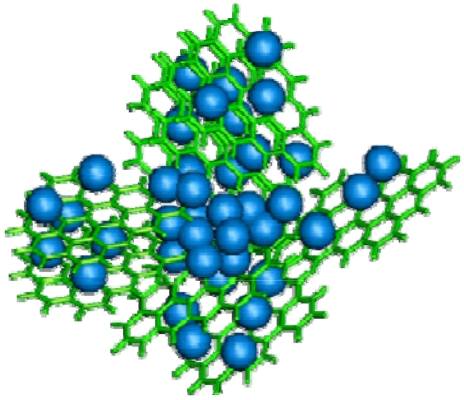
Anode material for LIB

CARBOTRON ®

Kureha, Changing the Future of Batteries



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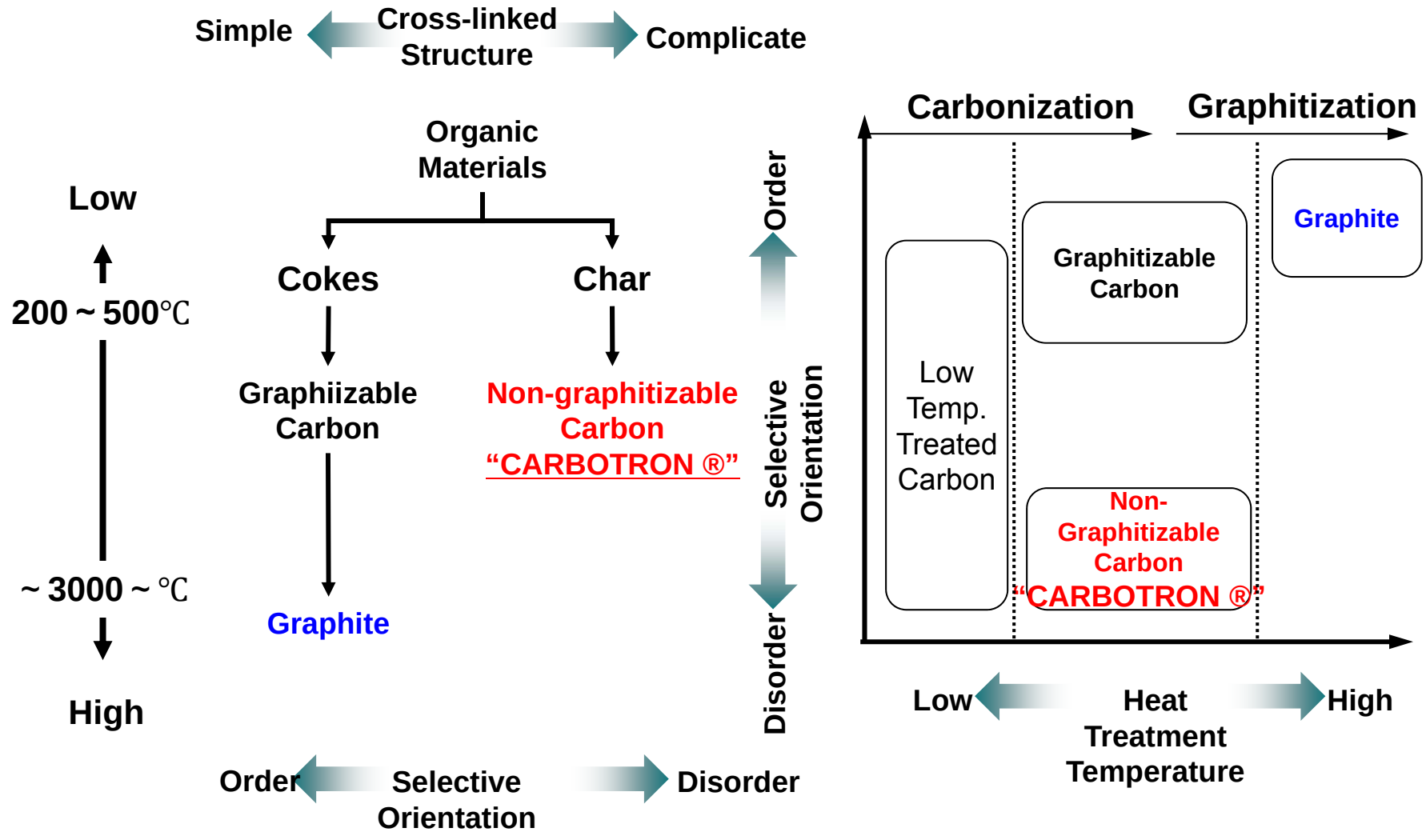
Kureha Battery Materials Japan Co., Ltd.

