High-end imaging in the palm of your hand

Phenom Pharos Desktop SEM with STEM Sample Holder

Bring biological sample examination and materials research in house with the STEM Sample Holder for the Thermo Scientific™ Phenom Pharos™ Desktop SEM. It's the world's first desktop scanning transmission electron microscope sample holder combined with a field emission gun (FEG) source.

It delivers high contrast under low voltage, increasing visibility of structures and morphology. It can also switch between lower and higher magnifications, accommodate a wide range of materials, and cover large sample size areas to help you screen samples and get results faster.

The STEM Sample Holder for the Phenom Pharos Desktop SEM is an ideal solution for a variety of applications and users:

- Capture detailed images of features below 10 to 15 nanometers to view morphology, structure, and contrast of materials
- Image cell and tissue samples for pathology and histology research
- Train and empower novice SEM microscopists

What is STEM?

When developing new materials, checking the quality of existing materials, or characterizing biological samples in detail, you need a full understanding of your samples to significantly advance your research.

Differences in image contrast

Scanning electron microscopy (SEM) is a powerful imaging tool for this work—it offers high-resolution images that can reveal the smallest details, and it's becoming increasingly popular. Some modern SEMs offer a more advanced imaging technique called scanning transmission electron microscopy (STEM) which transmits the scanning beam through the sample and collects the signal underneath. This results in different contrast than is achieved with SEM imaging, delivering additional information.

For example, these two imaging techniques complement each other in the production and development of conductive (nano)composite materials, which typically use carbon nanotubes that can vary in thickness and length depending on the production method. It's important to accurately characterize the physical appearance of these nanotubes, including aspect ratio, because it directly affects the mechanical and conductive properties of the composite.

However, it's easy to miss these details because they are small and hidden in the 3D structure of the material. As shown below, the SED image nicely reveals the thickness of the tubes and how they are interwoven.

The STEM image, on the other hand, shows the presence of particles that can indicate inhomogeneities and alter the overall bulk properties of the material that are not visible in the SED image. With STEM imaging, these details are no longer hidden.

