Preface

Electron microscopy has long been the de facto standard for materials scientists to obtain structural information that now approaches the atomic scale. Scanning electron microscopy and transmission electron microscopy, along with the many peripherals now available, provide information about three-dimensional structure, particle size and morphology, layer thickness, as well as elemental, chemical, and magnetic information, to name just a few characteristics. Traditionally, electron microscopy has been performed in high vacuum or even ultrahigh vacuum, in order to prevent sample contamination, preserve the performance of the electron source, and maintain coherence of the electron wave. However, for several applications, observing samples under vacuum conditions is far from a realistic scenario when one considers the actual working environment of the material under study.

To remedy this situation, the controlled atmosphere microscope was conceived. Using various adaptations either to the sample holder or to the microscope, a certain volume of gas can be maintained around the sample without compromising the microscope itself. Such adaptations were suggested previously by Ernst Ruska, the inventor of the transmission electron microscope in the 1940s. Since then, several experimentalists have modified electron microscopes to allow for gas entry.

Over the last three decades, the technique has become much more mainstream and instruments are now commercially available. Inspired by the developments of Boyes and Gai, the concept of differentially pumped electron microscopes now allows samples to be exposed to a gaseous atmosphere of the order of 1000 Pa. The concept has now made its way to the newer microscopy platforms and high-end microscopes.

There are many scientific challenges that can be addressed by electron microscopy. Among these are the structure and stability of two-dimensional materials such as graphene, which has been suggested as a future candidate to replace silicon for semiconductor devices when properly structured, the active state of catalytically active materials, or the structure of semiconducting devices with electrical bias applied in a gaseous environment. In order to move forward in the understanding of the working state of these materials, a multitude of complementary characterization techniques should be applied.

This text is aimed at graduate students, but the experienced microscopist should also find it to be a valuable reference book. The book describes the development and construction of the environmental transmission electron microscope, or ETEM for short, as well as the peripherals such as cameras and detectors that allow for the thorough and exhaustive characterization of a sample. It is supplemented by several example chapters highlighting the use of the technique for different scientific cases.

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