Application Note - Quality Control of Lithium-Ion Batteries for Electric Vehicles

Application of Spectrophotometers in Quality Control for Lithium-Ion Batteries in Electric Vehicles

A Quality Control Approach Based on Reflectance Measurement in the Electrode Slurry Coating Process

Konica Minolta's measuring instruments are used in the manufacturing and inspection processes of lithium-ion batteries for electric vehicles.
In particular, in the electrode manufacturing process, especially for negative electrodes, coating thickness, uniformity, and the presence of defects are critical quality control factors that directly affect battery performance. Since EV batteries are produced in large volumes and require 100% inspection, spectrophotometers that enable non-destructive and stable measurement based on reflectance are widely utilized.

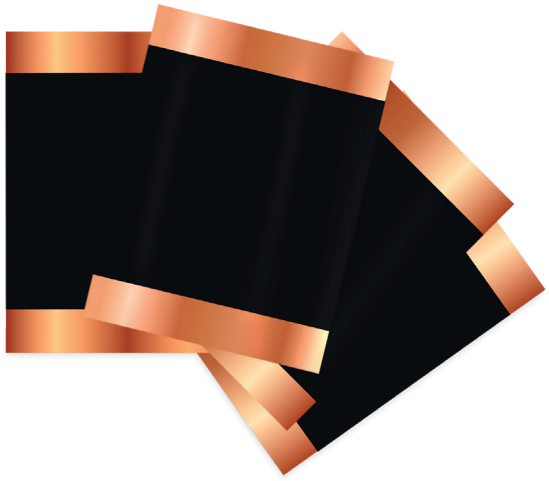
The production volume of electric vehicles (EVs) continues to increase year by year and is expected to expand further, driven by government policies in many countries.

As a result, batteries, one of the key components of EVs, face growing demands for improved performance, capacity, lifetime, and safety. Currently, lithium-ion batteries are the most widely adopted battery technology for EVs.

In battery manufacturing processes, even slight variations can have a significant impact on battery performance and safety, making strict quality control essential.

Negative Electrode Manufacturing Process of Lithium-Ion Batteries

The negative electrode of a lithium-ion battery is produced by coating a graphite slurry onto a copper foil substrate. The copper foil thickness is typically 8-20 µm, and the total electrode thickness after double-sided coating ranges from several tens to about 200 µm. The slurry, composed of graphite, binder, and organic solvents, is uniformly applied to the copper foil. Because the slurry is highly diffusive and opaque, optical interference does not occur, and the coating thickness cannot be directly determined from the reflectance spectrum using HSI technology. Therefore, the reflectance characteristics of the coated slurry surface are evaluated and managed in correlation with coating thickness and coating conditions.



Negative electrode coating: copper foil coated with graphite slurry

Electrode Coating Thickness Control by Reflectance Measurement

Application

- The reflectance of the slurry surface after coating is measured and controlled based on its correlation with coating thickness.
- Since a direct relationship exists between slurry coating thickness and reflectance, thickness can be effectively managed via reflectance measurement and predefined calibration models.

Process Relationship

Slurry properties (thickness, viscosity, mixing ratio, dispersion)

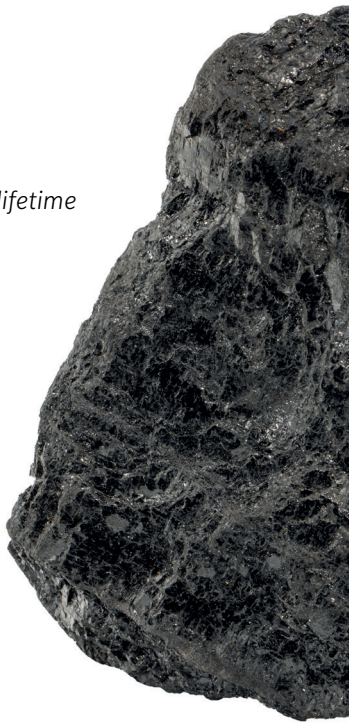
> *Coating thickness* > *Reflectance signal* > *Process control* > *Battery performance & lifetime*

Benefits

Enables non-contact and non-destructive coating thickness control

Allows in-process control of critical parameters affecting battery performance and lifetime

Provides a direct link between coating quality and final cell performance



Quality Control along the Cell Production Process

Copper foil quality control
Measurement of reflectance, gloss, etc.

Thickness Control
Measurement of Reflectance

Coating Uniformity and Variation Control (Process Stabilization and Yield Improvement)

Application

- Evaluation of average values and variations through multi-point measurements across the sheet.
- Control using specific wavelength ranges or L(Y) values (10°/D65).

By performing multi-point reflectance measurements, coating non-uniformity and process variations can be quantitatively evaluated.

Benefits

Early detection of coating non-uniformity and process variations

Contributes to quality stabilization and improved yield

Flexible selection of control indices (full spectrum, specific wavelengths, or L*)

Recommended Portable Spectrophotometers

Because the slurry surface is highly diffusive, selecting appropriate measurement geometry and conditions is essential to achieve stable reflectance measurements.

By using a d/8 geometry under MAV/SCI conditions, the influence of surface scattering can be minimized, enabling highly reproducible measurement results.

CM-17d / CM-16d
Fast and highly accurate color measurements on small, curved, or flexible surfaces with an ergonomic vertical design.

CM-25d
A cost-effective horizontal model designed for fast and efficient color measurement in the field.

CM-26dG
Dual capability: high-precision color measurement and integrated 60 degree gloss measurement in one.