Study employs image-recognition AI to determine battery composition and conditions

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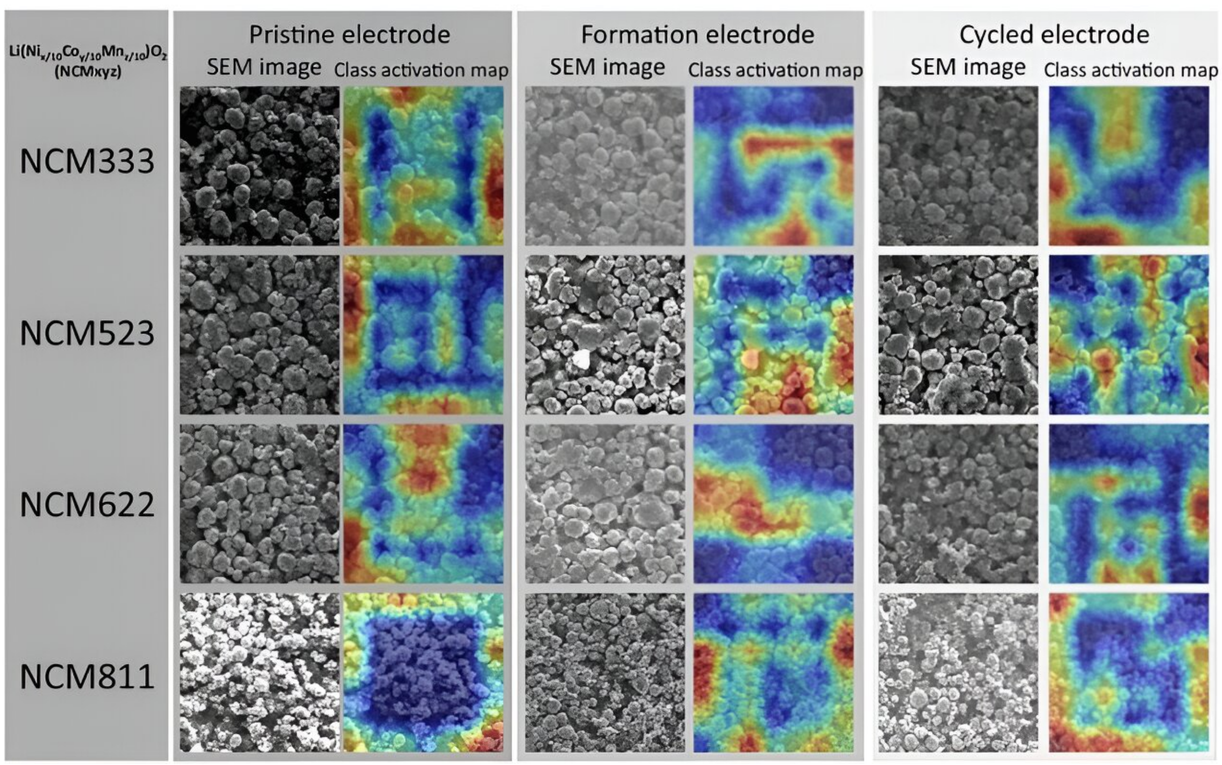


Example images of true cases and their grad-CAM overlays from the best trained network. Credit: KAIST Materials Imaging and Integration Lab

