The Scanning Electron Microscope As A Precision Instrument

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I began using scanning electron microscopes to solve problems encountered in the fabrication of x-ray diffraction gratings. Since these diffraction gratings consist of very regular lines and spaces, and produce high contrast images from the SEM, my microscopy work often points out problems with the microscope.

One time, for example, I went to the university SEM lab I often use, and was advised that the microscope was down that day due to major field problems. This lab often had problems with stray fields for reasons no one could explain. Usually I was the only one to complain about stray field distortions since they are most obvious when imaging straight lines at high magnification, but on this occasion, the problem was serious and obvious to all.

The microscope had just been serviced and as the lens coils had been replaced, they were expected to be the cause. The service technician was called in and determined that neither the coils nor the microscope electronics were the problem. After the microscope was down for two weeks, the students, professors and myself were very concerned.

A gaussmeter was brought in to measure the ambient magnetic fields in the room and hopefully identify the source of the annoying field which had shut the lab down. At the microscope, the magnetic field was about 10 times the recommended maximum. Closer to the east wall, the field became stronger. The conclusion was that the stray field was coming from behind the wall - and from underground!

After further evaluation it was determined that the building water-main was the culprit as it was carrying 1.5 amps of current. To determine the cause of the current, various pieces of equipment were turned off, all with no effect. The building power was shut off, still with no effect. The power line transformer was disconnected, yet still with no effect.

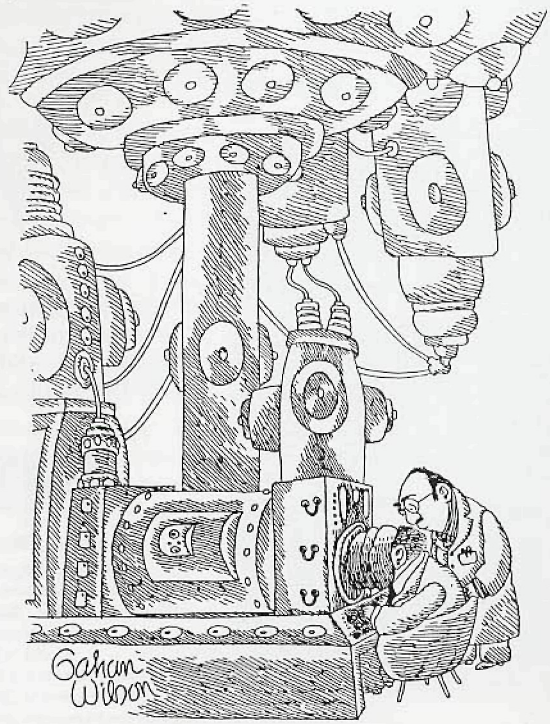
The problem was finally found! In designing the EM lab, great care was taken to establish a very good ground plane to ensure low noise. In fact, it was a much better ground than the power company's ground in the community. The EM lab ground was so good that it pulled 1.5 amps of current down the water pipe from outside the building.

While strange problems like large currents on a water pipe don't happen to everyone, very few microscopists live in a building completely under their control. Someone can install a new, power-hungry device upstairs or down the hall, and suddenly cause all kinds of nasty ambient magnetic fields. In such situations, being able to determine when a problem first appeared and link it in time to any facility modifications can be invaluable in solving the problem.

A routine performance check of the microscope is the best way to identify problems before they become severe. This routine check need involve nothing more than a high magnification image of a regular pattern of lines and spaces or a grid. In the case of current on the water main, an image of a regular pattern of lines and spaces would have shown obvious distortions. The lines would be wavy and anything but straight. For other common image distortions, such as "pincushion distortion," the lines would be bowed iward or outward or progressively lean to one side or the other.

A proper calibration specimen needs to cover a wide magnification range because effects that are negligible at 10,000X can be quite severe at 50,000X. It also needs to be rectilinear. Imaging microspheres or other shapes do not expose imaging distortions and problems in the same way that looking at a field of regular lines or a uniform grid can.

A routine performance check, using a regular pattern like that provided by the MOXTEK calibration specimens, could have eliminated the long and costly shutdown caused by the water pipe current. Remember that magnetic field distortions in the SEM are proportional to the strength of the ambient field. Since the current flowing down the water pipe had been increasing for some time, images taken weekly with such a calibration specimen would have shown that there were increasing magnetic field problems. By recording an image or two each week and keeping them in a log book, it would have been obvious that the level of distortion was increasing. This knowledge would have saved at least two weeks lost to chasing the wrong problem, as the symptoms did not fit many of the potential causes. Also, with this information, the cause could have been investigated, appropriate maintenance and testing scheduled in advance, and the problem resolved without shutting down the laboratory unexpectedly for an extended period. ■



"I think I may have spotted something"

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