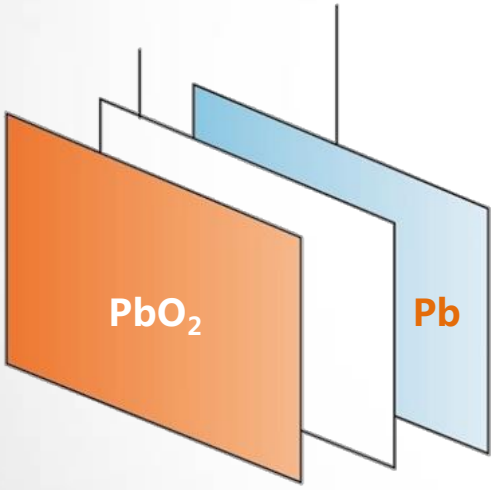
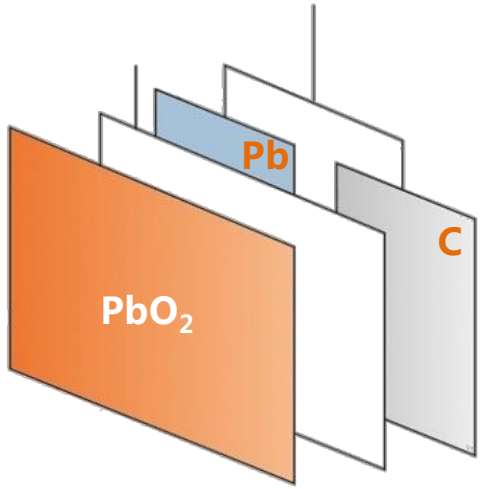
Lead-carbon technology

The principle of lead-carbon

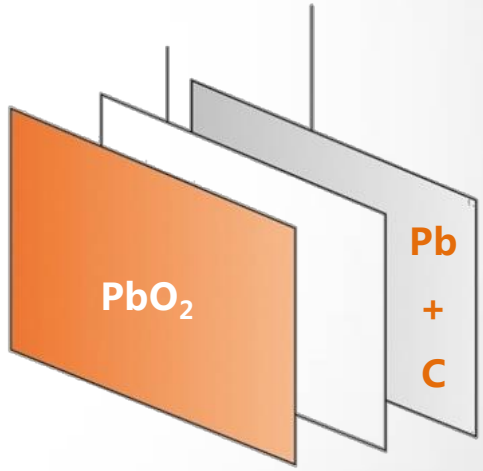
Conventional Lead-acid



Lead and carbon in parallel



Internal mixed Lead-carbon



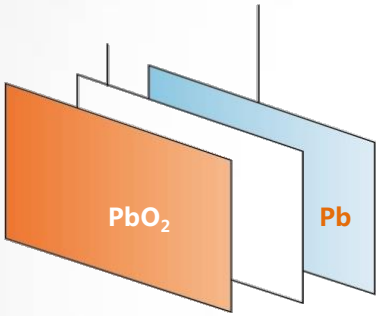
The lead-carbon battery is a perfect combination, which contains advantages of high energy capacity and density from lead-acid battery, as well as high power rate, fast charging and long cyclic lifespan from ultra capacitor

Narada®

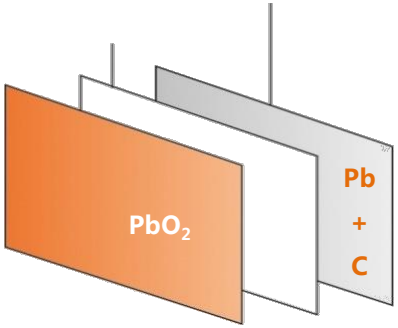
Stored Energy Solutions for a Demanding World!

Lead-carbon technology

The principle of lead-carbon



Lead-acid battery



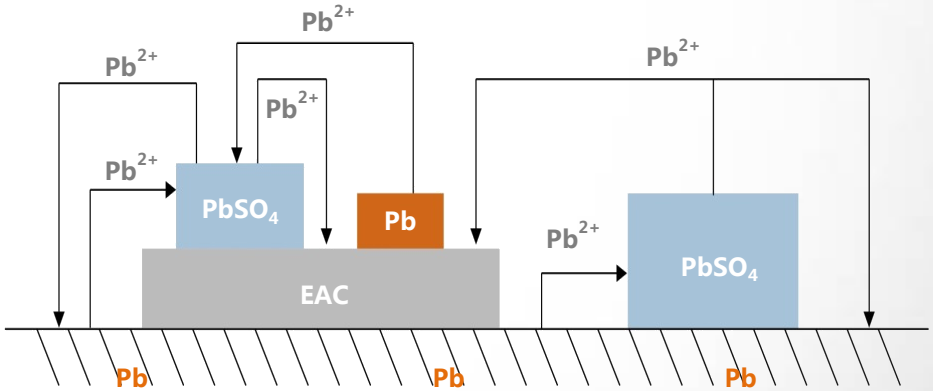
Lead-carbon battery

> **Discharge**

$$Pb + HSO_4^- - 2e^- \xrightarrow{\text{Dissolution}} Pb^{2+} + SO_4^{2-} + H^+ \quad (PbSO_4 \text{ precipitation})$$

