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Ease of Use Solution for Fast and Automated TEM-Lamella Preparation.

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The main application for Focused Ion Beam (FIB) microscopes still is to gain information from regions underneath the sample surface. To access these regions it is sometimes sufficient to mill a trench and image the cross-section surface. But in other cases more sophisticated investigations in terms of resolution or chemical analysis are needed. Then it is necessary to extract a piece of the material for analysis in a TEM (Transmission Electron Microscope), STEM (Scanning Transmission Electron Microscope) or a SEM (Scanning Electron Microscope) with STEM detector [1].

The preparation of such a so called TEM lamella can be time consuming since wide trenches have to be milled into the sample material to the complete target depth. The closer the beam gets towards the lamella surface the smaller FIB currents have to be used to avoid amorphization, which elongates the overall milling time. Additional steps like the deposition of a protection layer or the milling of a cut-out add time as well. An operator performing the workflow by hand would waste a lot of valuable working time watching the microscope and waiting for one step to finish before executing the next. This can be avoided by using intelligent software, that once set up executes all necessary steps automatically.

With its last generation of Crossbeam microscopes Zeiss introduced SmartFIB, a new software for FIB control. Besides all kinds of conventional shape milling, SmartFIB also comes with easy to use, workflow oriented wizards for cross-section and TEM lamella preparation. User interaction is only needed during parameter setup and choosing regions of interest. The actual milling is carried out afterwards in a row and unattended. This allows over night or weekend runs, providing the operator with a bunch of prepared samples to continue working on.

The new TEM lamella wizard of SmartFIB consists of four main steps that are fully customizable to fit actual needs. The first step is defining the region of interest and dimensions of the TEM lamella. Secondly, the deposition of a protection layer by using a fitted Gas Injection System (GIS) can be set up. Thickness, margins and deposition material can be chosen. The third step is milling of the trenches. These can be divided into several milling steps, like coarse, medium and fine milling. Each of these millings steps is definable with respect to FIB current, proximity and overlap. Additionally the operator can decide if the milling shall take place in loops which drastically reduces redeposition of sputtered material. It is also possible to define an additional stage tilt to assure plane parallel milling at the surface of the lamella. The last main step is the cut-out. It can be configured regarding its dimensions and shape. Links can be set to remain on both sides or just one, providing compatibility for the lift-out with any micro manipulator configuration.

The complete lamella configuration can be saved and imported again for another session. This drastically speeds up the setup. The milling can be started right away or transferred to a process list together with further milling jobs. These can be spread all over not only the current sample but all samples mounted on the microscope stage at that time. There are no restrictions regarding sample height or orientation. During the milling an advanced drift correction algorithm assures that the chosen regions of interest are relocated and that the lamella stays within the field of view during necessary stage tilting.

Figure 1 shows a screenshot of SmartFIB illustrating the variety of options in the TEM lamella wizard to fit every need. The setup of such a lamella does not take longer than three minutes and can be even sped up by using previously exported layouts and parameters. The milling of a corresponding lamella can take between 10 and 60 minutes, depending on the chosen parameters and sample material. During this time no user interaction is necessary. Afterwards the TEM lamella is ready for lift-out and further polishing as illustrated in Figure 2. The polishing can be supported by live thickness measurements based on electron backscatter contrast to assure precise polishing including end-point detection at a chosen lamella thickness [2].

We illustrated the capabilities of the new SmartFIB software by Zeiss. It allows fast setup of multiple milling sites through an easy to use but powerful wizard. All layouts can be added to a process list which is processed automatically without the need of user interactions including GIS operations and stage tilting. SmartFIB is available for the new Crossbeam 540 and Crossbeam 340 microscopes.

References:

[1] LA Giannuzzi and FA Stevie, Micron **30** (1999), p. 197
[2] R Salzer and L Lechner, Microscopy and Microanalysis **18** (2012), p. 654.

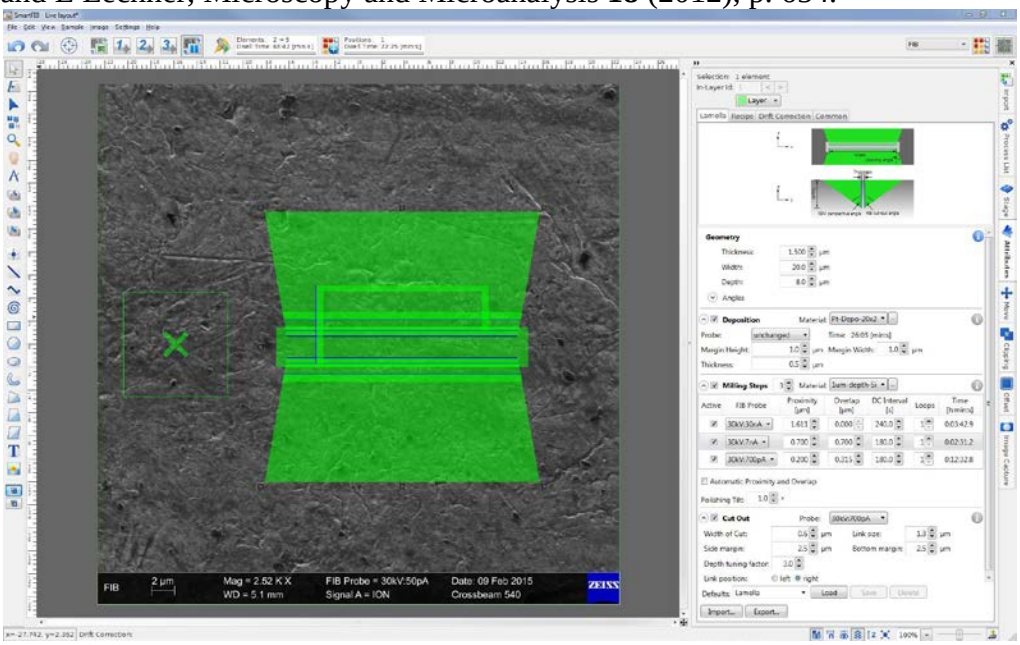

Figure 1. Screenshot of SmartFIB showing the TEM lamella wizard.

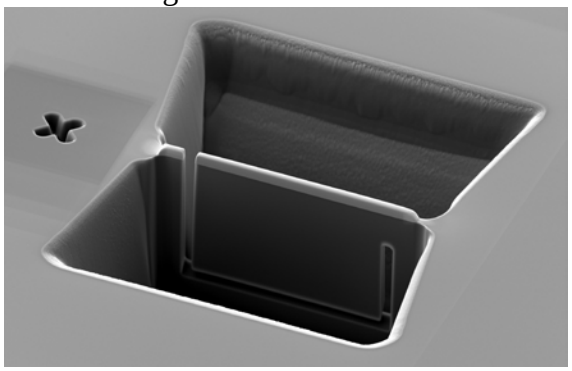

Figure 2. Exemplary result of a single TEM lamella milled by SmartFIB in silicon.