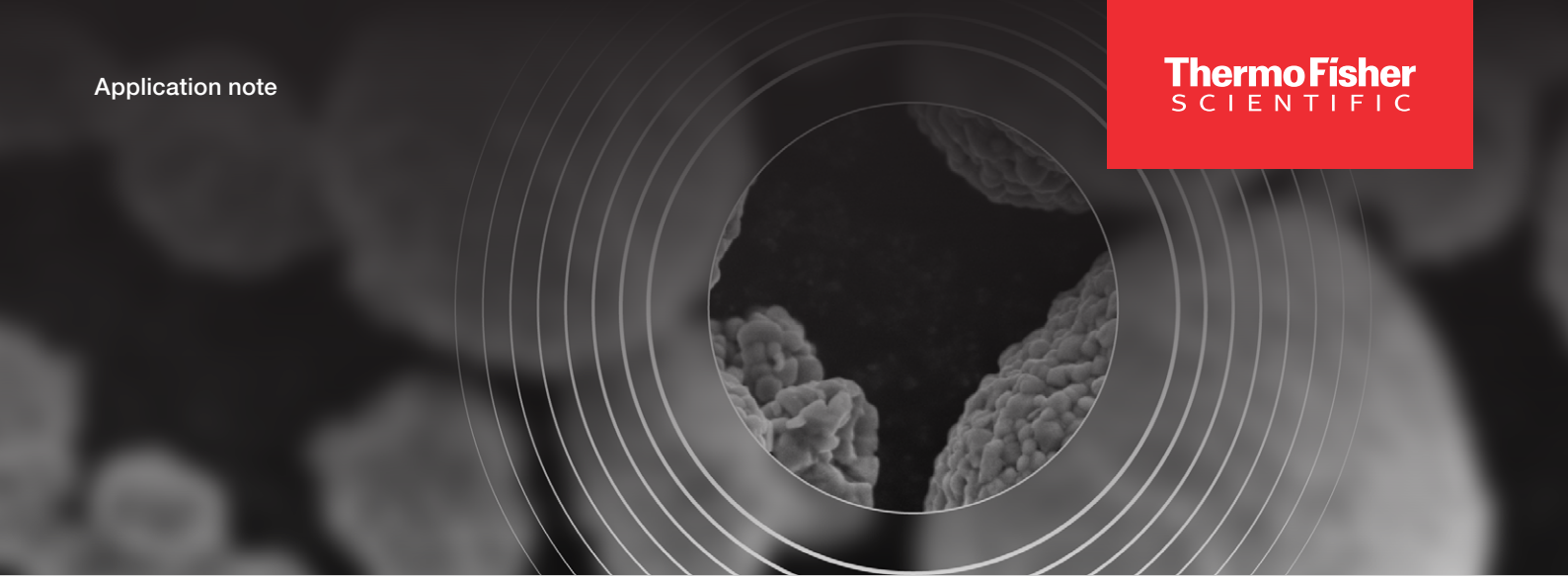
Application note



Benefits of the Phenom XL G2 Desktop SEM's argon compatibility for lithium battery research

From mobile devices to transportation, batteries are an integral part of our everyday lives. As we strive to decrease our impact on the planet with energy-efficient electric vehicles and sustainable energy sources, new and improved battery technology is vital.

With superior energy and power density performance compared to other commercially available battery technology, lithium-ion batteries are highly efficient energy storage devices. Currently, lithium-ion finds widespread usage in an increasing number of applications such as the batteries that power smartphones and electric cars.

Challenge

However, there have been newsworthy cases where lithium batteries have exploded while in use in popular products, prompting a major recall. The entire air travel industry adopted new safety regulations after lithium-ion batteries in smartphone devices caused fires during flights. There have also been cases where batteries in electric vehicles have combusted and proven to be both extraordinarily difficult to extinguish and prone to reignition.

Current technology has led to the advent of lithium batteries with liquid electrolytes, with solid-state lithium batteries set to be the next stage of battery research. Solid-state lithium batteries could help solve two key issues:

1. Offering a larger energy density
2. Providing a much safer product

The key challenge with the analysis of lithium battery materials is that they are very reactive in air. During the research and development of solid-state lithium batteries, the sample must be protected from reacting with the environment during sample preparation and analysis. An argon environment prevents lithium from reacting with oxygen, nitrogen, and/or water, thus preventing potentially dangerous outcomes.

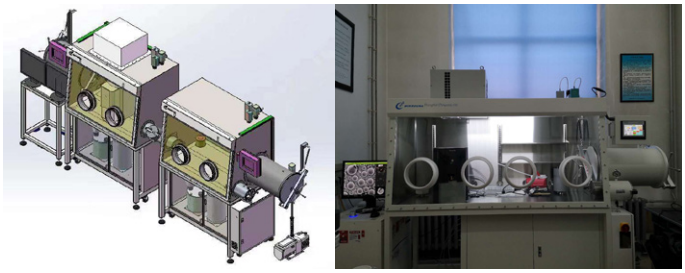


Figure 1. Left: schematic of workflow incorporating a Phenom XL G2 Desktop SEM inside a glove box. Right: actual setup of Phenom Desktop SEM inside argon filled glove box.