> **Charge**

$$PbSO_4 \xrightarrow{\text{Dissolution}} Pb^{2+} + SO_4^{2-} + 2e^- + H^+ \quad (Pb + HSO_4^- \text{ precipitation})$$



Lead sulfate irreversibly accumulated on surface of the negative plate into a layer, which is dense and coarse

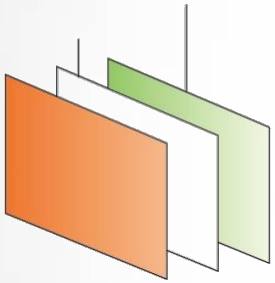
The sulfation can be successfully restrained, as a result, the charging acceptance and lifespan can be improved

Narada®

Stored Energy Solutions for a Demanding World!

Lead-carbon technology

Four sorts of lead-carbon

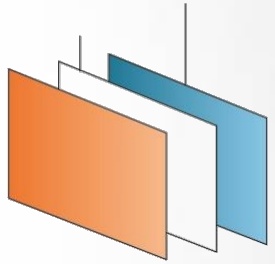


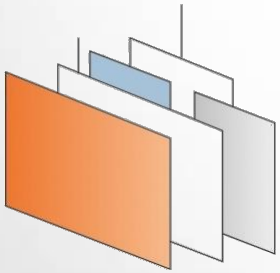
Full carbon in negative

- Long cycle life, high specific power
- Low efficiency of charge & discharge
- **Axion Power**

3D carbon in negative

Quite high specific energy & power -
3D structure makes cost quite high -
Firefly Energy, CEA-INES -



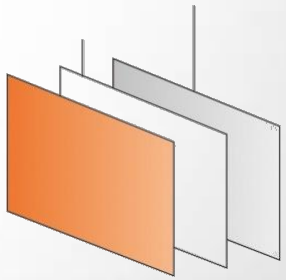


Partial carbon in negative

- Excellent long cycle life
- Complicated manufacture
- **CSIRO, Furukawa, East Penn**

Special carbon in negative

Extraordinary HRPSoC cyclic lifespan -
Much easier for industrialization -
Narada authorized by ALABC -

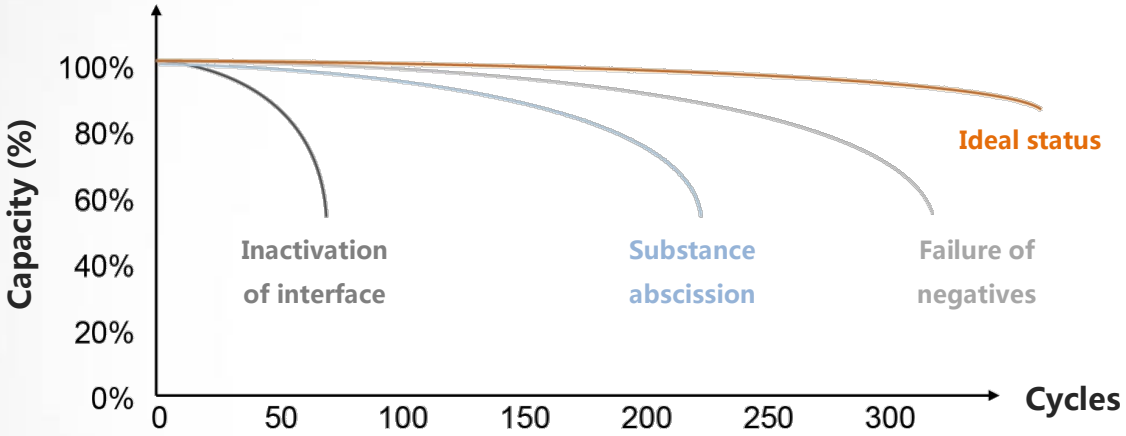


Narada®

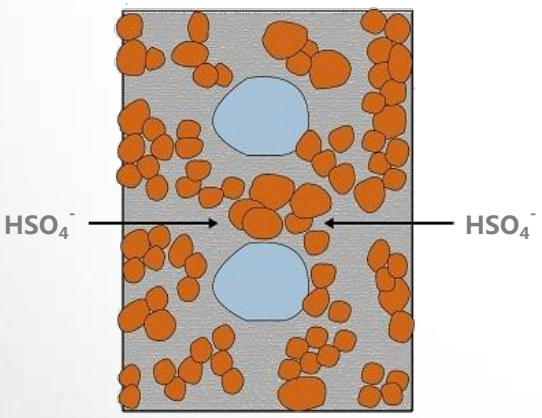
Stored Energy Solutions for a Demanding World!