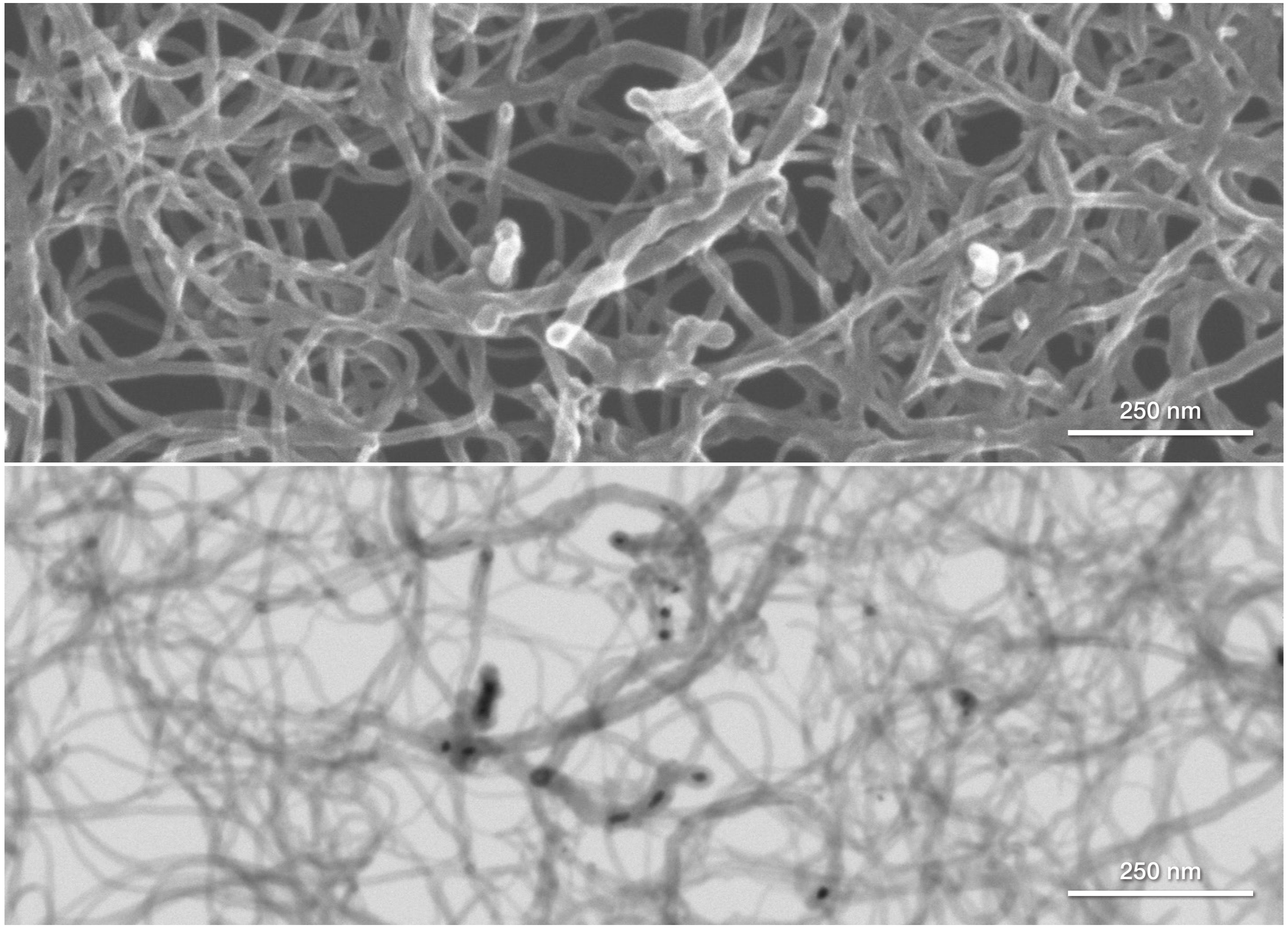


Figure 1: Carbon nanotubes imaged with SED (top) and STEM (bottom) imaging modes. While the SED image may be more appealing, the STEM image reveals the presence of particles.

Bright-field and dark-field imaging

When performing STEM imaging, transmitted signals can be collected on-axis (with very limited diffraction by the sample) or off-axis (with significant diffraction by the sample), as shown on the right. The inner part of the transmitted beam is referred to as the on-axis signal. Because the sample partially blocks electrons, it appears darker than the surrounding background. Hence, this imaging technique is referred to as bright-field (BF) imaging. The dominant factors in BF imaging contrast are sample composition and thickness. A thicker sample containing more Z elements allows fewer electrons to transmit through the sample, resulting in darker areas that are more difficult to interpret.

Dark-field (DF) imaging, on the other hand, makes use of the electrons that are significantly scattered by the sample—the off-axis transmitted electrons. Higher Z elements scatter more electrons while lighter elements scatter fewer. This means that higher Z elements appear brighter in the image than lower Z elements, typically resulting in a bright sample on a dark background. The outer signals have the highest angle respective to the optical axis, so these signals are referred to as high-angle annular dark-field imaging, or simply HAADF. Put simply, these three techniques deliver varying degrees of contrast that benefit different use cases.

