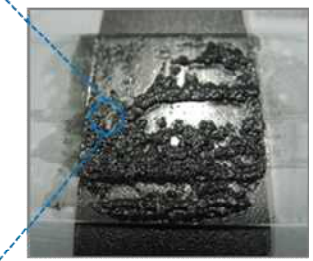


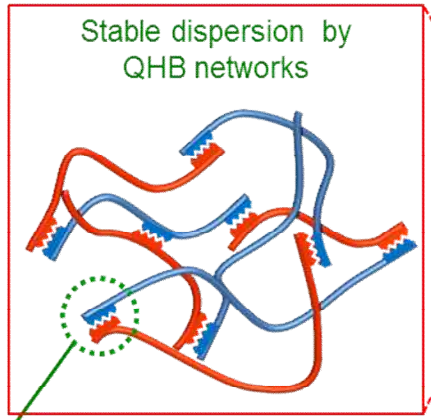
Supra-NC

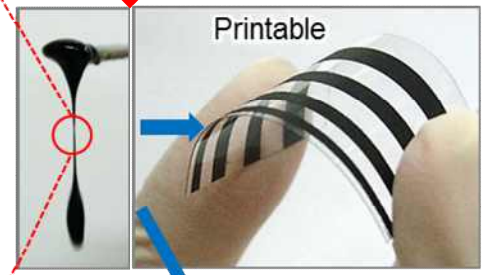
Quadruple hydrogen bond



NCs-COOH



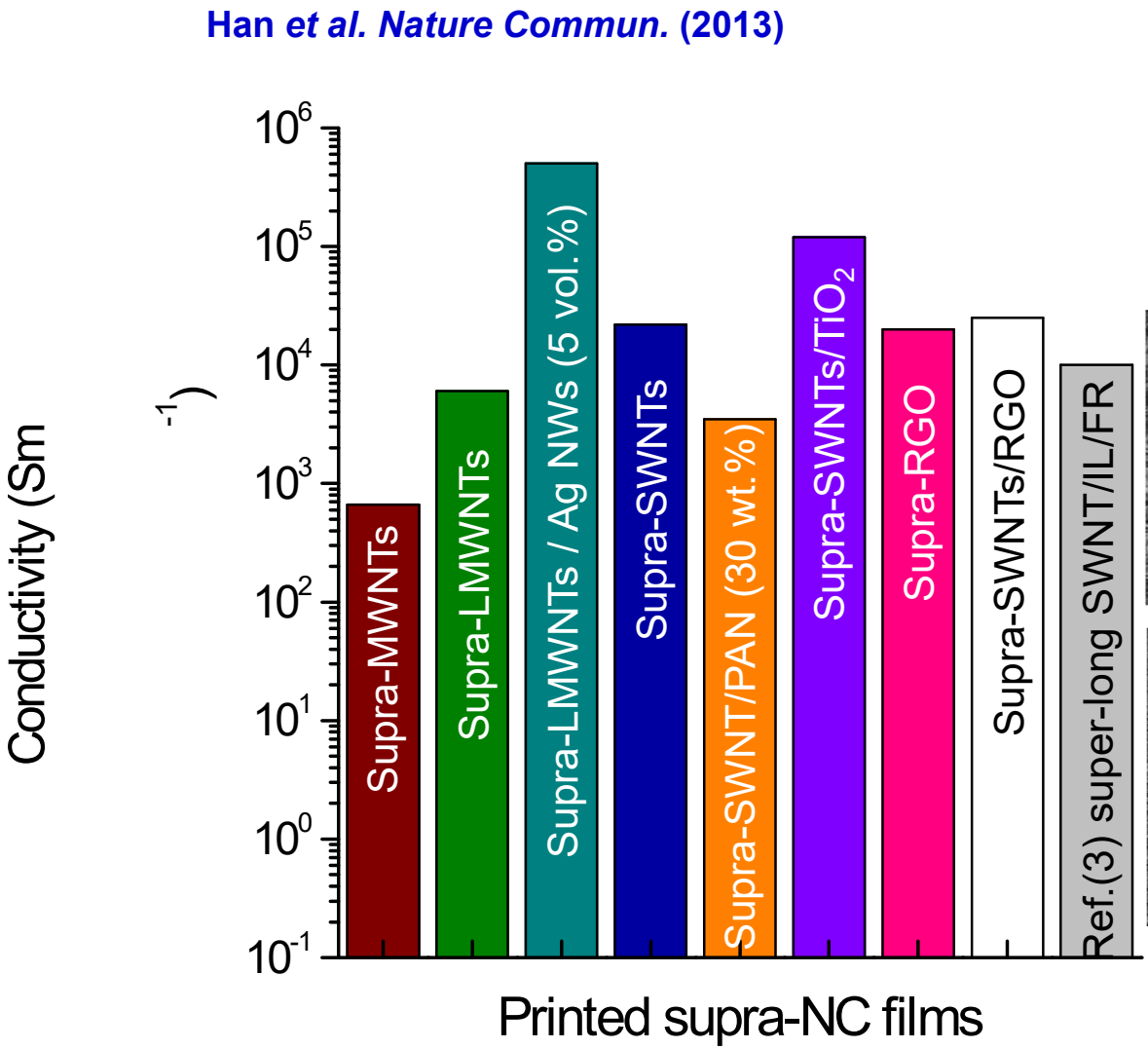


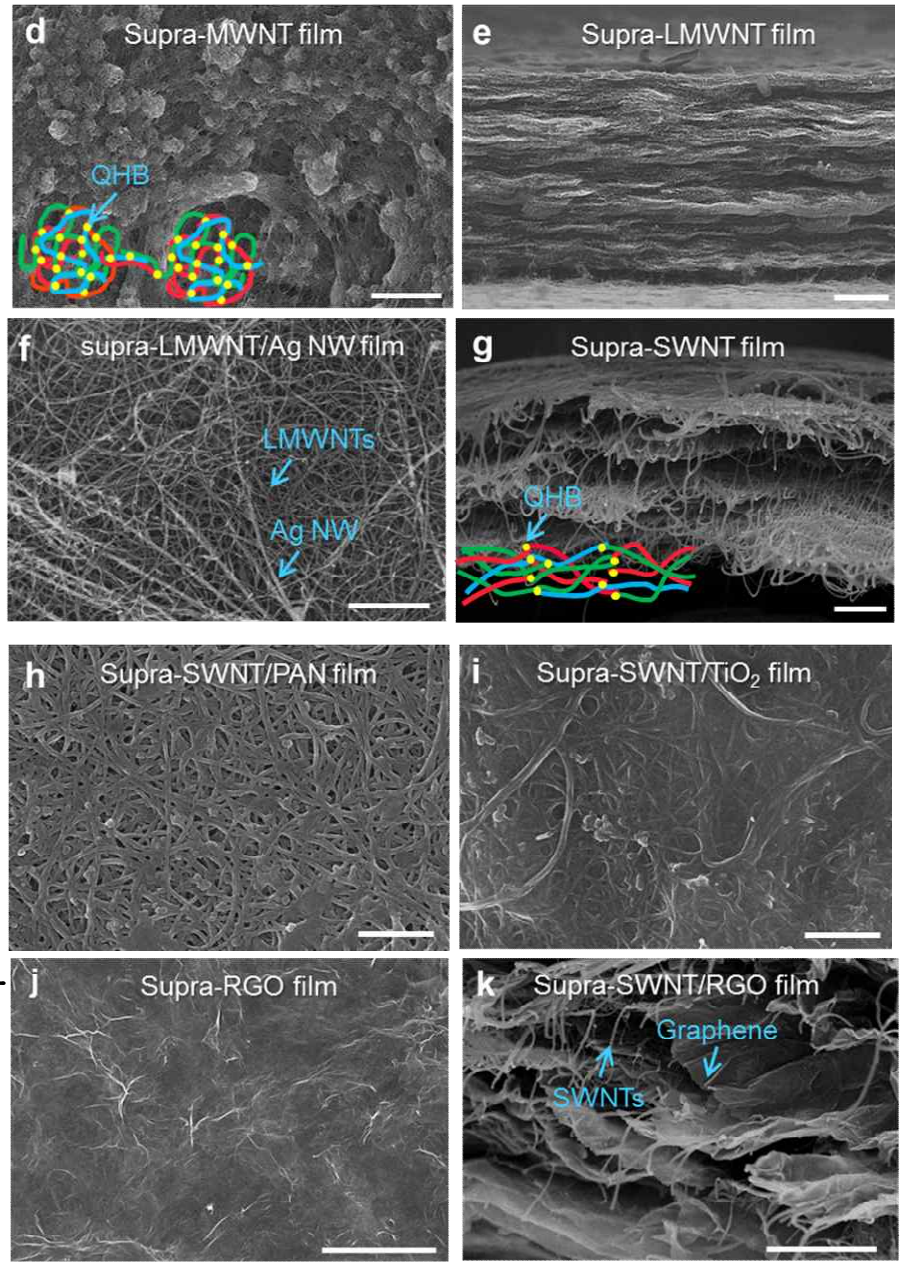


