DOI: 10.1017/S143192760550103X
Microsc Microanal 11(Suppl 2), 2005

SEMXM – Past, Present, and Future

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I have had the privilege of participating in the development and use of the scanning electron microscope (SEM) and electron probe micro-analyzer (EPMA) over the past 40 years. The use of these instruments has expanded from the research laboratory to every type of science, engineering, and technology laboratory. The SEM is now so heavily used that it is similar to the optical microscope in its popularity.

At Lehigh University, we recognized the need to educate researchers and users of the SEM and EPMA in the fundamentals of scanning electron microscopy and the application of these fundamentals to solving microscopy problems across many disciplines. Lehigh SEM short courses have been given for some 35 years, educating almost 5,000 students. These students have been very fortunate to have had instructors in these courses such as Dale Newbury, David Joy, Charles Lyman, Eric Lifshin, David Williams, and Patrick Echlin. The course instructors have published 4 SEMXM text books, Fig. 1, over 3 decades and almost 50,000 copies have been purchased.

There have been significant advances in the field of scanning electron microscopy and x-ray microanalysis (SEMXM) over the last 10 years. The development of a stable field emission gun has made high resolution scanning on the nm scale possible. The variable pressure – environmental SEM has given us the ability to look at wet samples or samples subjected to various atmospheres. Stable low voltage operation at less than 5 keV has enabled one to minimize charging, to improve x-ray resolution and to optimize the observation of surfaces. Digital composition mapping with wavelength and/or energy dispersive x-ray detectors has allowed microscopists to obtain compositional maps of specimens, storing huge amounts of data for further processing. For many, the biggest advance in compositional mapping is the ability to compliment optical microscopy information, see Fig. 2. New Monte Carlo techniques have enhanced our abilities to obtain quantitative chemical data on complex samples and new x-ray detectors are beginning to allow larger x-ray throughput. The development of the focused ion beam (FIB) instrument has helped investigators optimize specimen preparation for the SEM. For example, specific regions of interest such as precipitates, interfaces and surfaces can be cross sectioned for optimum observation. Finally the development of the electron backscatter diffraction (EBSD) technique for the SEM has finally allowed investigators to obtain crystallographic information about a sample that can be viewed in the SEM. With this technique, crystallographic information with about a 0.1 um resolution can be obtained along with maps of crystallographic regions of similar orientation, see Fig 3. The crystallography of unidentified precipitates and specific regions of interest can be determined. Combining such data with chemical and microscopic information leads to a much more complete analysis of the sample of interest.

With all these recent advances, can we expect more advances in SEMXM in the future? Although I have never been particularly good at predicting the future, I believe that we will see the SEM used in even more application areas. The continued development of automation will allow even more effective use of the instrumentation although users will probably understand less about the basic operation and sophistication of the instrumentation. Certainly the development of new x-ray detectors will continue and the techniques for manipulation of very large amounts of x-ray data will improve. The development of aberration free electron microscopes will have an impact of the

SEM allowing for higher currents and better spatial resolution. The EBSD technique will continue to advance and there will be an increased amount of shared or virtual operation of SEM instrumentation as the price and sophistication of high end instruments increases. I see no end in sight for the need to educate SEMXM users and I expect that the Lehigh course and other complimentary courses will continue for some time. The SEM and EPMA have allowed for dramatic breakthroughs in many fields and I am confident that this trend will continue for some time.

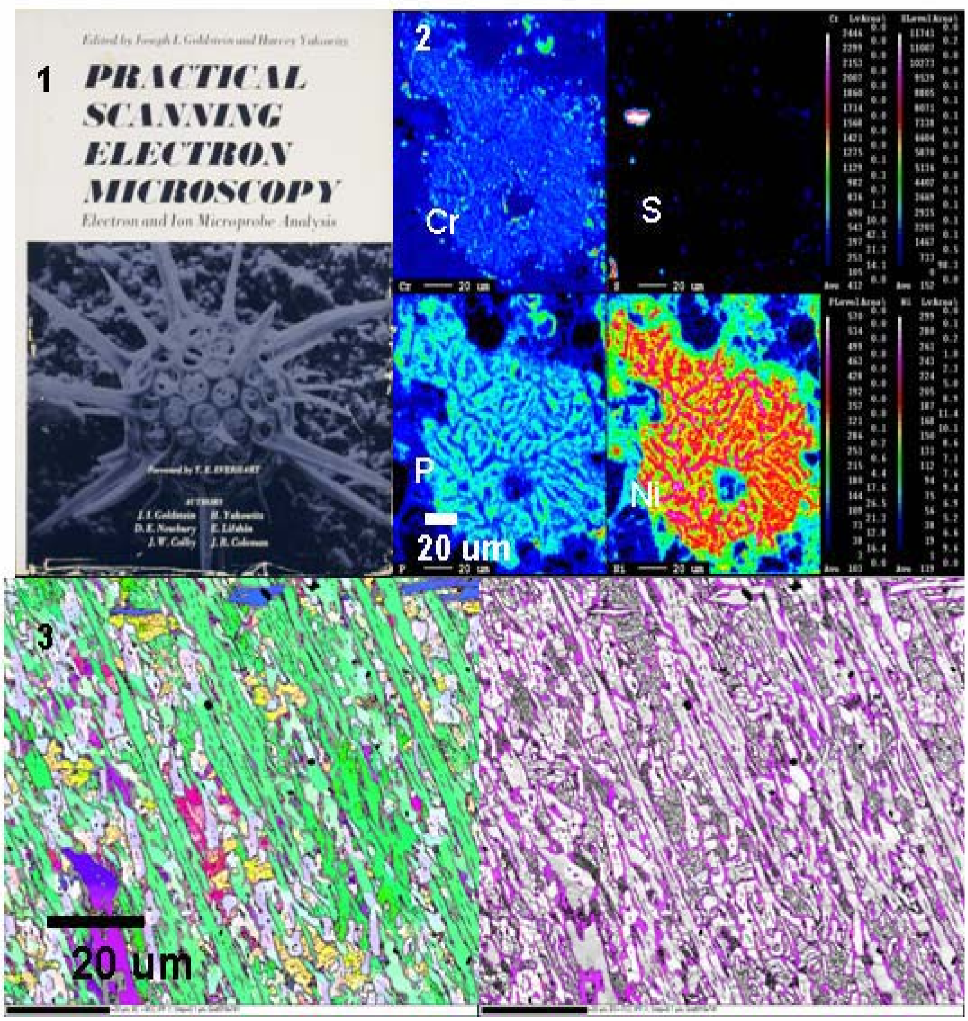
References

[1] Financial support from NASA through grant NAG5-11778 and previous NASA grants for over 30 years is acknowledged and is much appreciated.

Figure 1. Cover of PSEM, the first text book produced by the instructors of the Lehigh Short Course

Figure 2. Digital composition map of the Ni, P, Cr and S distribution in metal particle A1 in the Acfer CH chondrite. Research in cooperation with Dr. Rhian Jones, Univ. New Mexico.

Figure 3. Distribution of bcc (left) and fcc (right) phases in the Cape of Good Hope IVB iron meteorite as determined by EBSD. Scanning steps of 0.1um were obtained. Research in cooperation with Dr. Joe Michael, Sandia Corp.



https://doi.org/10.1017/S143192760550103X Published online by Cambridge University Press