

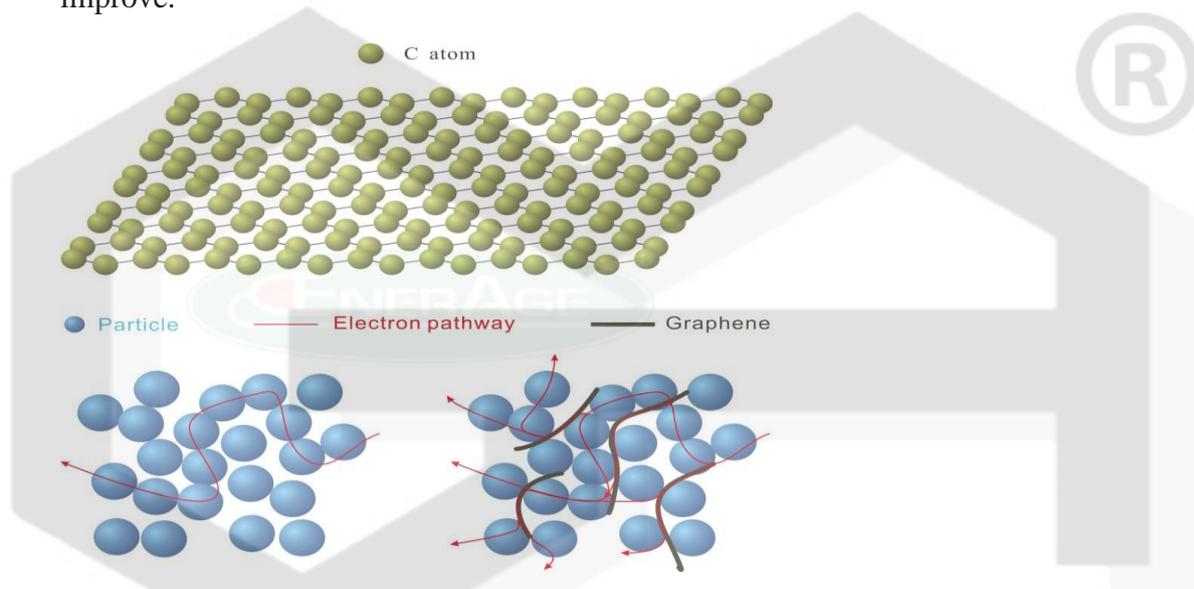
# **Graphene in Lithium Battery<sup>®</sup> Test**

Enerage Inc.

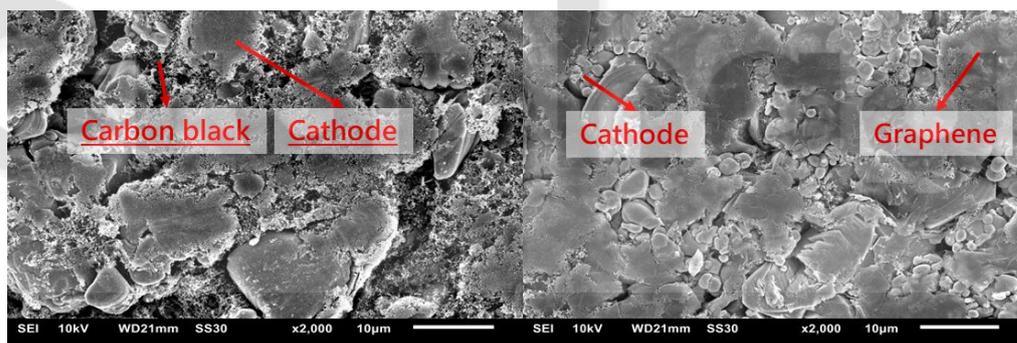


## Graphene in Lithium Battery

Lithium battery is a promising solution for the most electrically-driven equipment. The common cathode materials of the lithium battery include Lithium Cobalt Oxide ( $\text{LiCoO}_2$ ), Lithium iron phosphate ( $\text{LiFePO}_4$ ), and Lithium Nickel Cobalt Manganese Oxide (NCM). All the cathode material has its own advantage at certain applications, but the electrical conductivity is the downside. With an addition of graphene in the cathode, not only the conductivity but also capacity and life cycle can significantly improve.