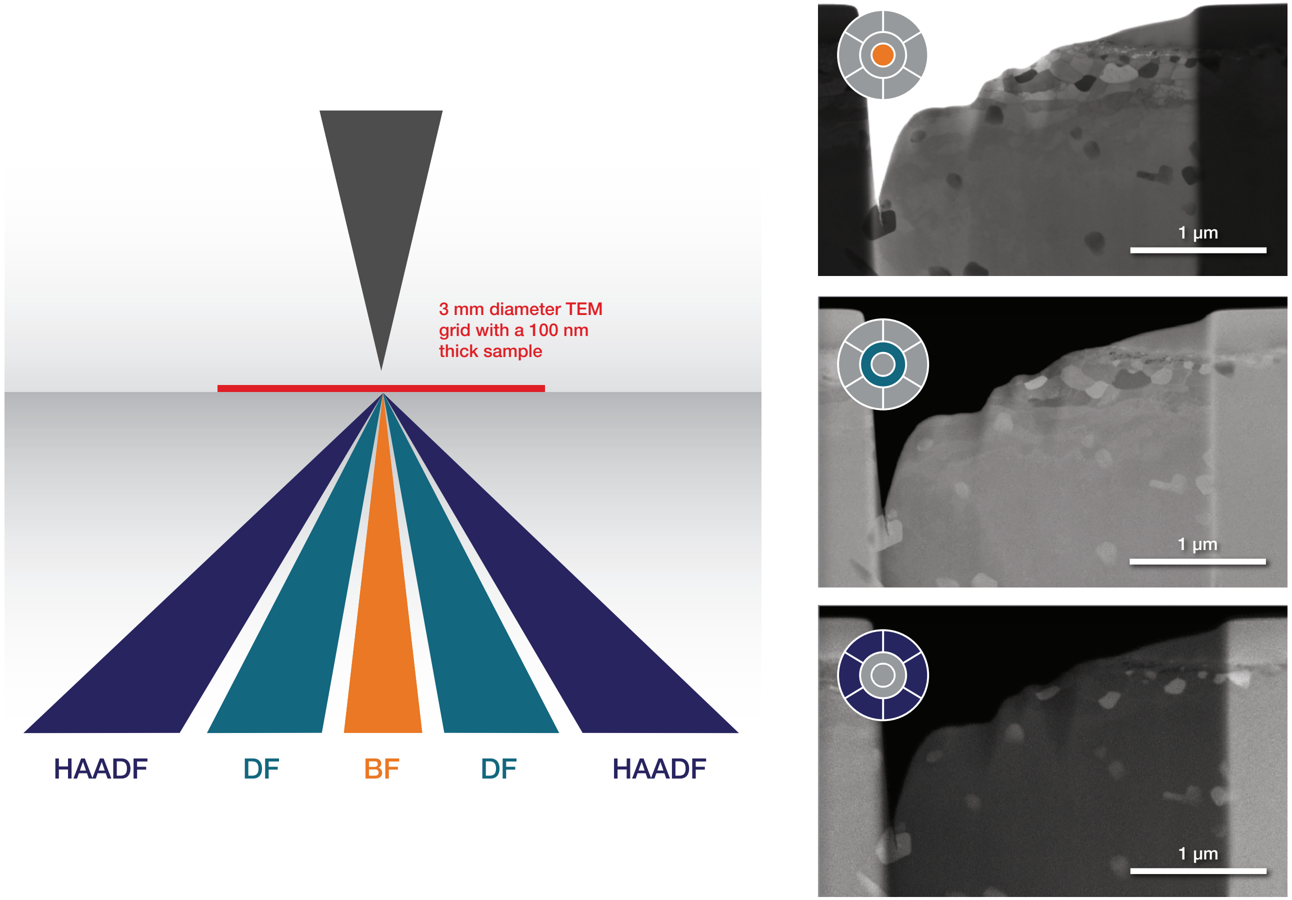
