Synthesis of Fluorescent Fluorinated Graphene Quantum Dots by Plasma Treatment

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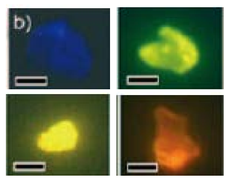
Introduction

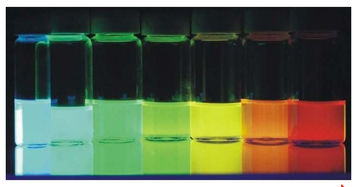
Graphene quantum dots (GQDs)

- Few layers to tens of layers of graphene with a size less than 30nm
- Photoluminescence (PL) by quantum confinement effect & surface passivation

Phys. Chem. Chem. Phys. 19. (2017) 30445--30463.
Illustration of GQDs



Angewandte Chem. Inter. 49.26 (2010): 4430-4434
Fluorescent properties of GQDs



Increase oxidization => Red-shifted PL

◆ Fluorinated GQDs

- Wide energy gap
- Possession of high potential to use in electrical fields for semiconductor

◆ Application of fluorescent GQDs

Quantum Display

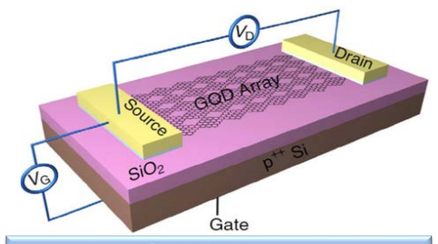
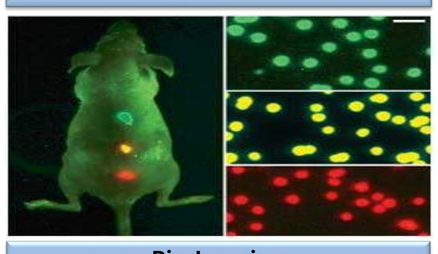


Photo Detector

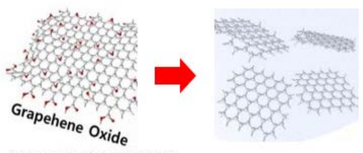
Quantum Ink



Bio Imaging

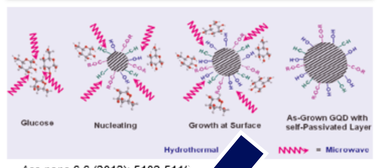
◆ Conventional methods for fluorescent GQDs synthesis

Hydrothermal reduction of graphene oxide



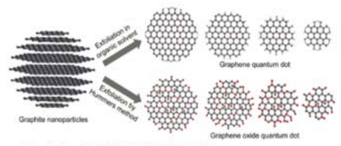
ACS nano 7 (2013): 7207-7212.

Microwave-assisted hydrothermal method



Acs nano 6.6 (2012): 5102-511(

Exfoliation of graphite nanoparticle

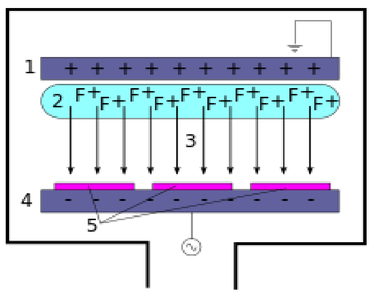


Adv. Mater. 25.27 (2013): 3657-3662.

Disadvantage of conventional methods

1. Using harmful & various chemicals
2. Impurities
3. Difficult in achieving precursors

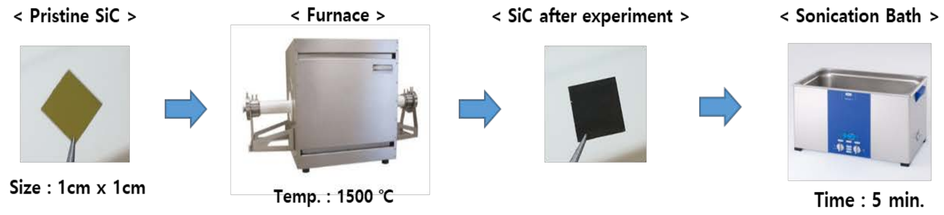
◆Plasma Etching-Reactive Ion Etching (RE-RIE)



