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APPLICATION NOTE

Investigate batteries with a SEM for better performance

Insights on what can be revealed on batteries structure and composition with a scanning electron microscope

The secret to improving the specifications of new-generation batteries is miniaturization. SEM is an unrivaled technique for inspecting and analyzing nanoscale materials, improving production processes or detecting the reasons for failure. Gain insights into how Phenom Desktop SEMs can be used to boost the performance of your products.

The battery production cycle is a long process that involves several stages. Intermediate checks are necessary to verify the quality of the production system, starting with the inspection of raw materials to the production of intermediate components. Additionally, checks on the final product require the system used for the investigations to be highly versatile.

The insulating materials in batteries are, by definition, non-conductive. When imaging with a SEM, this causes an accumulation of electrons on the surface of such samples, compromising the quality of the final picture and often hiding important details. In order to flawlessly image structures of interest, different solutions are available. Reducing the vacuum level in the imaging chamber can help to discharge the sample, immediately improving image quality.

The value of the current that is applied can also be altered to reduce the interactions and, when dealing with very delicate samples, prevent surface damage. If both of the previously mentioned techniques fail, a thin layer of gold can be applied on the surface, making it conductive and ready for high-resolution imaging.

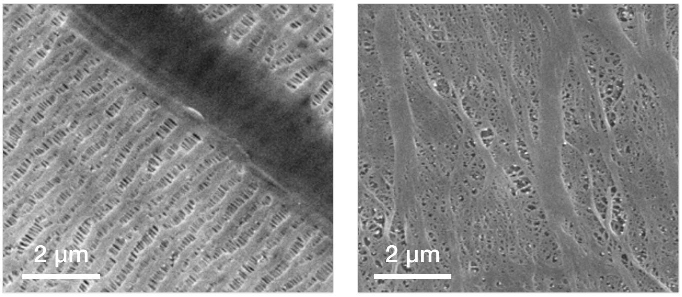

Figure 1a. Figure 1b.
SEM images of battery insulating membranes. Highly non-conductive samples require special treatment for imaging. Operating at a different vacuum level can reduce charging effects. Coating the sample with a thin gold layer will dramatically reduce this issue.

Advantages of electron microscopy
Access to nanoscale magnification
Integrated, non-destructive EDS analysis to measure chemical composition of the sample locally
Automated routines to gather data on pores, particles and fibers, quickly and without wasting the operator's time
3D reconstruction of the surface to measure morphology
With an electron microscope, you can observe: • Size and granulometry of powders used as raw materials • Size and orientation of pores and fibers in insulating membranes • Three-dimensional structure of electrodes after production processes • Response of materials to electrical or thermal solicitations • Presence of contaminants in the battery sublayers

Raw materials, such as powders, can be easily imaged at very high magnification. Particles can then be measured to evaluate the granulometry and shape distribution within the sample. With more advanced software analysis, these measurements can be automated, providing more accurate results and saving operators a great deal of time.

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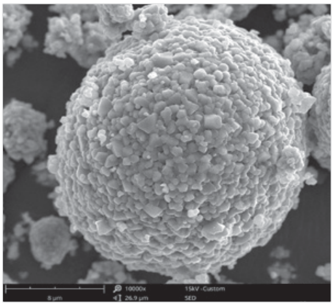

Figure 2a.

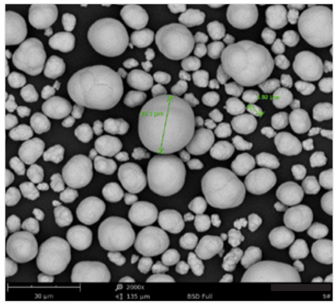

Figure 2b.

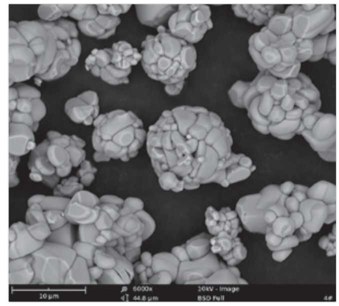

Figure 2c.

Raw powders used in the production of cathodes. SEMs are ideal tools for investigating small particles in the range of micrometers or nanometers.

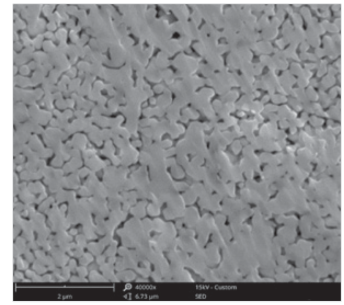

Figure 2d. Ion-milled surface of a battery electrode. The data can be used to investigate the internal structure of the material.

The shape and orientation of the electrodes' nanostructure is crucial for ensuring that batteries have a long lasting and high efficiency. In particular, the secondary electron detector (SED) can be used to inspect the morphology and surface topography of the sample.

With a backscattered electron detector (BSD), the image will show a different contrast for areas with different compositions. It is a formidable tool, combined with the energy dispersive detector (EDS), in the hunt for contamination and identification of areas to analyze.

Samples of interest can also be tilted and rotated to inspect them from different points of view. Shape from shading and stereoscopic reconstructions can be used to create threedimensional models of the surface and evaluate its shape and roughness.

Inspecting behavior at different temperatures, or while the sample is connected to a power supply, is also possible via SEM. This form of testing will provide valuable information regarding the physical and chemical properties of the sample when exposed to critical environments during its life cycle.

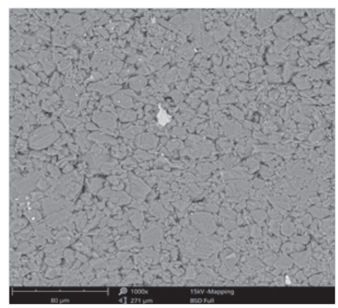

Figure 3a. The structure of an electrode imaged with a BSD detector. The bright particle close to the center has a different composition compared to the rest of the sample

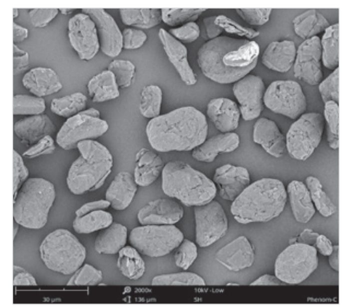

Figure 3b. Powders used in the production of anodes.

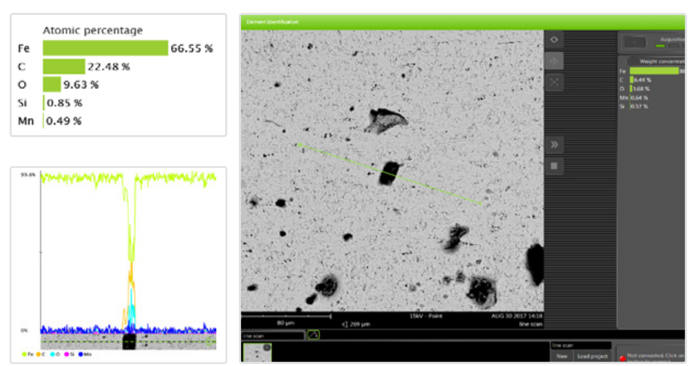

Figure 4. An example of how EDS can be used to trace how the sample composition changes along a line. Spot analysis, line scan or area map can be used to monitor the distribution of different phases in a specific region of the sample.

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