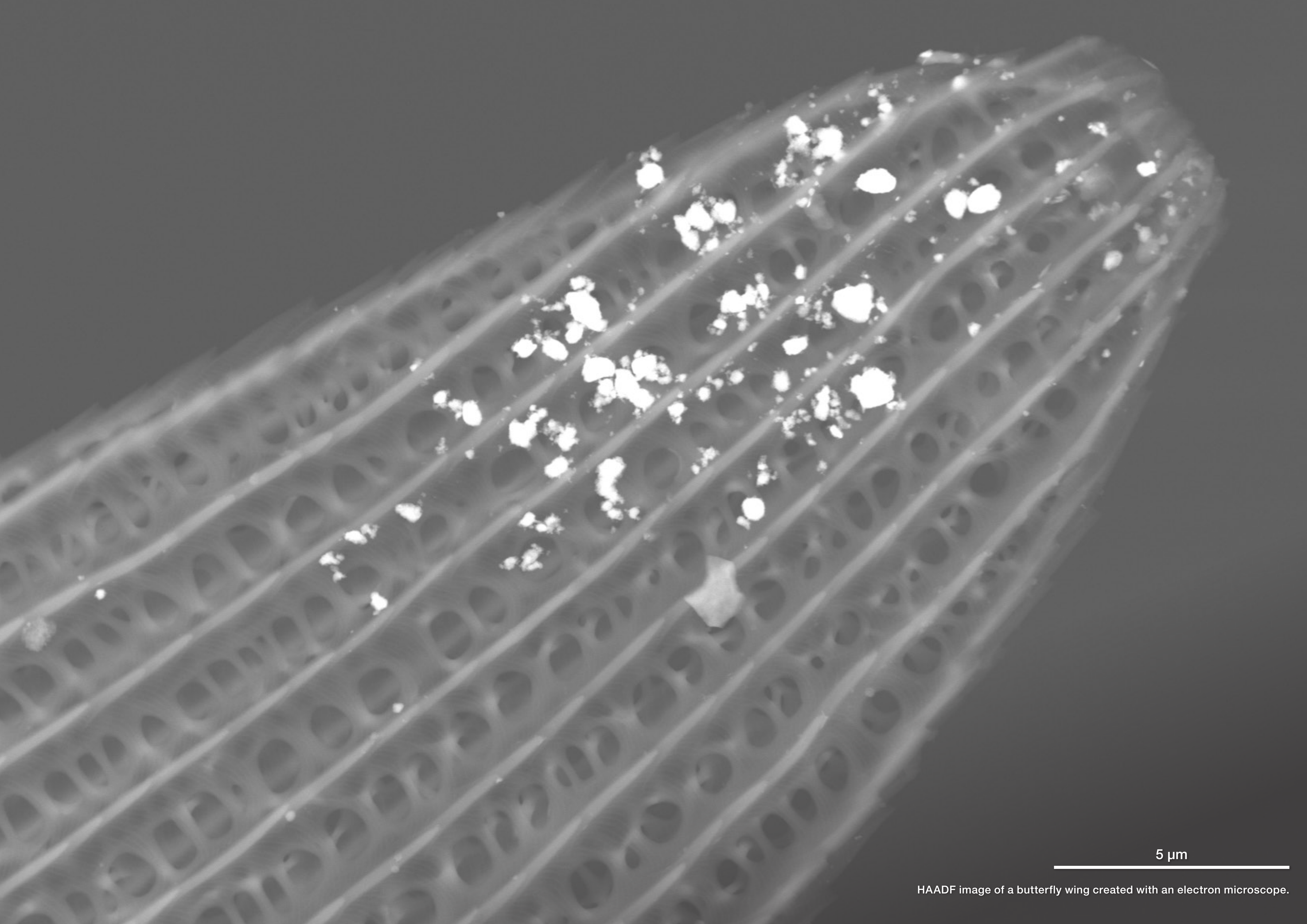


