FIB Systems As TEM Specimen Preparation Tools for III-V Compound Semiconductor Materials

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Abstract

As dimensions of semiconductor devices shrink down to the sub-micron regime, and their structural complexity increases, characterization and failure analysis of such small devices has become increasingly difficult. Although a transmission electron microscope (TEM) is the only tool to effectively characterize and/or troubleshoot such sub-micron devices, it has not been fully utilized as a routine diagnostic tool in the semiconductor industry, primarily because of its slow delivery of analytical results. The slow analysis time actually originates from time-consuming steps involved in preparing site-specific TEM specimens. A TEM examination of an already-thinned specimen is relatively quicker, compared to the time spent preparing the specimen. The conventional mechanical polishing/ion milling method, which relies on the resolution of an optical microscope, is no longer feasible in making site-specific TEM specimens for sub-micron devices in a timely fashion. An improvement in the specimen preparation technique, therefore, has been a major challenge for TEM analysis for many years.

Recently, focused ion-beam (FIB) systems have emerged as a powerful tool for making TEM specimens. The most attractive feature of the FIB technique is its ability to cut a TEM specimen accurately at any user-defined site in a short time. Many of the semiconductor companies have successfully introduced FIB systems as dedicated specimen preparation tools for TEM analysis in recent years. In the meantime, analytical capabilities of a TEM instrument have advanced steadily to meet today's stringent requirements demanded by the semiconductor industry. FIB systems have indeed generated numerous useful TEM specimens, which have helped solve problems associated with IC and optoelectronic devices.

This paper presents a brief overview of TEM specimen preparation methods for semiconductor materials. We first describe how a FIB system is used to prepare TEM specimens, and then discuss advantages/disadvantages of TEM specimens prepared by this technique. Finally, we will present several specific examples of TEM work on III-V compound semiconductor devices.