Lead-carbon technology

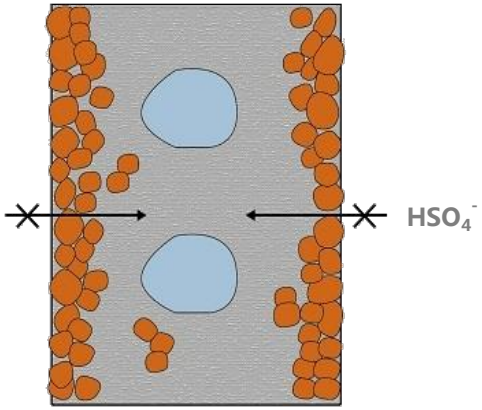
Failures of lead-acid battery



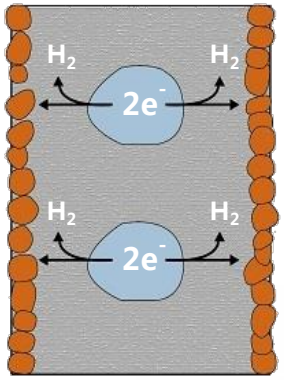
Corrosion of positive grid



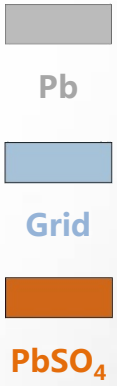
Low rate discharge



High rate discharge



Recharge



Narada®

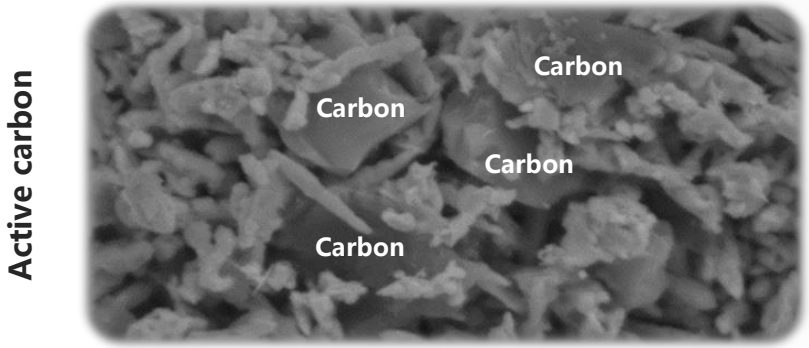
Stored Energy Solutions for a Demanding World!

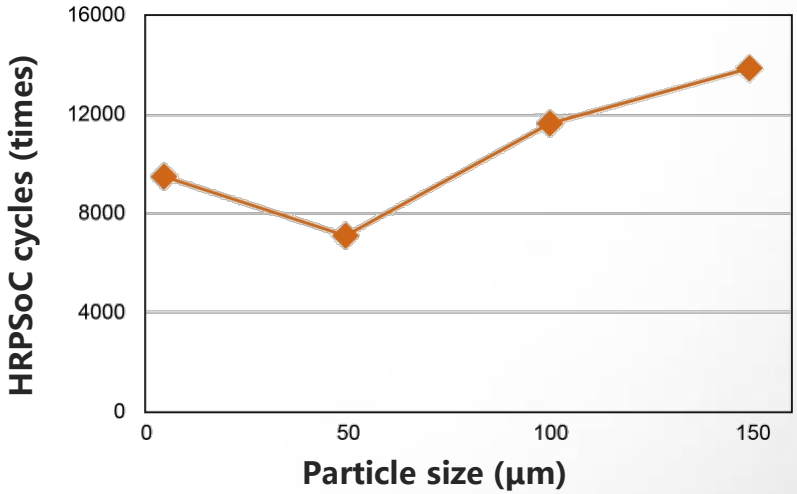
Lead-carbon technology

Main functions

- Oxidation reaction on carbon surface
- Influence of Electro-osmotic pumping
- Restriction upon growth of crystalloid
- Evolution of hydrogen over impurities
- Conductivity & capacitive contribution
- Intercalation of hydrogen into graphite
- More additional locations of nucleation

