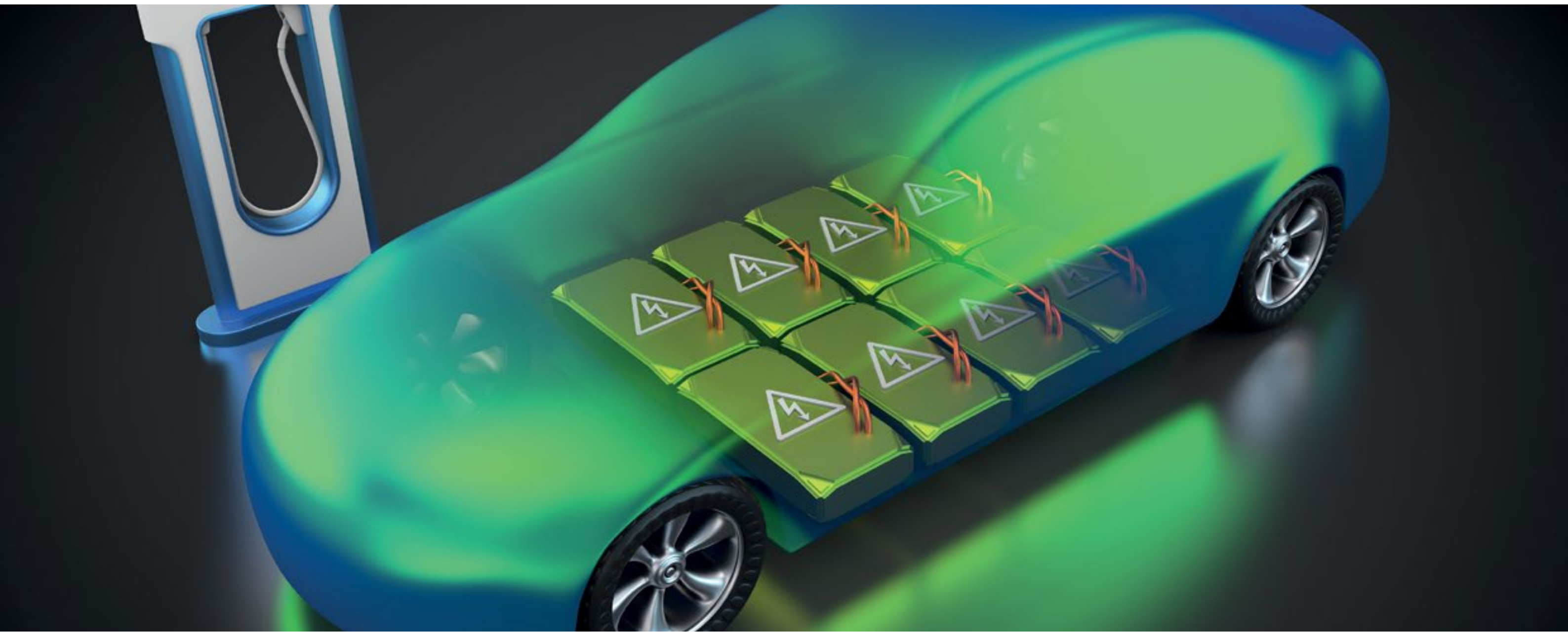


APPLICATION INFORMATION

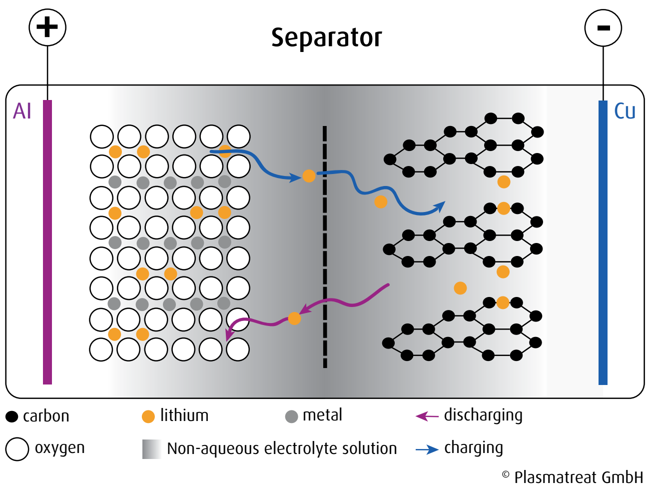
Pretreatment of high quality batteries

Cleaning and activation with Openair-Plasma® – fast, functional and oxide-free

Lithium ion batteries (LIBs) are now used worldwide in a wide range of electrical devices in the consumer electronics and electromobility sectors. They have a comparatively high energy density compared with nickel-metal hydride batteries and other conventional electrochemical storage systems. As a result, they are widely used in electrical devices and electric vehicles which require a compact, high-performance energy storage system, such as smart phones, e-bikes and especially, electric cars and utility vehicles (buses, lorries). Increasingly, they are also being used in home energy storage systems, since the price per kWh of usable energy has fallen dramatically in recent years. With regard to their use in electromobility, a further increase in energy density combined with a significant reduction in production costs is needed to make electric vehicles more accessible to the general public in the future.

Structure of an LIB

A lithium ion battery basically consists of a negative graphite electrode applied to a copper conductive foil and a positive electrode consisting of a lithium-metal oxide applied to an aluminum conductive foil. The electrolyte is lithium hexafluorophosphate (LiPF6) - a conductive salt – dissolved in a non-aqueous organic solvent such as ethyl carbonate or dimethyl carbonate. To prevent the electrodes short-circuiting, they are separated by a plastic membrane which allows only the lithium ions migrating between the electrodes during charging and discharging to pass through. During charging, the positively charged lithium ions move from the positive pole to the negative pole and embed themselves in the cavities of the graphite (graphite intercalation compound). When the battery discharges, this process is reversed.



Structure of a lithium ion battery – charging and discharging processes.

The requirements of high quality lithium ion batteries for cleanliness, tightness and wettability can be met by activating the interfaces with Openair-Plasma®.

Cleaning and activating the contact surfaces of high quality batteries with Openair-Plasma®

Applications

Copper and aluminum conductive foils are cleaned effectively with Openair® Plasma. Organic residual contamination can be removed from foils several meters wide at speeds of up to 70 m/min without oxidizing the foil or impairing the surface in any other way. This significantly improves subsequent wetting with the slurry, leading to improved adhesion of the active material to the conductive foil after calendering.