Figure 2. Left: Diagram of BF, DF, and HAADF signals after passing through a sample. Right: Comparison of BF (top), DF (middle), and HAADF (bottom) images.



HAADF image of a butterfly wing created with an electron microscope.

Interpreting contrast

The different STEM operational modes are ideal for correlative studies. While lighter elements are clearly visible in BF imaging, they scatter electrons poorly and are therefore difficult to see in HAADF. This can be demonstrated with an organic sample like the tobacco mosaic virus shown in here.

The rod-shaped virus contains organic material that is clearly visible in BF imaging. However, the denser lipid globules surrounding the virus are thicker and less permeable for electrons. In DF imaging, the denser lipids provide stronger diffraction, leading to enhanced contrast of these features. Also note the darker background in the HAADF mode. When further off axis, less scattering is found from the thinnest and least electron-dense areas. This is often the case for the carrier material, which in this imaging mode doesn't generate contrast. As you can see, these different imaging methods allow you to focus on different features in your sample.

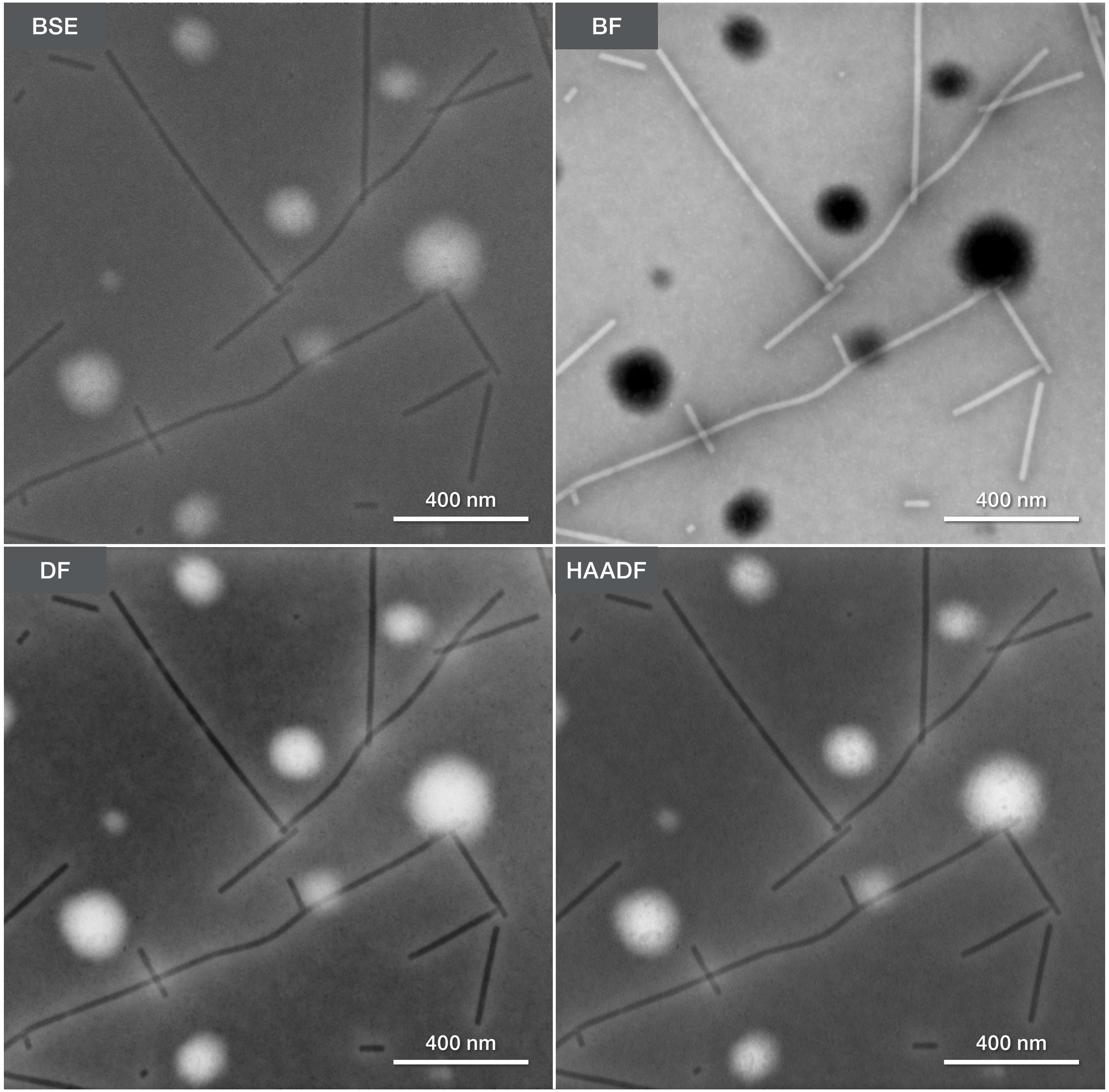


Figure 3: The four different imaging modes compared to a backscattered image of the tobacco mosaic virus. In BF mode, the virus is clearly distinguishable. In the DF modes the lipoids become more apparent.

Advantages of transmission mode on a desktop SEM

Electron microscopy has been used for almost a century to study all kinds of materials and has evolved to fit different applications in both the academic and industrial sectors.