The mechanism of carbon



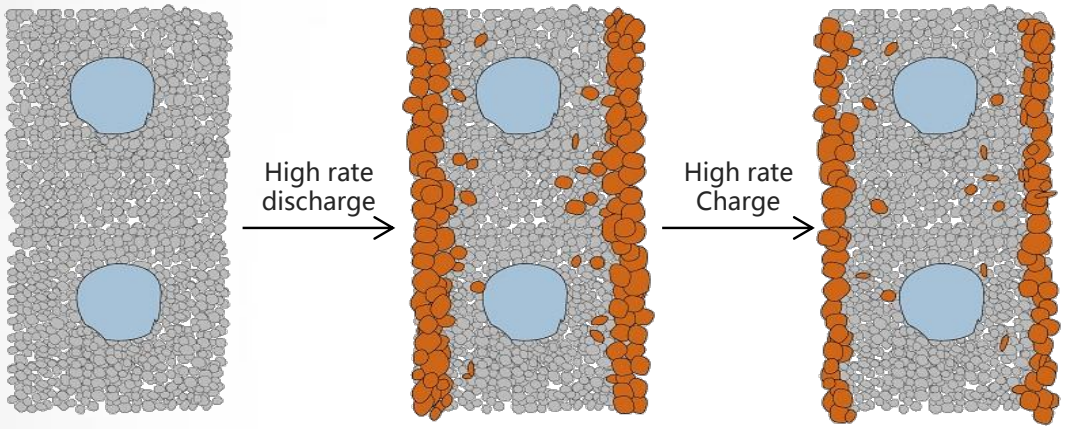


Narada®

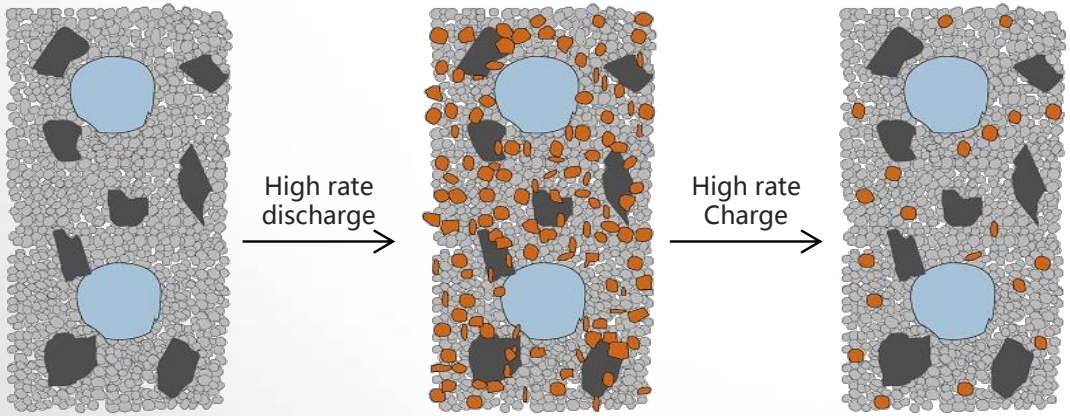
Stored Energy Solutions for a Demanding World!

Lead-carbon technology

The mechanism of carbon



Conventional battery plate



Battery plate with active carbon

Pb

$PbSO_4$

Grid

Carbon

Acid storage

--- Provide enough HSO_4^- and H^+ as a storage container of acid

--- Improve chemical crystallization $Pb^{2+} \rightarrow PbSO_4$ during discharging

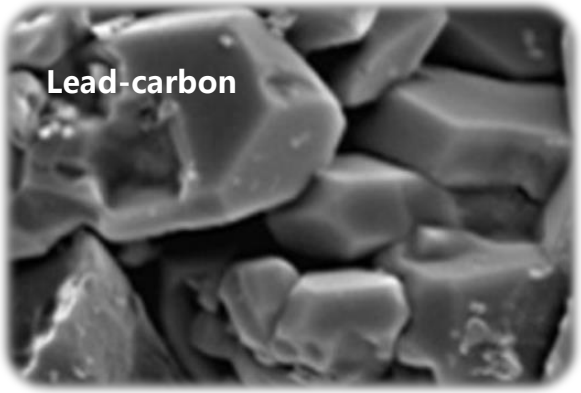
--- Improve chemical dissolution $PbSO_4 \rightarrow Pb^{2+}$ during charging

Narada®

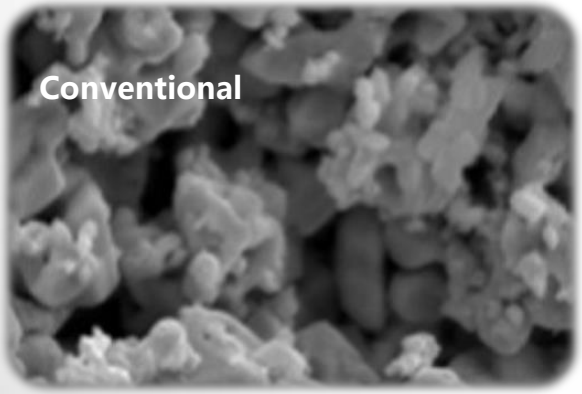
Stored Energy Solutions for a Demanding World!