For particularly demanding requirements and to significantly increase the cycle stability of the LIB, a conductive adhesion promoter can be applied to the foil with the aid of PlasmaPlus®. This is done by incorporating an additive into the plasma, which is excited within the plasma and polymerized onto the foil material. The film deposited on the surface in this way not only improves the adhesion of the active material and thus the mechanical stability of the cell, it also improves electron transfer between the active material and the conductive foil and so increases the battery's efficiency.

Benefits for LIB production

The use of Openair-Plasma® technology in the production process optimizes workflows:

- Significant increase in energy density
- Lean production processes
- Significant cost reduction
- Substantial increase in LIB cycle stability
- Approved adhesion of the active material
- Increased battery efficiency

Benefits for cell production

- Layers of active material can be applied more thickly (higher stacking factor) by improving adhesion between the active material and the foil
- Thinner conductive foils can be used (higher stacking factor)
- Increasing the stacking factor increases the capacity by up to 20%
- Higher cycle stability due to improved mechanical resistance (up to 1000 charge and discharge processes at 80% of output capacity)
- Enables short-term higher discharging currents

Process engineering

Plasma treatment to enhance adhesion – essential even in battery manufacturing
The finished cells are connected in series and in parallel to form a battery pack with the desired voltage and capacity. Cleaning and activation with atmospheric pressure plasma can also be used in the various downstream processes involved in producing the finished battery pack.

Pretreatment and bonding of the battery pack's plastic housing to the protective aluminum casing
In modern electric cars, the lithium ion battery is usually located in the vehicle underbody. This reduces the center of gravity and thus significantly improves the vehicle's road holding ability. However, there is a risk of damage if the vehicle bottoms out or due to stone chips. The plastic battery housing containing the cells connected to form a battery pack is therefore bonded inside an aluminum casing and sealed to protect it from moisture. Plasma pretreatment of the plastic housing ensures a long-time stable adhesive bond and reliable seal, even under humid climatic conditions and in areas with severe temperature fluctuations.

Cross-section of battery pack with plastic housing

Pretreatment of battery modules (cells) and adhesive bonding to form a battery pack
Bonding the modules after pretreating the housing with plasma gives the battery pack a stable structure. Plasma treatment with rotary nozzles activates and cleans the painted surfaces before the modules are glued together.

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Subject to technical changes and misprints.