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Possible Approaches for Combined Use of Xenon and Gallium Ion Sources for Task Specific Focused Ion Beam Sample Preparation

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Gallium (Ga) is the most commonly used liquid metal ion source (LMIS) for commercial focused ion beam (FIB) instruments, and in terms of scanning electron microscopy (SEM), is also the most commonly used ion column in platform instruments called “dual-beams” (FIB-SEM) [1]. Although there are a few reasons why it is advantageous to use this type of source, e.g., Ga low melting point, long source life, high angular intensity with a small energy spread, etc., there are also disadvantages, which FIB users should avoid. One of those problems, often present in transmission electron microscopy (TEM) sample preparation (FIB-SEM prepared TEM lamellae), is implantation of Ga ions in the specimen [2]. A few years ago, “dual-beams” with plasma source focused ion beam (PFIB-SEM) were introduced, preferably using noble gas Xenon (Xe) ions. Here, we would like to demonstrate various possible approaches for combined use of these powerful platform instruments.

In our laboratory, we have two main approaches for TEM lamellae preparation using a combination of both, Ga and Xe FIB-SEM instruments, according to the task specification. In the cases TEM lamellae preparation needs to be done exclusively in a specific “dual-beam” instrument, we can choose whether to start with Ga or Xe FIB-SEM first, as shown later.

The first approach in our laboratory is for cases where we know that Ga ions will not affect TEM lamellae, i.e., prohibit TEM observations and analyses. In this case we take advantage of high Xe ion beam currents, which enables removal of large volumes of material in a relatively short time. It is a great benefit that puts us in a position of not just “blindly”, or with a limited information, choosing the region of interest (ROI) for lamella production. This gives us a powerful tool revealing what is under the surface and then choosing the optimum ROI for the task. We can always support this search by additional analyses of the large cross-section, such as electron backscatter diffraction (EBSD), energy dispersive spectroscopy (EDS), etc. We also use this approach not only in the search of the optimum ROI, but also for statistics where removing large volume of material provides us with the possibility of producing more lamellae in specific axis, depths or any other way required.

However, there are more and more cases where Ga ions penetrating the specimen are a serious problem for TEM analyses, but even in this case you are not limited to PFIB-SEM. If the position and size of the lamella is not unusual, for many materials, it is still acceptable to start with Ga ions, prearrange TEM lamella (thickness depends on the material, but several microns are usually enough), perform the lift-out, attach the lamella to the holder and transfer it to PFIB-SEM. Here you can finish the lamella with low ion beam currents and therefore remove the layer with implemented Ga ions. From our experience this is rather a quick way of preparing Ga-free TEM lamella using a combination of Xe and Ga ion sources.

Today there are institutes and facilities with access to both types of instruments. Here, we want to show how to take advantage of this asset to help other users to improve and save time during sample preparation [3].

References:

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