Traditional conductive carbon black has only point to point contact with cathode materials, but graphene has high point to face contact with cathode materials. It means the presence of graphene increases more pathways to conduct electrons.



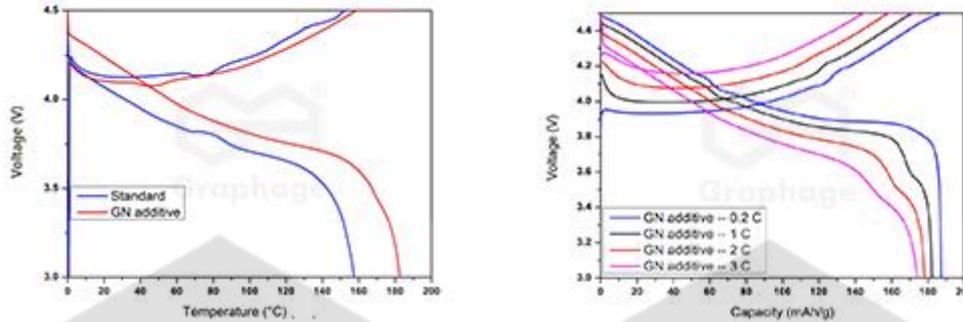
### A. Cathode material: Lithium Cobalt Oxide ( $\text{LiCoO}_2$ )

Test setup: Temp stable@25 °C · Voltage 3.0~4.5V

Test object : Coin Cell

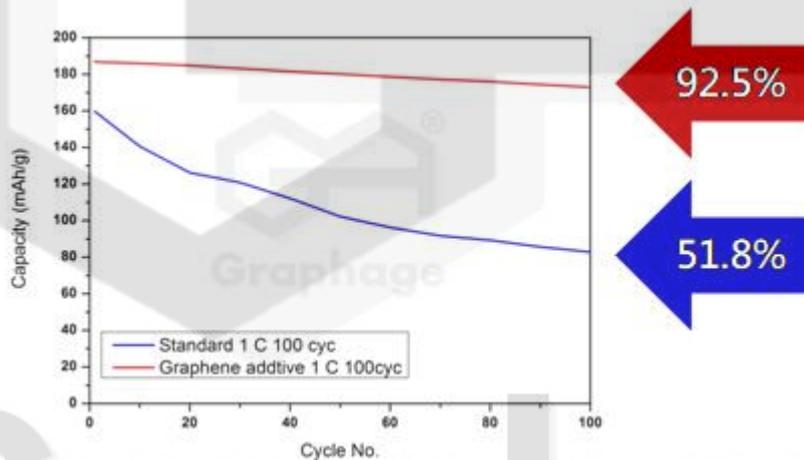
### 1. Capacity increased

By adding the graphene additive, the capacity at 1C increases 28% compared to the test adopting double amounts of traditional conductive additive.



### 2. Cycle life increased

By adding the graphene additive, the capacity under high voltage and after 100 cycle test maintains 92.5%, which is 40.7% higher than the traditional conductive additive's.



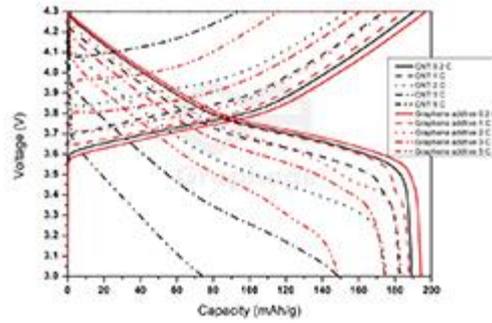
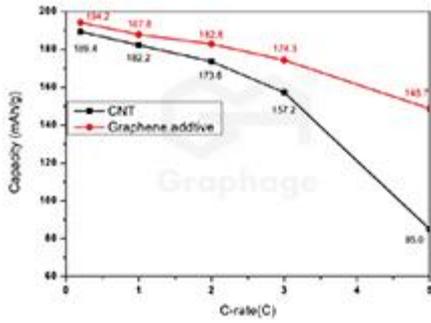
### B. Cathode material: Lithium Nickel Cobalt Manganese Oxide (NCM)