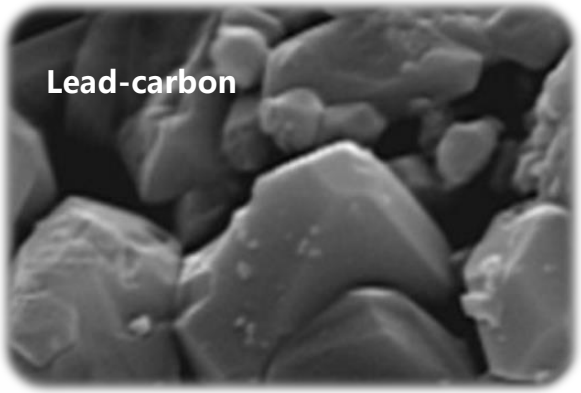
Lead-carbon technology

The mechanism of carbon



Comparison on surface





Comparison internally

Structure builder

--- Set up 3D structural network, to provide active positions for $PbSO_4$

--- Inside of conventional electrode, there are too many spongy lead

--- Inside of lead-carbon electrode, there are only big & bulky $PbSO_4$

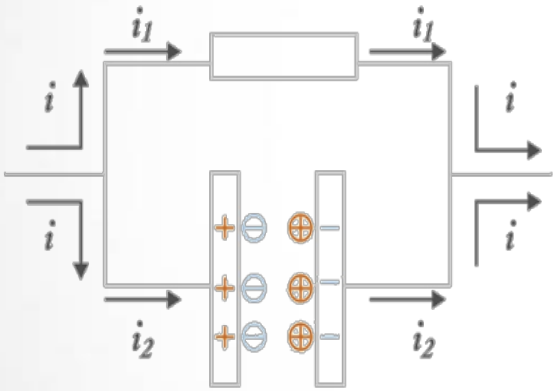
Narada®

Stored Energy Solutions for a Demanding World!

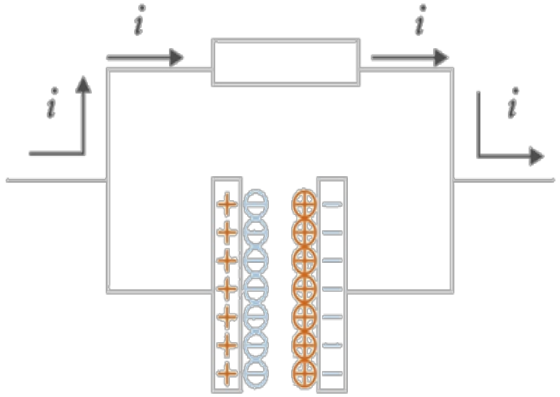
Lead-carbon technology

The mechanism of carbon

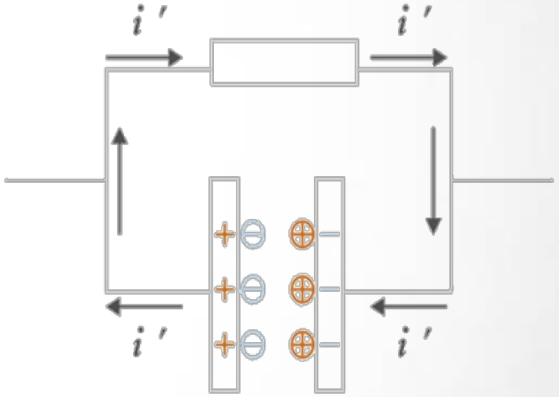
Buffer as a capacitor



Initial period of charging



Stable period of charging



Final period of charging

The phase transition from $PbSO_4$ to Pb --- "R" and adsorptions and desorptions of electric charges --- "C"

The negative plate of lead-carbon battery is just like innumerable R-C micro-circuitry in parallel connection