1. Simple process
2. No uses of chemicals & solvent
3. Directly synthesized on substrate

Methods

① Preparation of high-quality GQDs

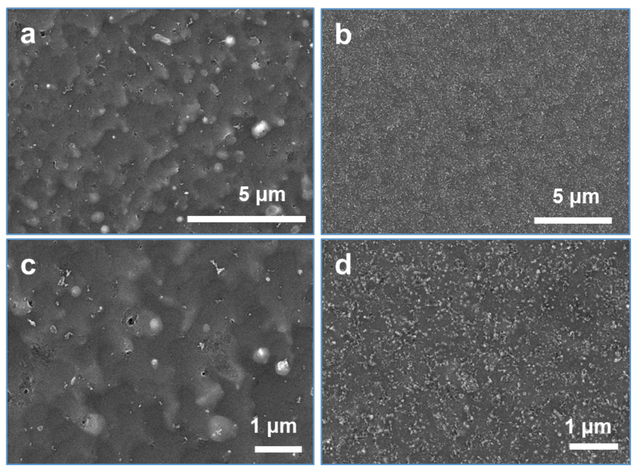


② RIE process on high-quality GQDs

- Fabricated high-quality GQDs were placed in PE-RIE system (AllForSystem, Korea).
- Internal pressure was kept to vacuum by rotary pump subsequently CF4 gas was injected to the device with flow rate of 10 sccm pressure was maintained to 150 mTorr.
- Etching time : 10 min
- Radio frequency power : 20 W. .

Results & Discussion

◆ SEM image of fluorinated GQDs on SiC

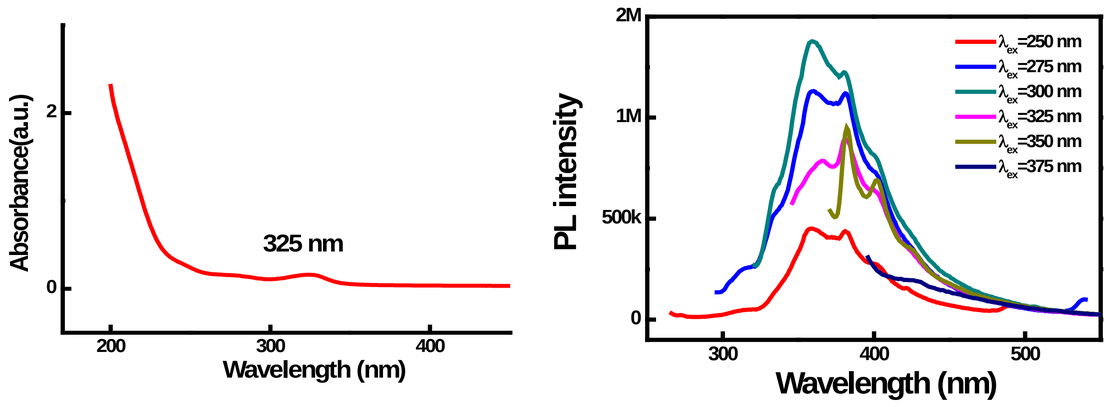


SEM image of (a),(c) GQDs on SiC and F-GQDs on SiC etched by fluorine plasma for (b),(d)10 min (a,b: Magnification is 10k, b,d: Magnification is 20k).

(at.%)	0 min	10 min (on SiC)	After detachment
F	0	34.78	3.5
C	76.25	39.19	76.54
O	14.06	13.47	19.96
Si	9.69	12.56	-

Atomic ratio of GQDs and F-GQDs on SiC and F-GQDs after sonication process

◆ Optical properties of F-GQDs



- F atomic ratio significantly increased to 34.78%, after etching process
- F atomic ratio of F-GQDs was decreased to 3.5% after sonication process
- High absorbance of UV to 300 nm, resulting from π-π* transition of aromatic C = C bonds and absorption band at 325 nm, attributed to n-π*
- The F-GQDs dispersed in water show the strong UV/blue light emission

Conclusion

- **CF_4 plasma etched the surface of GQDs and functional groups are attached to the surface of F-GQDs**
- **F-GQDs are separated from the SiC plates by sonication process**
- **F-GQDs are well dispersed in water**
- **PL emission spectra of F-GQDs exhibit the strong blue emission**

Acknowledgements

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