Optical Microscopy vs. Scanning Electron Microscopy: How Scanning Electron Microscopy Can Take Your Medical Device Inspections to the Next Level

Optical Microscopy and Scanning Electron Microscopy are fundamental inspection methods in the medical device industry, but there is one key difference between these methods that gives them unique benefits and capabilities. The main difference between a Scanning Electron Microscope (SEM) and an Optical Microscope (OM) is the type of beam applied to the sample. For optical microscopy, a beam of light is applied to the sample, allowing the observer to analyze the effects of light as it interacts with the sample. For scanning electron microscopy, a beam of electrons is applied to the sample, allowing the observer to analyze the effects of electrons as they interact with the sample (Figure 1).

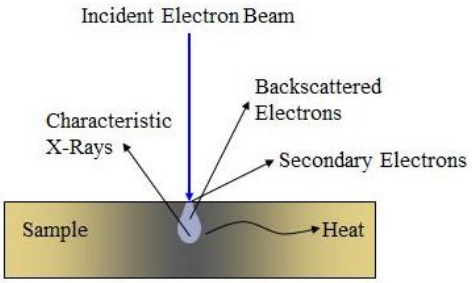

Figure 1: Electron Beam Interactions

Optical microscopy is an ideal method for general inspection purposes, but scanning electron microscopy can provide the user with incredibly detailed topographical and compositional information. A scanning electron microscope typically features three types of detectors: a Secondary Electron Detector (SED), a Back-Scattered Electron Detector (BSED), and an Energy Dispersive Spectrum Detector (EDS). The SED provides detailed topographical information to the user since secondary electrons interact primarily with the sample surface and have a large reflection angle (Figure 2). The BSED provides both basic topographical and basic compositional information to the user since back-scattered electrons penetrate further into the material and have a smaller reflection angle (Figure 3). The compositional data is relative – low-atomic-number materials appear dark and high-atomic-number materials appear light in the SEM, but the exact chemical composition cannot be provided by the BSED. The EDS provides detailed chemical compositional information (Figure 4).

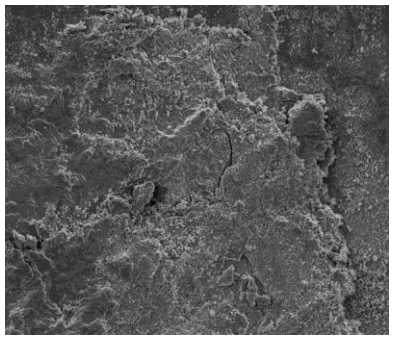

Figure 2: SED Image

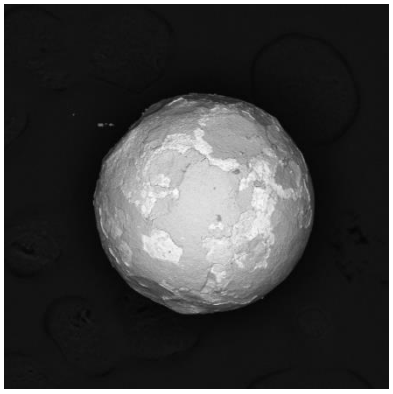

Figure 3: BSED Image

In some cases, it is beneficial to use scanning electron microscopy as a secondary inspection method. First, optical microscopy is used