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Solution

The Thermo Scientific™ Phenom™ XL G2 Argon-Compatible Desktop SEM is the only scanning electron microscope that can be placed entirely within an argon-filled glove box, allowing you to perform research on air-sensitive lithium battery samples.

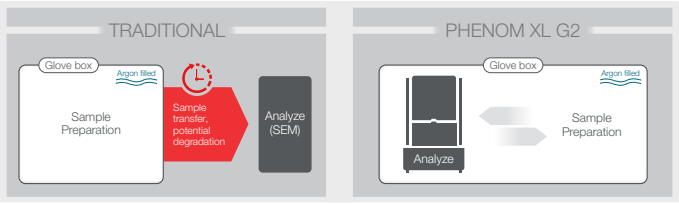
Normally, when transferring a sample from glove box to SEM, the sample will undergo changes due to exposure to water, oxygen and/or nitrogen. Existing solutions, such as a vacuum-transfer kit, are expensive, complex or not sufficiently protecting the sample. With an SEM inside the glove box, the workflow would be much faster as the sample and SEM analysis are in the same environment.

However, although lithium does not react with argon, the investigation in an argon environment does still pose some challenges.

A scanning electron microscope uses high acceleration voltages of 15,000 volts (or even higher). The use of voltages this high in an argon environment without appropriate precautions can cause sparking because of the low breakdown voltage of Argon, which will ultimately damage the electronics inside the SEM. The Phenom XL G2 Argon-Compatible Desktop SEM employs dedicated technology to avoid this sparking issue, offering a protected environment in which to characterize air-sensitive battery samples.

Benefits

By using the Phenom XL G2 Argon-Compatible Desktop SEM in an argon-filled glove box, you can perform both sample preparation and SEM/EDX analysis in tandem in that one glove box. This not only makes the processes of sample prep, imaging, and analysis fast, but it also means that the lithium samples remain protected by the argon environment. Thus, you can perform research on the samples or take pre-screening steps before the sample is moved to other research equipment. Despite the use of thick gloves, handling of the sample holder is straightforward. Additionally, the system's long life source allows for many hours of use without intervention.



Comparison of traditional process versus the Phenom XL G2 Desktop SEM, showing time efficiency and sample preservation.

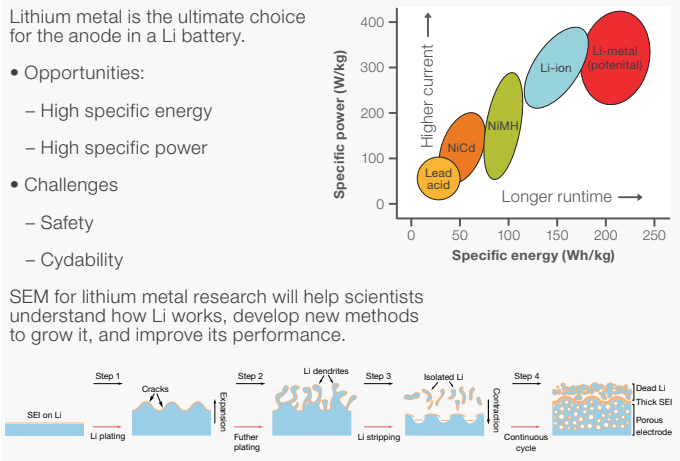


Figure 2. Opportunities and challenges for lithium metal anodes.

Example

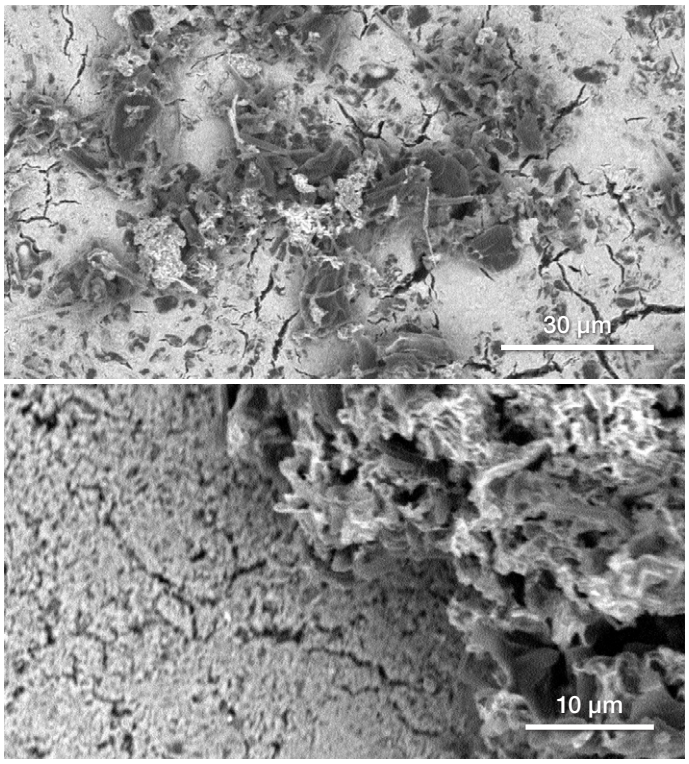


Figure 3. SEM images of lithium dendrites acquired with Phenom SEM inside argon filled glove box. The image below displays the script Ultra Depth of Focus, providing a cross-section sample of an anode.

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