Anode materials selection for LIB

- Basically three candidates for Anode materials
  - ∗ Graphite
  - ∗ Non-graphitizable carbon - “CARBOTRON ®”
  - ∗ Lithium Titanium Oxide (LTO)

- Criteria for selecting Anode materials
  - ∗ Energy density, Initial efficiency
  - ∗ Charge-Discharge performance
  - ∗ Cycle performance (Durability)
  - ∗ Cryogenic performance
  - ∗ Cost
  - ∗ Supply-ability

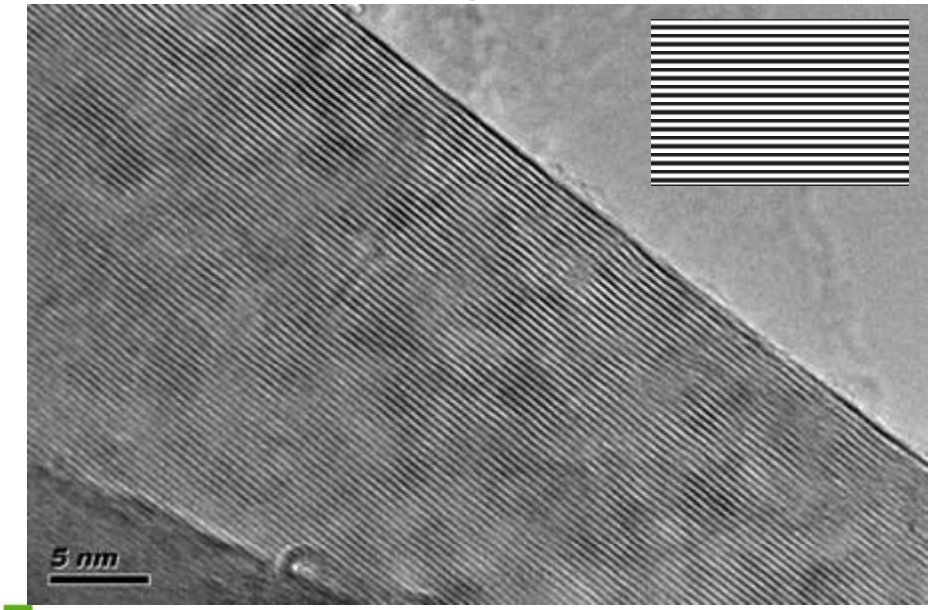
Structural variation of Carbon materials