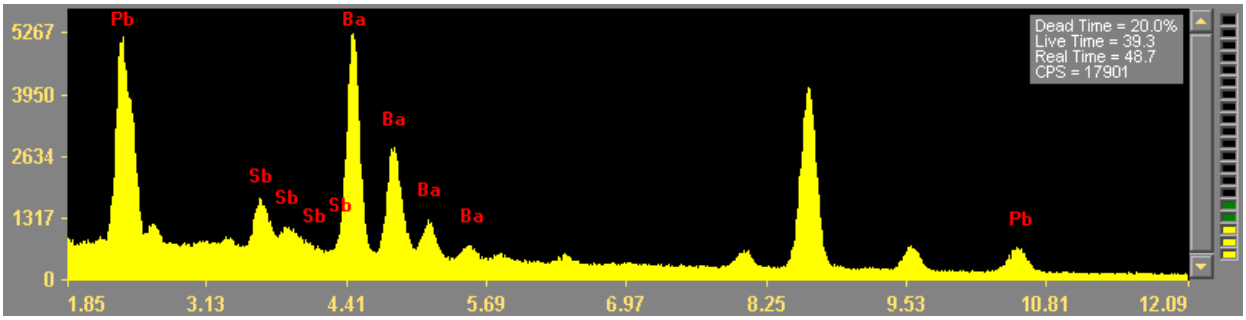

Figure 4: EDS Compositional Spectrum

to observe gross defects. The specimen can be easily maneuvered using this method, and all gross defects can be charted and documented relatively quickly for further review. Next, scanning electron microscopy is used to observe the charted gross defects in more detail and to observe micro-defects not visible with optical microscopy. This two-phase approach combines the benefits associated with each inspection method and provides the customer with a more detailed inspection in less time (as compared to an SEM-only full-surface inspection). A basic comparative summary between the two methods is provided below in Figure 5, and a visual comparison between the two methods is provided in Figures 6 and 7.

TABLE 1 Advantages and Disadvantages of Optical (Light) Microscopy

Advantages	Disadvantages
A. Lower magnification (typically <200×) speeds coarse inspection	A. Limited resolution
B. May allow inspection of stent system	B. Smaller depth of field (focus depth) as compared to SEM
C. No stent size limitations	C. Light reflections may mask features
D. Non-destructive	
E. Color differentiation (if applicable)	

TABLE 2 Advantages and Disadvantages of Scanning Electron Microscopy

Advantages	Disadvantages
A. Greater depth of field (focus depth) compared to Optical Microscopy	A. May be a destructive test
B. Higher magnification (up to 10 000× magnification) enhances view of small features	B. May require sputter coating (except for environmental SEM), precluding the use of a single test article for multi-time point inspections
	C. Slower manipulation compared to Optical Microscopy
	D. Inspection of the full length stent may not be possible within the chamber
	E. Grey scale only

Figure 5: Advantages and Disadvantages of Optical and Scanning Electron Microscopy. Tables were taken directly from ASTM F2743-11: Standard Guide for Coating Inspection and Acute Particulate Characterization of Coated Drug-Eluting Vascular Stent Systems.

Figure 6: OM Image

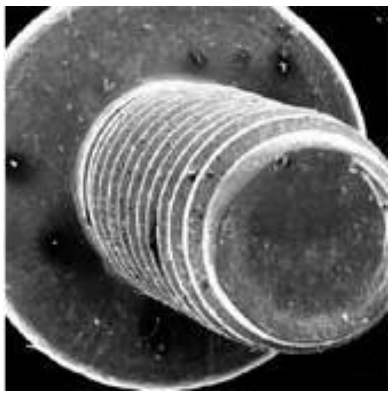

Figure 7: SEM Image

MDT has an Aspex Model 3025 SEM system with Automated Feature Analysis (AFA) Software and EDS (Energy Dispersive Spectrum) capabilities. The system is used for the inspection of defects on medical devices as well as particulate analysis studies. For the later, particulates shed from the device are captured on gold or carbon plated filters and up to 6 filters are placed in the SEM for subsequent analysis. The AFA software analyzes each filter individually and gathers a considerable amount of data on each particle. Click here for a white paper on particle inspection capabilities.

Optical Microscopy and Scanning Electron Microscopy are fundamental inspection methods in the medical device industry, and MDT offers both capabilities. Each has advantages and disadvantages, and MDT test engineers will help you determine which is most appropriate for your test needs. When combined with MDT's extensive testing knowledge, you can feel confident that the inspection data provided by MDT is the best available in the industry.