Nitrogen-Doped Graphene

Ideal Flat, Semiconductive and Transparent Material for Various Devices

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1. Back Ground

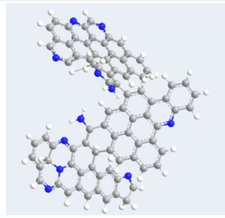
A certain **Heteroatoms-Doped Graphene** has unique characteristics and especially **Nirtogen-Doped Graphene** has been expected to have excellent characteristics. But there have not been any good methods to produce a "flat" Heteroatoms-Doped Graphene .

Graphene has ideal flatness structure

Graphene

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

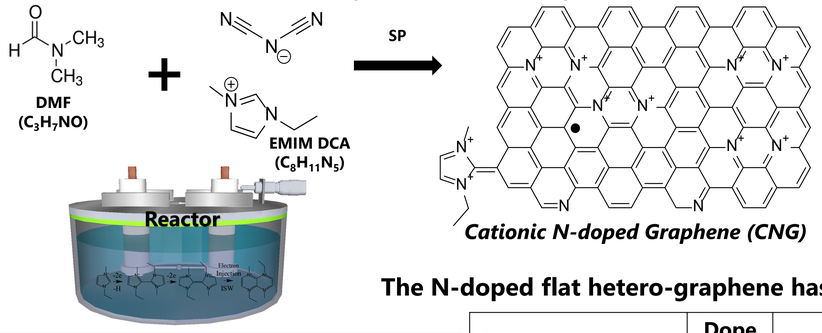
Disorder in Graphene

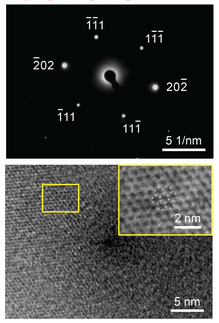


Doped Graphene

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.



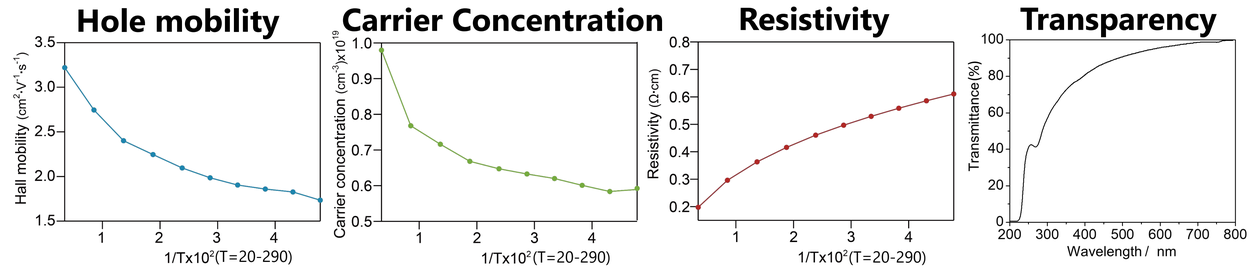


The N-doped flat hetero-graphene has highly crystallinity.

Power Supply	
Electrodes	W – W (Tungsten)
Gap Distance	1 mm
Frequency	200 kHz
Pulse width	1.0 μs
Base solvent	DMF*, 90 wt%
Ionic Liquids	EMIM DCA*, 10 wt%
Time	5 min.

Production method	Dope rate	Flatness	cost	Temp.℃ /pressure
Chemical Vapor Deposition(CVD)	Low	Low	High	800℃ /vacuum
Thermal Annealing Method	Low	Low	Low	1000℃ /normal pressure
(This Work) Solution Plasma Method	High	High	Low	25℃ /normal pressure

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**

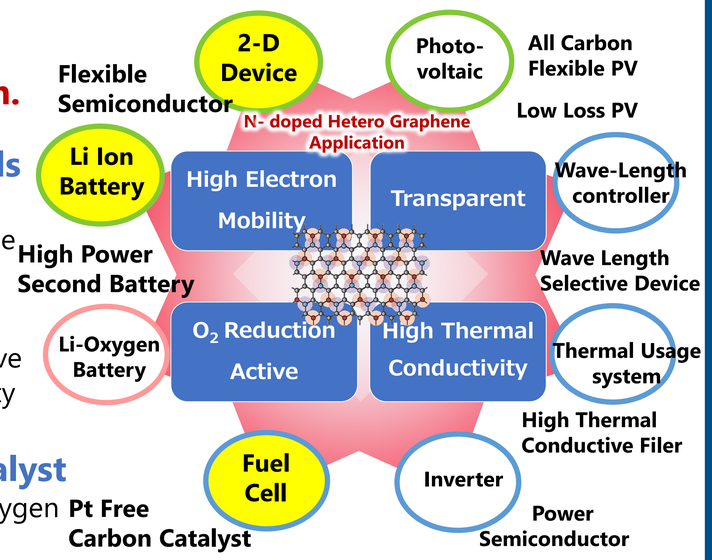
(2) P-type Semiconductive, Carrier concentration: **10^{19}cm^{-3} at 290K)**

(3) Sheet resistance : **16 Ω·sq⁻¹**

(4) Transparency : **more than 80 % at 400-800nm(as graphene)**

4. Application Examples

Our Heterographene 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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