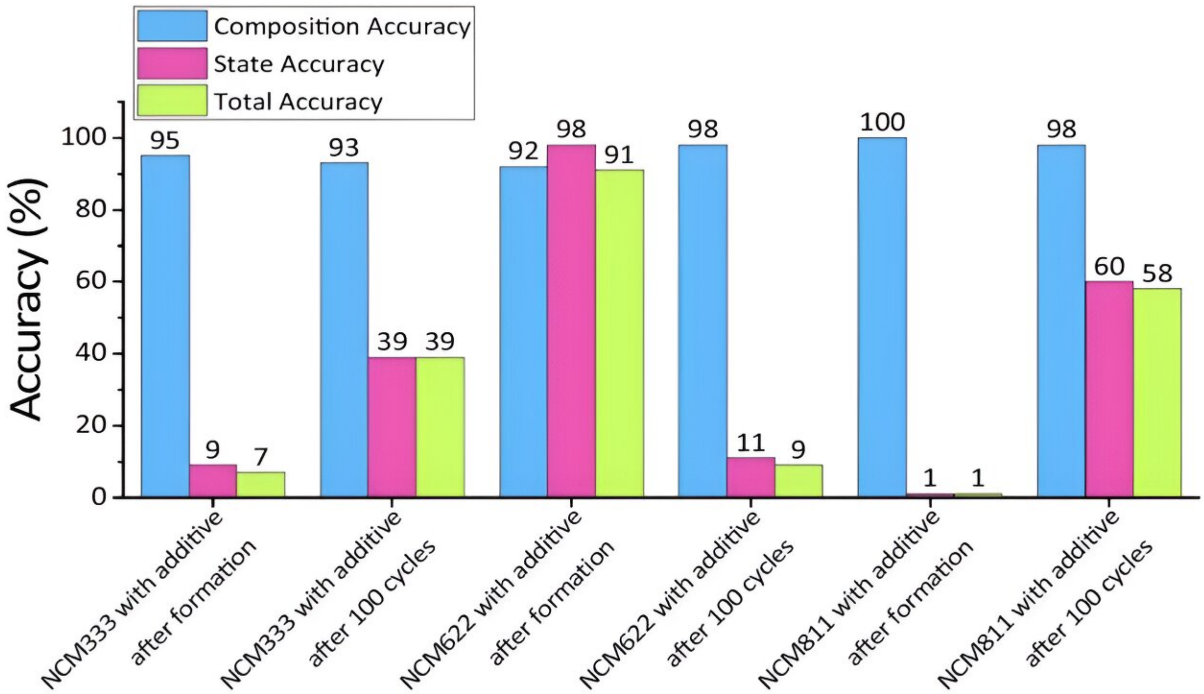
An international collaborative research team has developed an image recognition technology that can accurately determine the elemental composition and the number of charge and discharge cycles of a battery by examining only its surface morphology using AI learning.

Professor Seungbum Hong from the Korea Advanced Institute of Science and Technology (KAIST) Department of Materials Science and Engineering, in collaboration with the Electronics and Telecommunications Research Institute (ETRI) and Drexel University in the United States, has developed a method to predict the major elemental composition and charge-discharge state of NCM cathode materials with 99.6% accuracy using convolutional neural networks (CNN).

The paper is published in the journal *npj Computational Materials*.

The research team noted that while scanning electron microscopy (SEM) is used in semiconductor manufacturing to inspect wafer defects, it is rarely used in battery inspections. SEM is used for batteries to analyze the size of particles only at research sites, and reliability is predicted from the broken particles and the shape of the breakage in the case of deteriorated battery materials.

The research team decided that it would be groundbreaking if an automated SEM could be used in the process of battery production, just like in semiconductor manufacturing, to inspect the surface of the cathode material to determine whether it was synthesized according to the desired composition and that the lifespan would be reliable, thereby reducing the defect rate.



Accuracies of CNN Model predictions on SEM images of NCM cathode materials with additives under various conditions. Credit: KAIST Materials Imaging and Integration Lab

The researchers trained a CNN-based AI applicable to autonomous vehicles to learn the surface images of battery materials, enabling it to predict the major elemental composition and charge-discharge cycle states of the cathode materials. They found that while the method could accurately predict the composition of materials with additives, it had lower accuracy for predicting charge-discharge states.

The team plans to further train the AI with various battery material morphologies produced through different processes and ultimately use it for inspecting the compositional uniformity and predicting the lifespan of next-generation batteries.

Professor Joshua C. Agar, one of the collaborating researchers of the project from the Department of Mechanical Engineering and Mechanics of Drexel University, said, "In the future, artificial intelligence is expected to be applied not only to battery materials but also to various dynamic processes in functional materials synthesis, clean energy generation in fusion, and understanding foundations of particles and the universe."

Professor Seungbum Hong from KAIST, who led the research, stated, "This research is significant as it is the first in the world to develop an AI-based methodology that can quickly and accurately predict the major elemental composition and the state of the battery from the structural data of micron-scale SEM images.

"The methodology developed in this study for identifying the composition and state of battery materials based on microscopic images is expected to play a crucial role in improving the performance and quality of battery materials in the future."

This research was conducted by KAIST's Materials Science and Engineering Department graduates Dr. Jimin Oh and Dr. Jiwon Yeom, the co-first authors, in collaboration with Professor Josh Agar and Dr. Kwang Man Kim from ETRI.

More information: Jimin Oh et al, Composition and state prediction of lithium-ion cathode via convolutional neural network trained on scanning electron microscopy images, *npj Computational Materials* (2024). DOI: 10.1038/s41524-024-01279-6

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