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# CHOOSING AN ELECTRON BACKSCATTERING SYSTEM

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Recent advances in cameras and computers have made it possible to build electron backscattering diffraction (EBSD) cameras which can give crystallographic information from specimens in the scanning electron microscope (SEM) on a routine basis. There are a few hundred such systems world wide and the number is growing fast. In the case of crystalline samples (nearly all applications of SEM outside the biomedical field), it will surely soon be considered essential to fit an SEM with an EBSD system, just as it is now considered essential to have the SEM equipped with an energy-dispersive x-ray spectroscopy (EDS) system. There are at least four commercial manufacturers of EBSD systems. In the next few years, I anticipate that many owners of existing SEMs, as well as buyers of new instruments, will be faced with the problem of selecting an EBSD system. This article presents some of the issues involved in making such a choice.

As in many technical decisions, different people will have different needs and put different priorities on the specifications to be met. An instrument which is to be used to do repeated analyses of aluminum for beer cans will have different features from a system used mostly to teach crystallography, and these in turn will be different from a system used to determine which phases are present in geological samples.

An EBSD system has two main parts. The camera and the mounting hardware associated with it and the software used to handle the data. There are different kinds of camera which can be used and some manufacturers offer a choice. There are many parameters to consider: speed, noise, resolution, sensitivity. Since the performance of cameras is changing rapidly, I would recommend not getting into a detailed study of camera types. Rather I would suggest that the buyer concentrates on setting priorities for the complete system and leave the manufacturer to provide the best match. The option of building your own system is not recommended for most people. The camera would be easy enough to build, but it would be very difficult to match the huge effort which has gone into the complex software, used to analyze and interpret the data.

The different suppliers of EBSD systems have targeted different segments of the market and their systems have different strengths – although there are signs of convergence and in the future they may all claim to do all things. In the meantime, the choice of system will be determined by deciding which factors are most important. I would suggest that, before talking to any manufacturer, the buyer spend some time thinking about the uses to which the system will be put. The aim is to get a sense of which factors will be most important in making good use of the system after installation.

Here are some of the criteria which may be relevant:

- ease of operation
- flexibility and convenience of operation
- suitability for teaching
- the time to complete an automatic analysis (how many points can be mapped per second)
- the quality of the patterns

- the accuracy and reliability of the indexing
- success at identifying and indexing unusual structures
- linking to crystallographic data bases and the automatic selection of the *hkl* sets to be used
- ease of output of images and data
- the power and subtlety of the available forms of data analysis
- system control of a motorized sample stage
- the montaging of maps
- the use of EDS data (along with the crystallographic in formation) to identify phases
- the incorporation of EDS data into the mapping

For the moment, there are two quite distinct kinds of EBSD systems: those designed to operate at high speed to make orientation maps, and those designed for the best pictures of crystallography at specific positions on the sample. You have to go for one or the other.

**Which SEM to use?**

An EBSD system would normally be considered an accessory to the SEM and it costs a good deal less than most SEMs (and we can hope that the relative cost will drop further as the technology becomes more established). However, the function of the EBSD system is such an important part of the role of the combined SEM that it is worth asking what factors should taken into account in choosing an SEM.

The things which determine the EBSD performance are

- The need to get a large current into the probe
- The need to operate at a large working distance
- The absence of contamination

And (for some users)

- Freedom from drift
- A stage to accommodate large samples and to move them large distances
- A motorized stage for automated mapping of large samples.

The ultimate spatial resolution of an EBSD analysis is generally taken to be on the order of 100 nm for normal SEM energies; therefore there is no point in making the electron probe much smaller than that. However it is important to get as much beam current as possible into a probe of that size; in EBSD one of the most critical limitations is the weakness of the signal. The requirement for a large working distance is related to the fact that the sample is steeply tilted and that access to a reasonable area of surface implies going a long way down the slope. When the objective lens is operated weakly (as it is at a large working distance), the spherical aberration becomes very large. Therefore the current into a beam of a suitable size is much reduced. (This will be the subject of a future piece in Microscopy Today). A field-emission SEM will generally out perform other instruments because it gets more current into the beam and as such systems are typically cleaner. ■

*This article is based on a paper presented at the 1999 M and M meeting in Portland (pages 250-251).*

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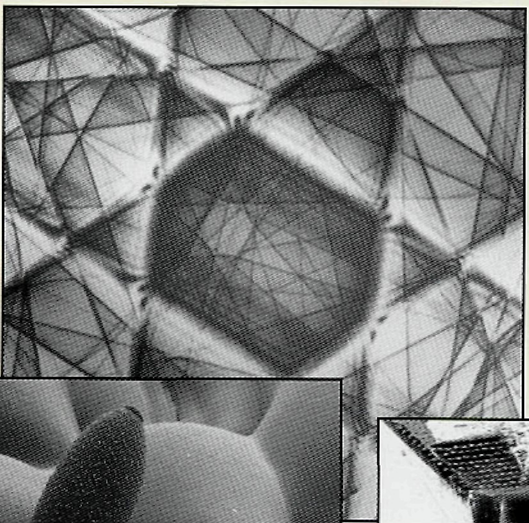
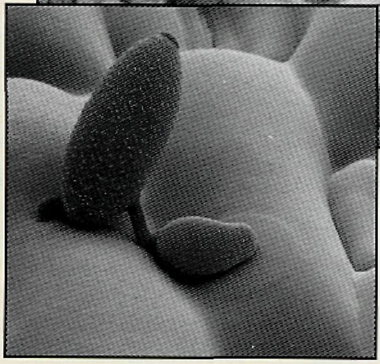
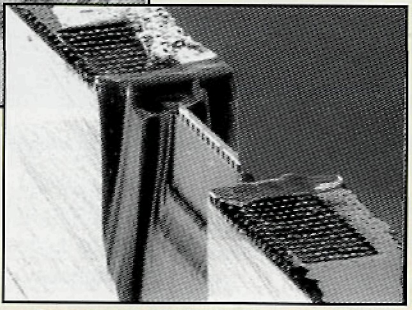




Germinating powdery mildew on a wheat leaf imaged at 5kV and -150°C in a Philips XL30 FEG-SEM (courtesy of Alison Daniels, ArgEvo UK)



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