

Nitrogen-Doped Graphene



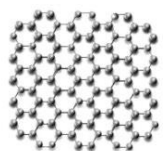
Ideal Flat, Semiconductive and Transparent Material for Various Devices

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1. Back Ground

A certain **Heteroatoms-Doped Graphene** has unique characteristics and especially **Nitrogen-Doped Graphene** has been expected to have excellent characteristics. But there have not been any good methods to produce a "flat" Heteroatoms-Doped Graphene.

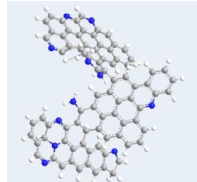
Graphene has ideal flatness structure



Graphene

By Doping heteroatoms to Graphene, the flatness of graphene loses.

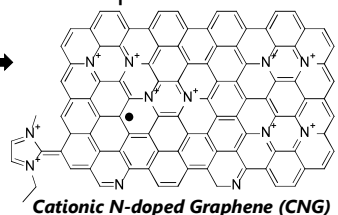
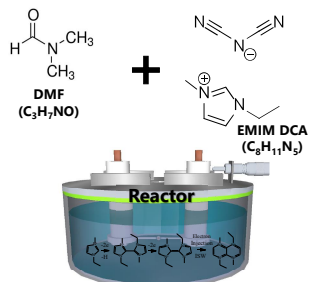
Disorder in Graphene



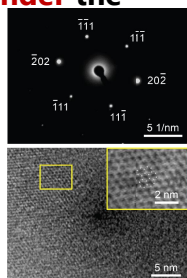
Doped Graphene

2. Our Technology

We invented the "**Solution Plasma Method**" for producing the "flat" Heteroatoms-Doped Graphene. The Method provides **highly doped and ultra "flat" Nitrogen-doped Graphene** under the condition of normal temperature and pressure.



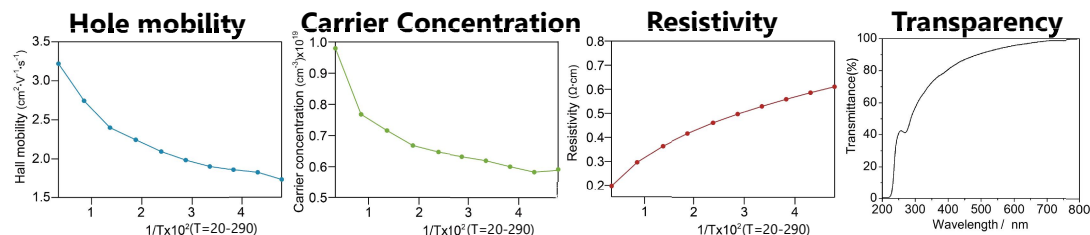
Cationic N-doped Graphene (CNG)



The N-doped flat hetero-graphene has highly crystallinity.

Power Supply		Production method	Dope rate	Flatness	cost	Temp.°C /pressure
Electrodes	W – W (Tungsten)	Chemical Vapor Deposition(CVD)	Low	Low	High	800°C /vacuum
Gap Distance	1 mm	Thermal Annealing Method	Low	Low	Low	1000°C /normal pressure
Frequency	200 kHz	(This Work) Solution Plasma Method	High	High	Low	25°C /normal pressure
Pulse width	1.0 μs					
Base solvent	DMF*, 90 wt%					
Ionic Liquids	EMIM DCA*, 10 wt%					
Time	5 min.					

3. Characteristics of the Nitrogen-doped Hetero Graphene



The Nitrogen-Doped Graphene shows best values among the other graphene

- (1) Hole mobility : **3.4cm²·V⁻¹·s⁻¹ at 290K**
- (2) P-type Semiconductive, Carrier concentration: **10¹⁹cm⁻³ at 290K**
- (3) Sheet resistance : **16 Ω·sq⁻¹**
- (4) Transparency : **more than 80 % at 400-800nm(as graphene)**

4. Application Examples

Our Hetero graphene leads to Transparent, Semiconductive thin film.

Flexible 2D Semiconductive Materials

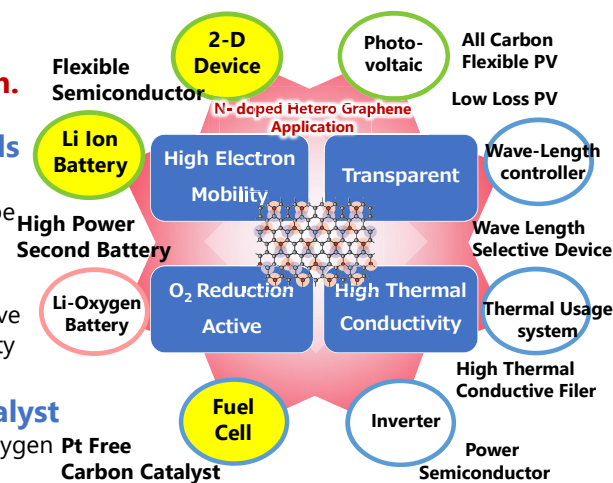
Use of the film in flexible semiconductors and electrode, application for flexible devices can be expanded.

Materials for Secondary battery

Use of the film in electrode catalyst or conductive additives of the secondary batteries, the capacity and life of the batteries can be improved.

Materials for Oxygen Reduction Catalyst

This film is expected for low cost material for oxygen reduction catalyst of fuel cell.



5. Patent Licensing Available

Patent No.: WO2019/066013 (International phase)

JST/ IP Management and Licensing Group

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