ENVIRONMENTAL SEM AND RELATED APPLICATIONS

Applications

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A key to defining the extent of the applicability of the ESEM can be found in the ability to image samples in multiple environments; from different gas compositions to different environments of sample temperature and humidity. Within these environments, many different applications have been developed. The most common is the imaging of non-conductive and beam sensitive samples using a wider range of accelerating voltages and the imaging of wet and live specimens. Other applications include dynamic imaging of solid-solid or gas-solid reactions, tensile force kinetics, as well as micro-liquid injection.
1. Introduction

With the advent of the ESEM, the field of scanning electron microscopy has been expanded beyond the conventions of the standard SEM. Many of the everyday applications adapted for the ESEM were pioneered with conventional SEMs, but were only available as complicated, one of a kind, "university" type of specialties. High temperature experiments were run on modified conventional SEMs but were limited in their range of temperature, ease of use, and duplication of technique. The development of the ESEM technology brought these one-of-a-kind capabilities out of the lab and into the main stream research. It also expanded the list of "unusual" SEM applications. This paper will describe those ESEM applications that are now considered normal. The list of ESEM applications is not limited to just these everyday/normal routines.

2. The Thermoelectric Stage

The thermoelectric stage, or Peltier effect stage, is a small sample sub-stage, which is used for moderate heating or cooling. The heart of this stage is a thermoelectric module, which acts as a small heat pump either heating or cooling depending on the current through the module. This single accessory has done more to expand the techniques in the ESEM than any other stage. While the stage has an ultimate range of -20° C to +80° C, this stage has been used primarily at temperatures around 7° C. This stems from the fact that the major use for the stage is to control the level of liquid water present in and around the sample. Figure 1 shows what bulk water looks like in the ESEM. The first detail of notice is that the electron beam does not penetrate into the water. No features are visible below the water surface. Water, even at thin layers has a strong scattering effect on the electron beam. Figure 2 shows a monolayer water film. Even at a thickness of only several angstroms, very few features are visible through the water film on the stub below. This single issue has defined the extent of the application of the ESEM to in fields of study where the information desired is covered by water and

![Figure 1. Bulk water in the ESEM.](image1)

![Figure 2. Thin water films on a Cu grid.](image2)