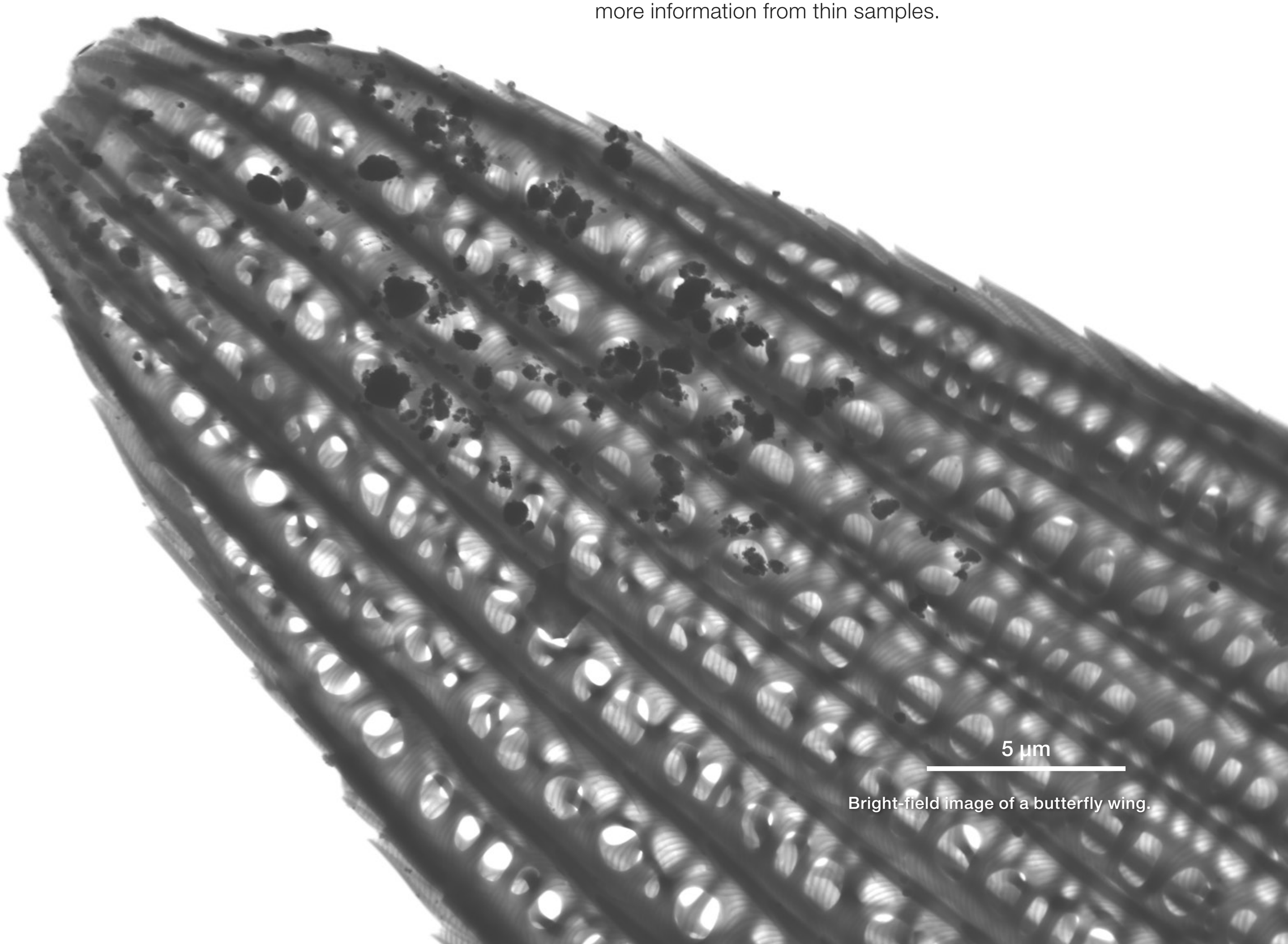
As use cases changed, so did the technology and performance of scanning electron microscopes (SEMs). In the last decade, state-of-the-art technology has been implemented in desktop SEMs and the enormous global installed base of several thousand systems leaves no doubt that materials scientists have embraced the smaller equivalents of powerful floor models.