Test setup: Temp stable@55 °C · Voltage 3.0~4.3V

Test object : Coin Cell

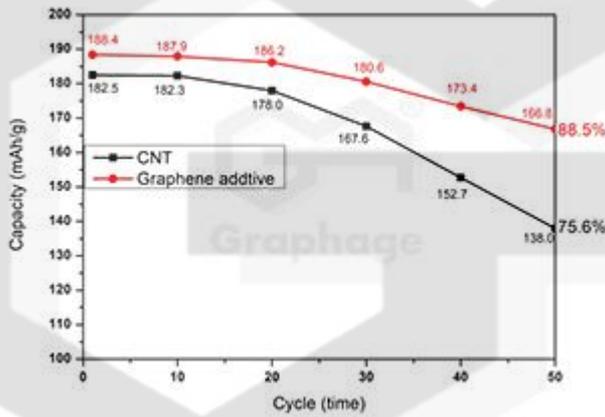
### 1. Capacity increased

By adding the graphene additive, the capacity at 5C increases 31% compared to the cell adopting CNT additive.

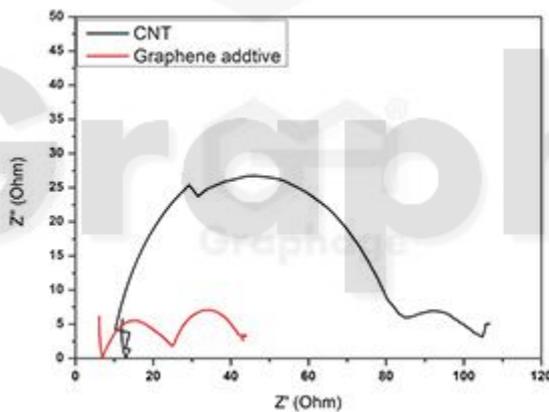


## 2. Cycle life increased

By adding the graphene additive, the capacity after 50 cycle test increases 12.9% compared to the test adopting CNT additive.



## 3. Resistance decreased



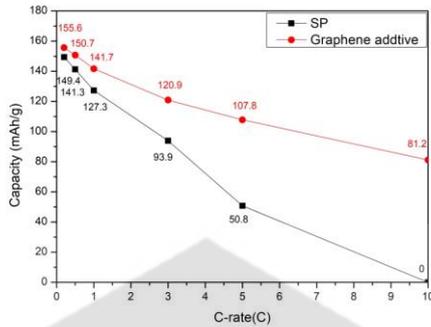
### C. Cathode material: Lithium iron phosphate (LiFePO<sub>4</sub>)

Test setup: Temp stable@25 °C · Voltage 2.5~4.3V

Test object : Coin Cell

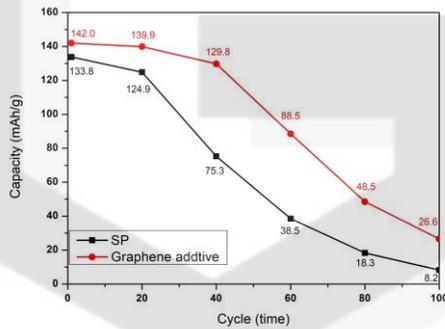
## 1. Capacity increased

By adding the graphene additive, the capacity at 5C increases 35% compared to the cell adopting conductive carbon black (SP) additive.



## 2. Cycle life increased

By adding the graphene additive, the capacity after 100 cycle test increases 12% compared to the test adopting conductive carbon black (SP) additive.



# Graphage