Narada®

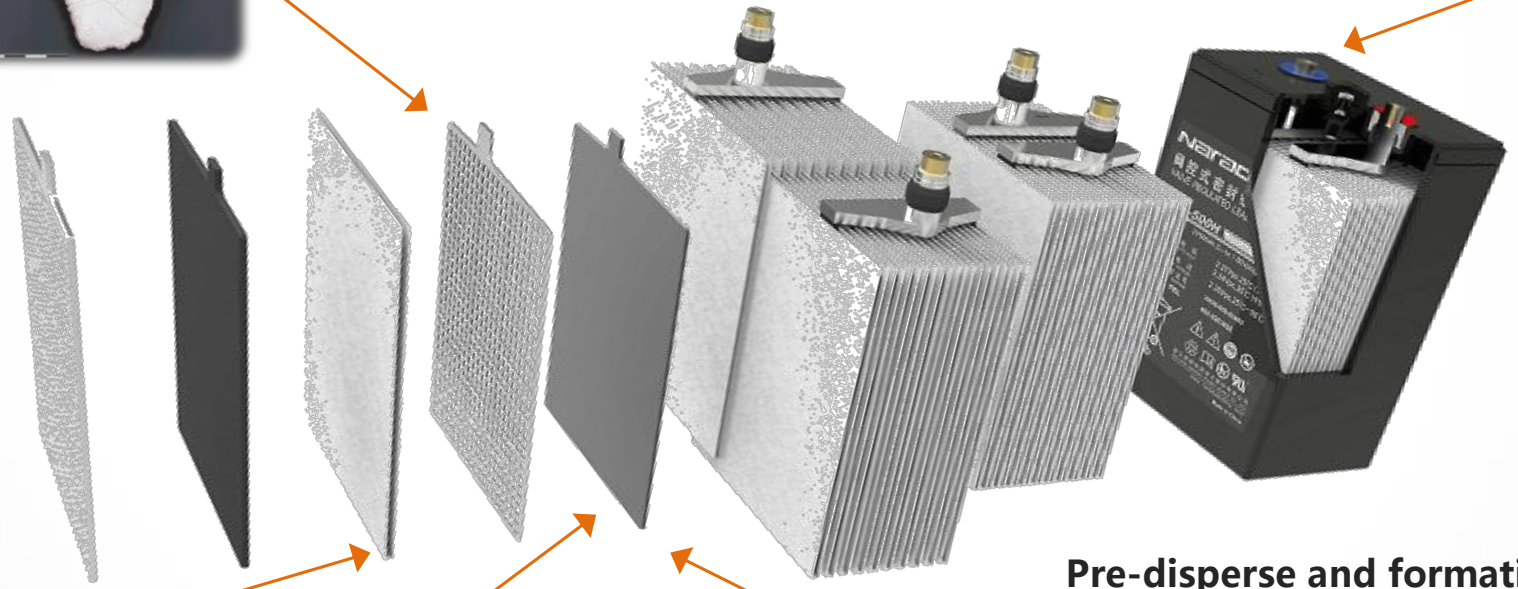
Stored Energy Solutions for a Demanding World!

Lead-carbon technology

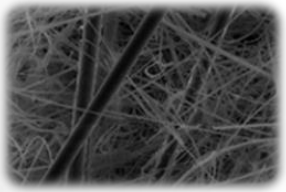
Well-chosen components

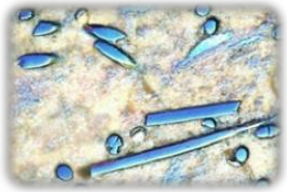
Patented alloy of grid

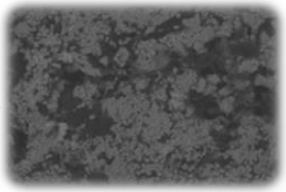
Innovative safety valve



Pre-disperse and formation







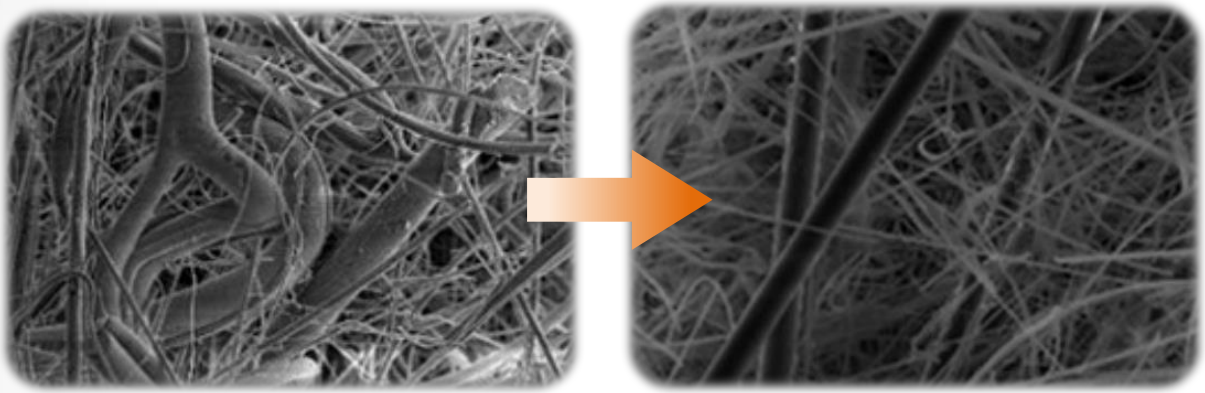
AGM separator and active carbon

narada®

Stored Energy Solutions for a Demanding World!

