Inspection of Li-ion batteries structure with the new TESCAN S8000G FIB-SEM system

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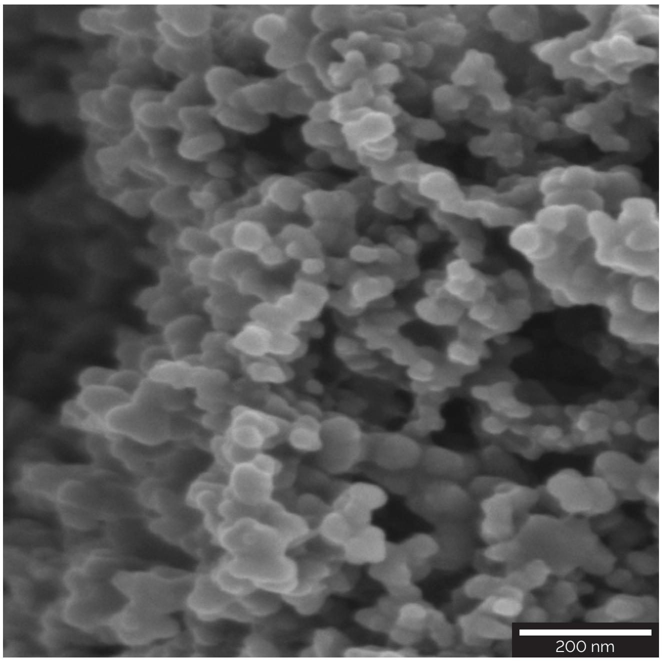
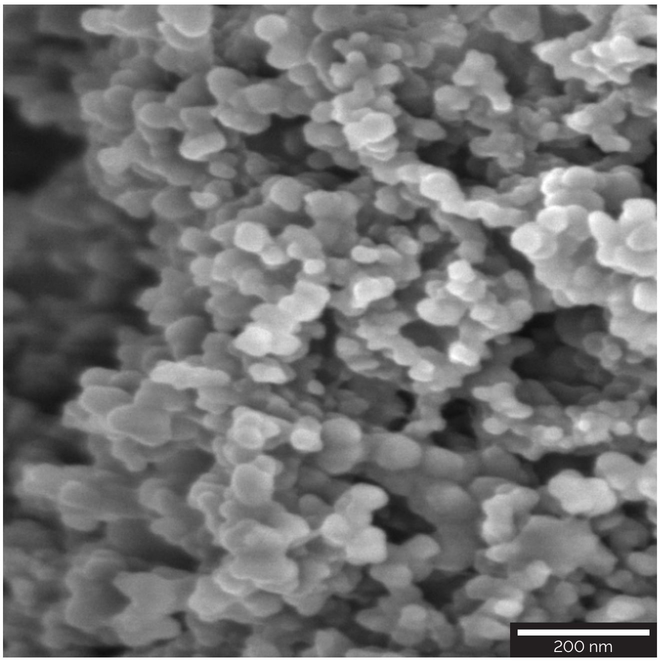
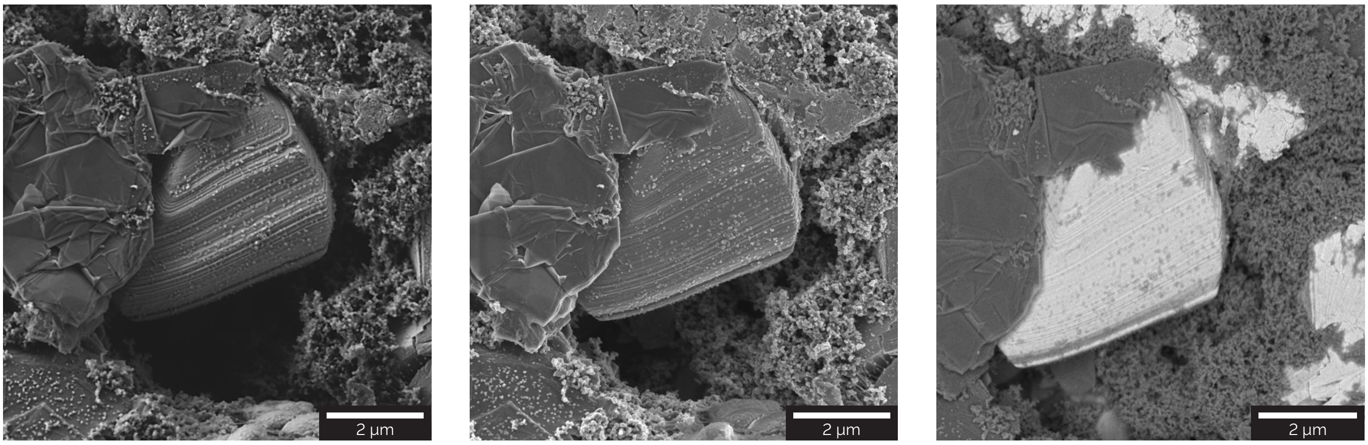
Li-ion batteries are power sources of many electronic devices of common use in daily life such as cellphones, car batteries, laptops, etc. These complex energy-storage devices can contain many different materials including polymers and metals. The polymer binders in these types of batteries are delicate beam-sensitive structures that can get easily damaged when scanned with a high-energy electron beam probe, a fact that can make SEM imaging of these samples really challenging. This represents a problem since the observation of the internal structure of electrodes of these batteries is of utmost importance for battery producers. This is because the internal structure of the electrodes of Li-ion batteries differs during their lifetime and such changes have significant effects on the performance and final quality of the batteries. Understanding these changing processes is vital to overcome performance problems and design better energy-storage solutions.