Bucky paper formation

Characteristics of supra-NC pastes

Han *et al. Nature Commun.* (2013)



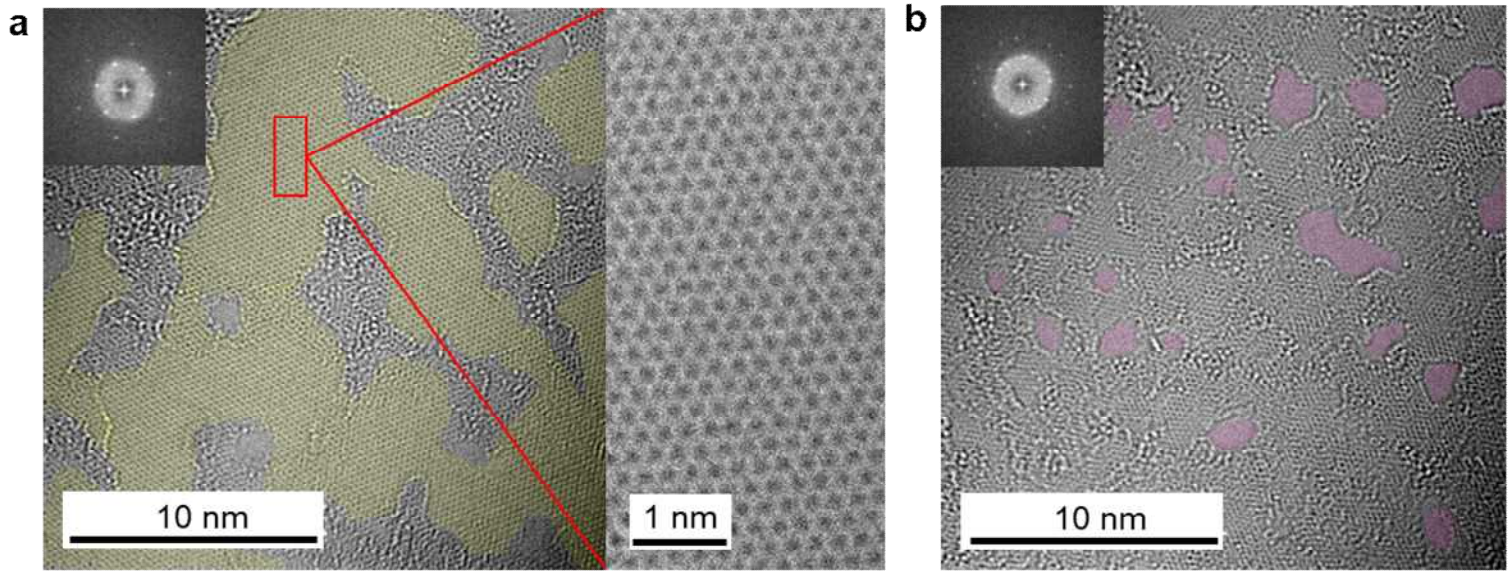


3) Control of basal plane structures

(Unpublished)

Chemically-reduced graphene oxide nanosheets

High quality (Brodie's) | **Highly porous (Hummers')**



Graphene oxide nanosheets were treated in KOH (pH>10) at 100 °C for 12h. After that, GO nanosheets were reduced by hydrazine monohydrate in solution.

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Thank you very much for your attention!