Lead-carbon technology

Well-chosen components

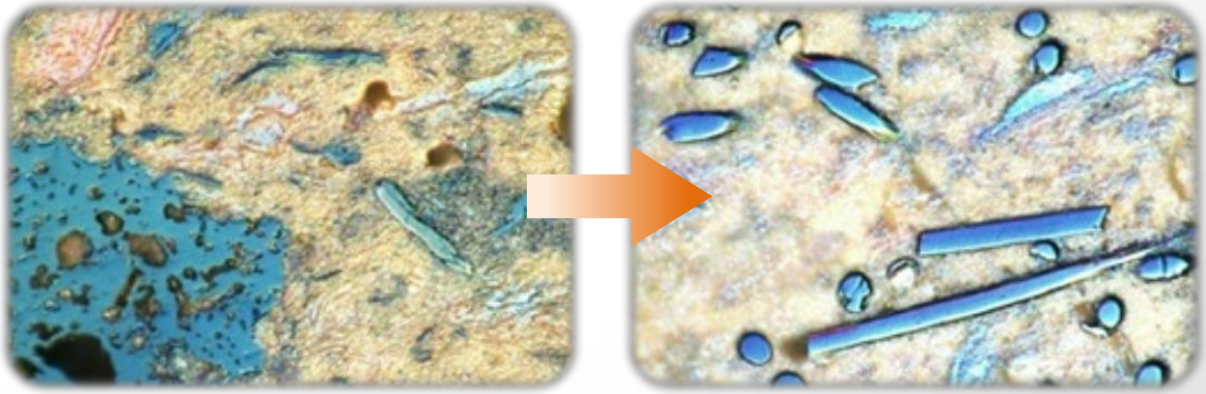


Special AGM separator

Made from ultrafine glass fiber with high strength, which has excellent ability in absorbability as well as maintenance of electrolyte material

Special carbon material

Unique carbon formulation in active substance of negative, which could restrain sulfate and improve cyclic life efficiently under partial SOC status



Narada®

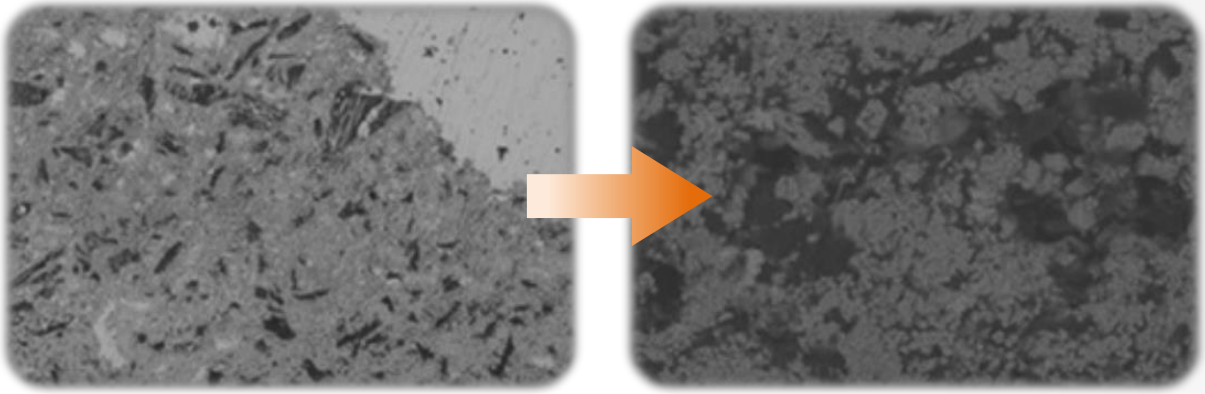
Stored Energy Solutions for a Demanding World!

Lead-carbon technology

Well-chosen components

Special pre-disperse tech.