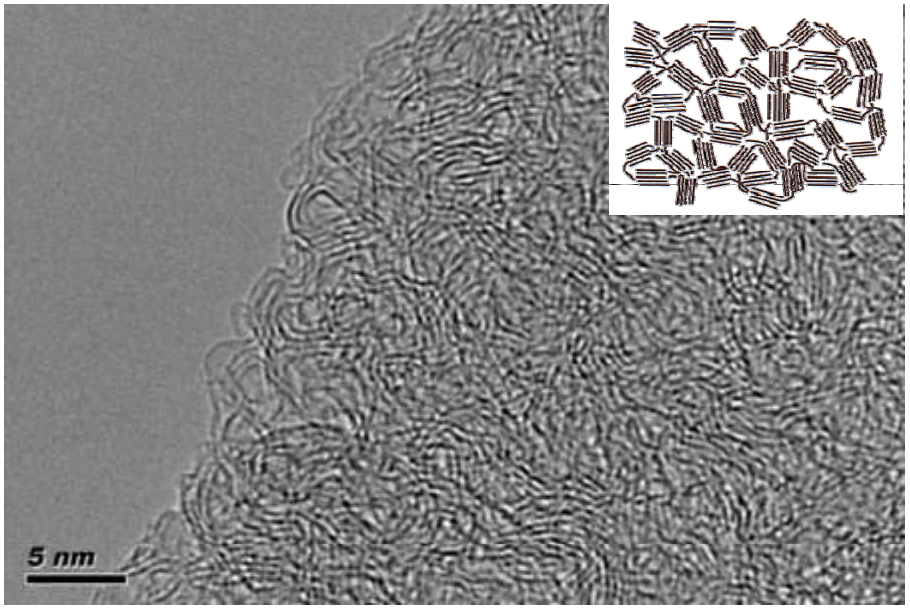
“CARBOTRON ®” developed by Kureha

Kureha developed Non-graphitizable carbon “CARBOTRON ® ”
for the world-first commercial base LIB released by SONY in 1991.
Kureha has been the only manufacturer selling Non-graphitizable carbon
on a commercial basis in the world.
Kureha has in-depth technology in controlling and designing carbon structure,
and is bringing it to automobile applications.

Graphite



CARBOTRON®



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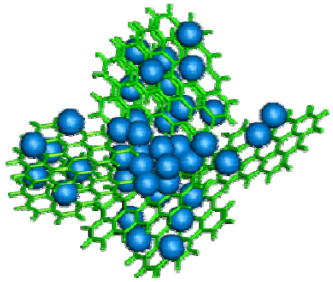
Difference of “CARBOTRON ®” , Graphite and LTO

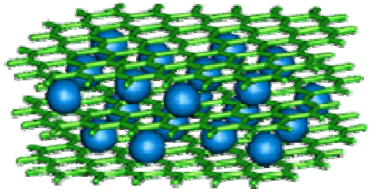
CARBOTRON ®



Li-ion storage in disordered microscopic pore by forming cluster.

- No swelling of layer → High durability
- Three dimensional Li-ion access → Good charge/discharge performance

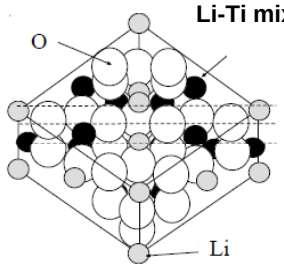
Graphite



Li-ion storage in graphite interlayer (0.335nm).

- Theoretical energy density – 372Ah/kg
- Interlayer expansion by Li-ion intercalation (0.371nm) → Concern on durability
- Li-ion access only from the edge of the layer → Less charge/discharge performance

LTO



Li-ion storage in LTO structure. (Spinel ⇔ Rock salt)

- Stable crystal structure on charge/discharge. → High durability
- Low operating voltage (2.5V) → Low volume energy density

Difference of CARBOTRON ®, Graphite and LTO

	Volume Energy Dencity	Weight Energy Density	Voltage	Discharge Performance	Charge Performance	Cycle Performance	Lithium Dendrite Risk
CARBOTRON ®	Good ~ Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Graphite	Excellent	Excellent	Excellent	Good	Good	Good	Good
LTO	Good	Fair	Good	Excellent	Excellent	Excellent	Excellent

CARBOTRON ® gives excellent performances which Graphite or LTO does.

New product from plant base materials

Kureha developed, through its ability to design the structure, CARBOTRON ® utilizing plant based new materials.

We will start to provide samples to our customers in mid 2012, and scheduled to start commercial production in 2013 through a JV with Kureray, who is a manufacturer of activated carbon.

By this development, we can achieve

1. Lower production cost.

2. Diversify our product portfolio.

3. Stabilize our supply by securing raw materials.

LIB in future

LIB is required to have different qualities depending on its application.
Kureha believes LIB suitable for high performing HEVs will be one of the main-stream product in the future.

1. Importance of safety and durability in cell level.

2. Achieve longer distance drive through the utilization of regenerative energy. (Charge performance)

3. Importance of better acceleration for automobiles. (Discharge performance)

CARBOTRON ® has superb properties for Durability and Charge/Discharge performance.