The new TESCAN S8000G FIB-SEM system is an ideal solution to satisfy the imaging and analytical needs required in the battery industry. On one hand, the S8000G microscope features the new BrightBeam™ SEM column capable of field-free ultra-high resolution (UHR) imaging and fitted with a robust detection system. The column delivers improved resolution especially at low electron beam energies which makes it suitable for imaging non-conductive samples as well as beam-sensitive specimens (such as the binder materials) at energies that can be as low as just a few hundreds of eVs without compromising image quality. In turn, the detection system is comprised of an in-lens detection system with energy-filtering and angle-selective electron signal capabilities thus enabling a variety of image contrast ranging from topographic to compositional with a clear discrimination of SE and BSE signals. Electron signal separation based on user-defined energy-filtering windows enables tunable surface sensitivity which can provide unique BSE material contrast of binder materials without damage and maximum information of the uppermost surface layers of the sample by selecting BSEs within a narrow range of energy. Different signals can be acquired simultaneously thus maximising information and insight into the nanostructure of lithium batteries, see Figs 1, 2. The energy-filtering capability can also be used for reducing charging artefacts during imaging.



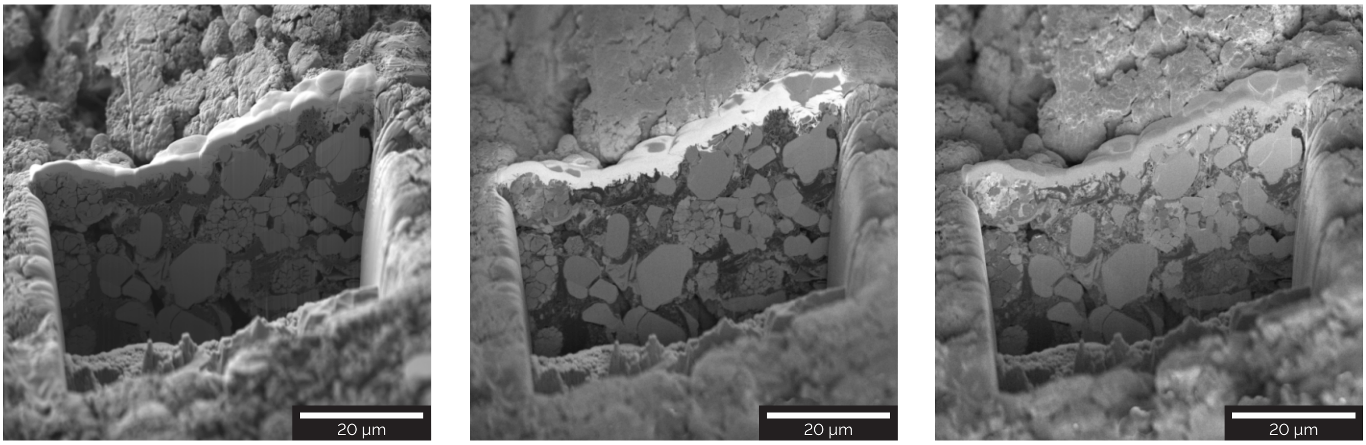


▲ **Fig 1:** Nanostructures of a Li cathode observed with the Multidetector (left) and the Axial detector (right) imaged at 2 keV.



▲ **Fig 2:** Cathode of a Li-ion battery imaged at 2 keV with the E-T detector (left), and, with the Multidetector with the energy-filtering grid OFF for detecting SE signal (centre) and ON for detecting BSE signal (right).

On the other hand, in terms of sample modification, the S8000G is equipped with the novel Orage™ Ga FIB column with improved ion optics for better resolution, excellent low-energy beam performance and high ion beam currents up to 100 nA for excellent results and maximum throughput. These features make it possible to prepare cross-sections (Fig. 3), high-quality damage-free TEM specimens, and FIB-SEM tomography for studying the microstructure of electrodes of Li-ion batteries at different cycles that provides better understanding of the internal structural changes that occur during these processes.



▲ **Fig 3:** 50-µm long cross-section prepared with new Orage™ Ga FIB column and imaged at 2 keV with E-T detector (left), Axial detector (centre) and Multidetector (right).

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