The success of desktop SEM instruments stems from their enhanced ease of use—even for analytical studies like EDS—and their outstanding performance under the most demanding circumstances. Some researchers have even taken their desktop SEMs on the road, providing on-site electron microscopy analysis in mobile laboratories.

Desktop systems offer great advantages for STEM imaging, as well. STEM imaging is often performed on a transmission electron microscope (TEM), which almost always requires a large, dedicated operating room. Plus, the high vacuum in a TEM leads to longer sample loading times and the high voltage could damage samples.

Desktop SEMs, on the other hand, have a smaller footprint, can be loaded more quickly, and operate at lower voltage that better suits beam-sensitive materials. For applications that don’t require the highest possible resolution, like screening, desktop SEMs offer an easier workflow and deliver data faster.

The STEM Sample Holder for the Phenom Pharos Desktop SEM allows you to study standard 3 mm TEM grids in transmission mode, expanding the instrument’s application range to nano-materials and soft matter. With full UI integration and BF, DF, and HAADF imaging modes, it’s easy to gather more details, enhanced contrast, and more information from thin samples.

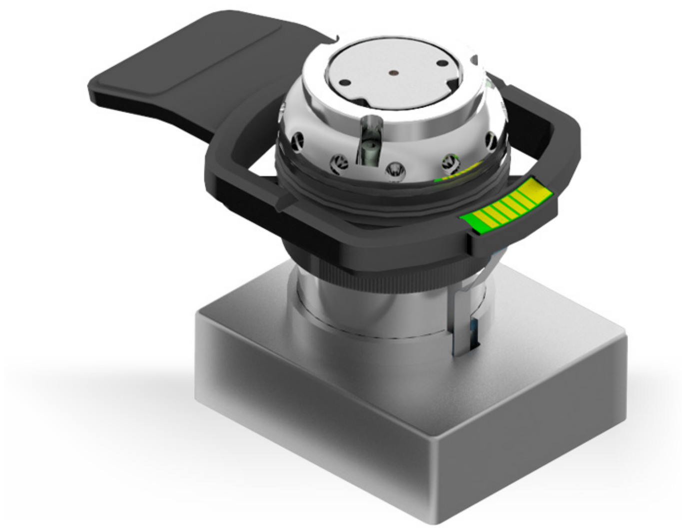


Bright-field image of a butterfly wing.

Phenom STEM Sample Holder

The Phenom STEM Sample Holder was designed for daily use and beyond.

It features an integrated STEM detector, which pre-optimizes the electronics to distinguish BF, DF, and HAADF signals from the sample. The camera length is optimized for most use cases, including life sciences. This integration makes the device a so-called smart sample holder: there are no cables attached and the interface board automatically identifies the STEM detector and will directly recognize available imaging conditions.



Phenom STEM Sample Holder

The sample mount is designed for heavy-duty work and can withstand many sample exchanges as well as many loading and unloading cycles. The STEM sample holder uses an optimized stub where the TEM grid is mounted under a clamp to guarantee sample flatness and grid protection.

Full UI integration for seamless workflows

After mounting the sample in the stub, the Phenom Desktop SEM user interface makes it possible to begin STEM imaging in less than one minute. The UI automatically recognizes the STEM detector and instantaneously enables the STEM imaging pane. After selecting your preferred imaging conditions (BF, DF, or HAADF), the detector is read out accordingly and the area of interest is imaged with the optimal signal-to-noise ratio. Like normal SEM imaging modes, accelerating voltages can be adjusted to the sample as needed.

The STEM mode is compatible with EDS detection, making elemental identification possible without adjusting the working distance.

To further optimize the user experience, all automated functions for swift imaging—like autofocus and auto contrast/brightness—are available for STEM imaging, as well. With the UI integration, switching between all four detectors (SED, BSD, EDS, and STEM) is seamless, making it possible to obtain all your data in just a few clicks.

