High-Accuracy Capacitive Thickness Measurement Optimizes Li-Ion EV Battery Plate Qualities

EV Battery manufacturers need to measure EV battery plate thickness with a high degree of precision (repeatable <2um accuracy and resolution) to optimize manufacturing efficiencies while maintaining uniform cell capacity and minimizing waste. The MTI Accumeasure System provides an effective means of monitoring plate thickness achieving sub 2um accuracy with high repeatability.

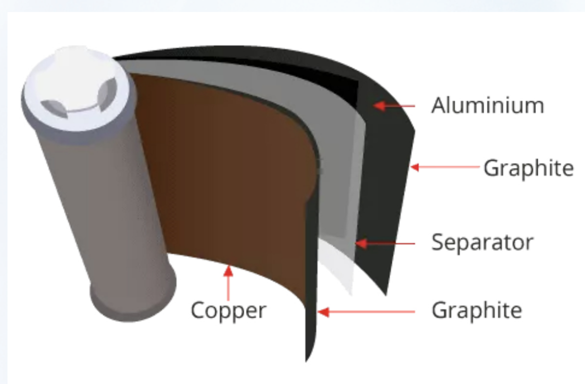
Introduction

The rapidly expanding demand for electric vehicles is driving advances in the production of rechargeable cells that comprise the first stage in the composition of EV battery packs.

Individual Li-Ion cells are combined to form modules that are then bundled into battery packs. Battery packs contain hundreds of cells and optimum capacity requires uniformity in the electrical characteristics of each cell.

Figure 1 describes the elements comprising a Li-Ion battery cell. The cathode is comprised of aluminum foil coated with a compound made up of active material (lithium ions), a conductive additive (graphite) and a binding agent. The anode is made of copper foil with active material, additive and binder. A separator (dielectric) and electrolyte complete the construction. Emerging solid-state electrolyte materials promise to add more capacity to each cell.

Each element must be produced to exacting tolerances. Typically, the cathode electrode and the anode electrode in an EV battery are each approximately 100-200 µm thick (0.004-0.008 inch). These plates are then calendared together with the dielectric in-between. Prior to calendaring, both the dielectric layer and the electrodes must be checked for thickness. Otherwise, the overall battery thickness may not be within specification and meet performance requirements.



MTI Instruments' Accumeasure Precision Thickness Measurement System

Measuring the thickness (step height) of the anode or cathode electrode material during manufacturing is performed by passing the composite film over a conductive roller and using MTI's proprietary capacitive probes system to measure the distances between them (Figure 2). Three probes are used to provide the most accurate measurement. Alarm limits can be set to alert the process engineer if the thickness goes out of tolerance.

Depending on the width of the material, two or more probes are aimed at the target material and two probes (Far Left and Far Right) at the roller.

The test system described uses three ASP 250M probes connected to the MTI D410 Accumeasure Capacitance Displacement Sensor Amplifier connected via USB to a computer running MTI's Accumeasure software for capturing measurement data.

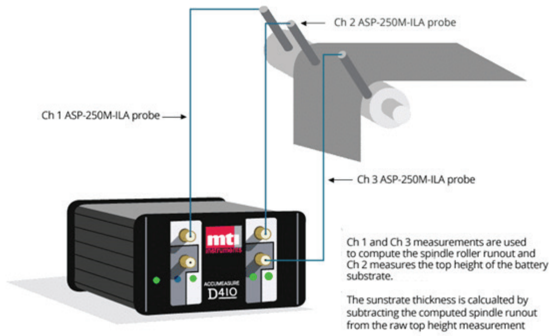


Figure 2. Accumeasure Three-Probe System for Measuring Li-Ion Battery Material Thickness

The probes are all mounted an equal distance from the roller. The Ch 2 probe is set to measure the distance to the battery material. The outside probes (CH1 and CH3) are set at the opposite ends of the roller to capture the effects of any roller tilt and wobble in height due to bearing alignment (runout) and the roller's shape. An encoder is connected to the working roller and sends 1440 pulses per roller revolution to the MTI D410. These pulses are synchronized to the roller's position, which is critical in calculating roller run-out subtraction and producing accurate measurements.

Calculating the true material thickness is performed in three steps.

1. Determine the average Pk-Pk run out of the roller used for measurement. This is measured by using the MTI probes at the two ends of the roller and calculating the average run out. (A separate paper is available to show the math).
2. Measure the step height of the material. This is the difference between the average roller displacement and the top of the material riding on the roller.
3. Calculate the material thickness by subtracting the average roller run out from the material height measurement. The result is the material thickness corrected for roller runout.

Sample Results

Figure 3 shows the before and after step height of sample electrode material of a full 360 turn of the roller. Figure 3a shows an example of the roller runout determined over the full rotation of the roller and the measured material step height without runout correction. Figure 3b shows the normalized thickness of the material corrected for roller runout.

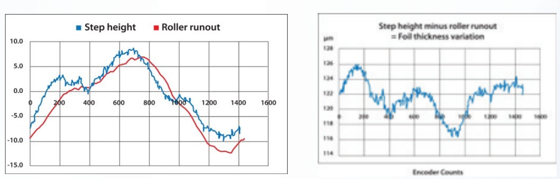


Figure 3. Examples of average roller run out. Unadjusted average step height with embedded run out (a) and corrected step height (b)

Conclusion

By monitoring the thickness of the anode and cathode composite plates, MTI's proprietary Accumeasure technology supports QC monitoring of these critical elements used in EV battery construction. For battery manufacturers, the benefits include maximizing battery capacity by using optimal thickness of materials combined with reduced labor and material waste and greater production efficiency. EV manufacturers also enjoy the benefits of close-tolerance plates as do EV consumers.

To learn more, visit www.MTIInstruments.com, call (800) 342-2203 or email sales@mtiinstruments.com.