The carbon materials are evenly dispersed in aqueous solution with high speed, that successfully makes lead and carbon particles mixed



Special formation process

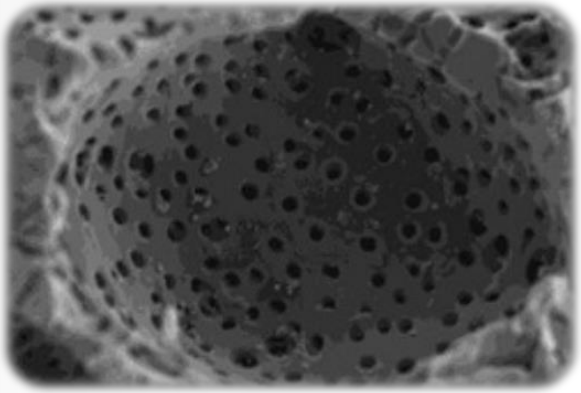
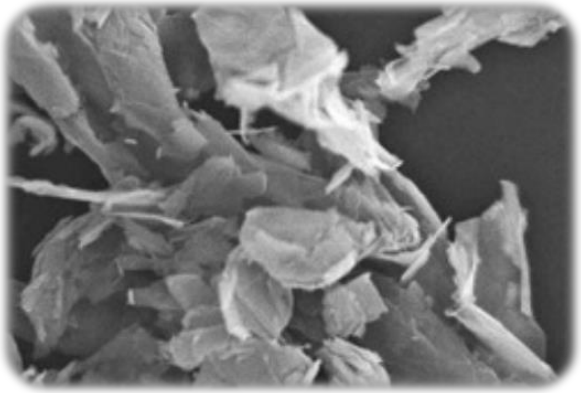
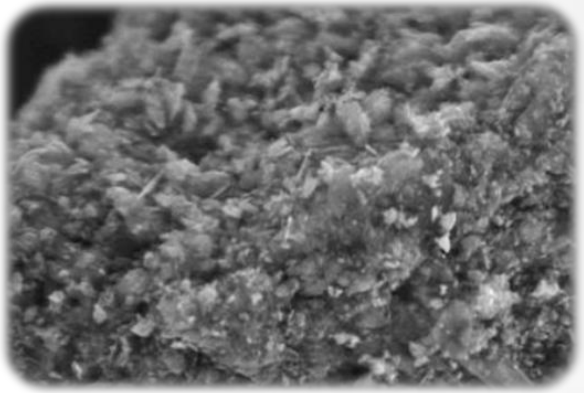
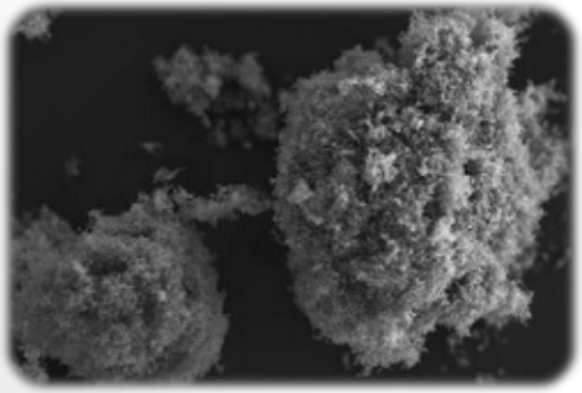
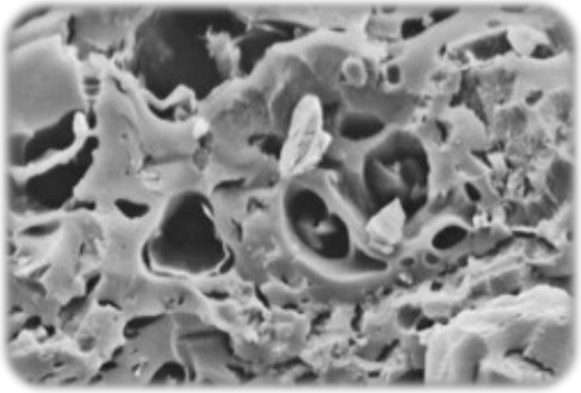
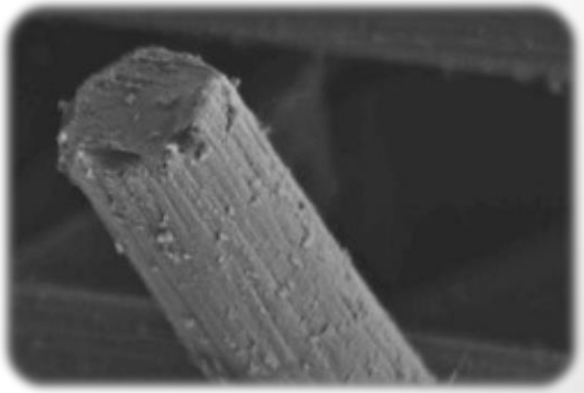
After so many experiments, Narada found out an exclusive procedure of formation, that can enhance both the capacity and cyclic life of batteries

Narada®

Stored Energy Solutions for a Demanding World!

Lead-carbon technology

Special carbon formulation

Narada has researched on many materials, such as active carbon, carbon fiber, carbon nanotube, graphene....etc.

Narada®

Stored Energy Solutions for a Demanding World!