Phenom Pharos Detector Sample Holder	
Sample mounting	Standard Ø 3 mm TEM grids
Electronics	Fully integrated, no cable connections
Imaging methods	Bright-field, dark-field, high-angle annular dark-field
Resolution	1 nm BF (10 nm Au on Cu/Al TEM grid)
EDS	Elemental identification possible
Software	Integrated Phenom UI

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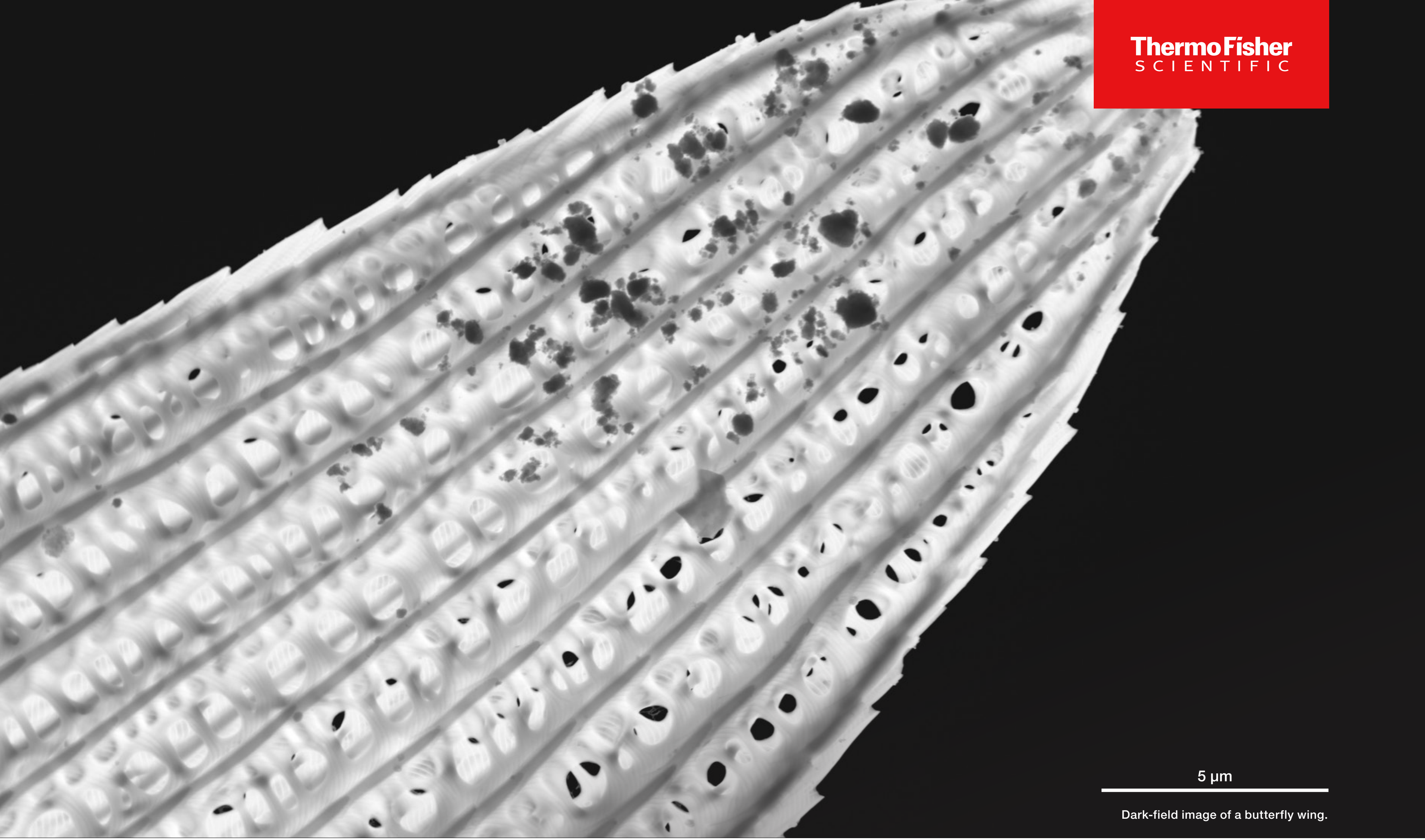

Dark-field image of a butterfly wing.

Learn more at **thermofisher.com/phenom-stemholder**