304
doi:10.1017/S1431927617002203

Microsc. Microanal. 23 (Suppl 1), 2017

Towards Automatic Lamella Thinning Using Live Thickness Measurements and Smart End-Point Detection

Tobias Volkenandt[1], Fabián Pérez-Willard[1], Michael Rauscher[1], Pascal Maria Anger[2]

[1.] Carl Zeiss Microscopy GmbH, Carl-Zeiss Str. 22, 73447 Oberkochen, Germany
[2.] Carl Zeiss Microscopy, LLC, One Zeiss Drive, Thornwood, NY 10594, United States

One of the most important applications of a focused ion beam scanning electron microscope (FIB-SEM) is the preparation of electron transparent lamellae for further analysis in (scanning) transmission electron microscopes ((S)TEM). The imaging capabilities of these instruments are constantly improving and thus make even higher demands on the lamella quality. Especially with regard to the lamella thickness. Often TEM lamellae need to be prepared that are not thicker than a few tens of nanometers. On the other hand, there is almost no technical solution available to measure the lamella thickness during the preparation so that the result strongly depends on the operator's experience. The amount of manual interaction that is needed hinders the automatization of the thinning process and thereby limits the reproducibility.

In this contribution, we present a solution that allows measuring the lamella thickness based on the backscattered electron (BSE) signal, also live during the lamella thinning process. The solution is integrated in the software controlling the FIB-SEM and thereby allows automated stopping of the thinning process when a predefined target thickness is reached (end-point detection).

The thickness measurement bases on the BSE signal intensity. The BSE contrast depends among other parameters on the maximal depth inside the sample from which electrons can still escape. A bulk sample with a thickness larger than this maximum backscatter depth (MBD) yields the strongest BSE signal. Samples thinner than the MBD produce weaker BSE signals because an increasing fraction of the electrons will traverse the sample and not be detected as BSE. This thickness dependent BSE contrast changes of course with the sample material but also with the primary electron energy. By means of Monte Carlo simulation, it was possible to derive a global normalized BSE transmission function (GNTF) for all elements in the periodic table.

The GNTF database has been integrated in the microscope control software. After selection of the current sample material and scaling of the minimum (background without sample material) and maximum (sample region thicker than MBD) grey levels, this allows to calculate the sample thickness from the grey value in each pixel of the image. The resulting thickness values can be displayed as a color-coded thickness map overlay, as shown in Figure 1, on the example of a partly thinned silicon TEM lamella.

Since the BSE signal is not affected by FIB induced secondary electrons, it is possible to observe the thickness map also live during the lamella polishing. This provides direct feedback about the polishing process and precise control of the lamella thinning. Further, the BSE signal can be used for end-point detection and thereby automatic thinning of the lamella is possible. Here, the software is constantly checking the measured average thickness in a chosen reference area and automatically stops the polishing process when a previously defined thickness limit is reached. The two windows marked in Figure 1 have been thinned in this way with target thicknesses of 100 and 50 nm respectively.

Figure 2 shows a top view SE image of the same lamella as in Figure 1. The thickness of the thinned windows can be measured directly. It has been determined as 99 and 54 nm respectively, which is in good agreement with the values determined using the BSE signal detection method during the polishing. The overall accuracy of the presented solution is estimated to be better than 20%, which is comparable to other methods for lamella thickness determination. However, the presented solution has the advantage that it can be used live during the FIB polishing process, providing direct feedback and facilitating reproducible results.

References:

[1] R Salzer *et al*, Microsc Micronal **15(Suppl 2)** (2009), p. 340.

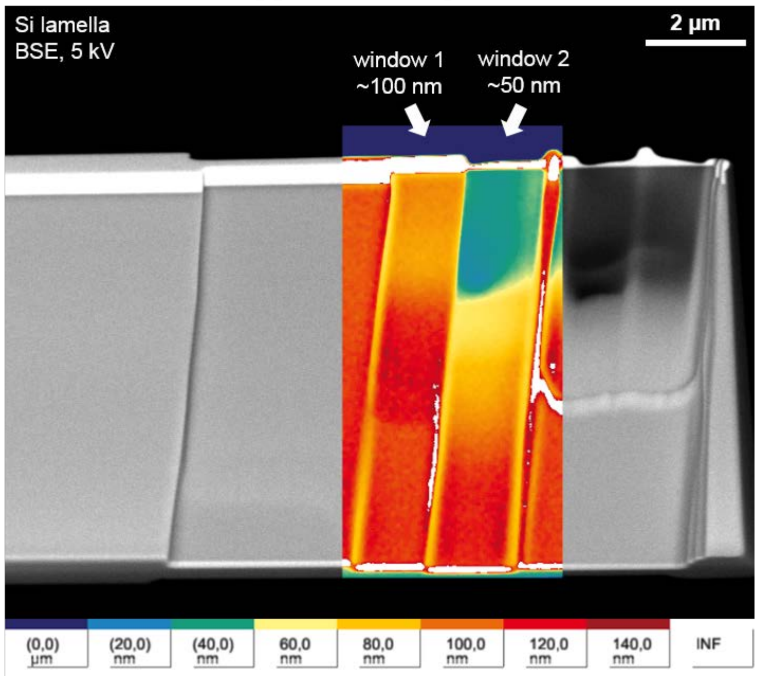

Figure 1. 5 kV BSE side view image of a silicon lamella with color-coded thickness map overlay. The windows have been thinned with automatic end-point detection. For window 1 (left, orange) the target thickness was 100 nm, for window 2 (right, blue/green) 50 nm.

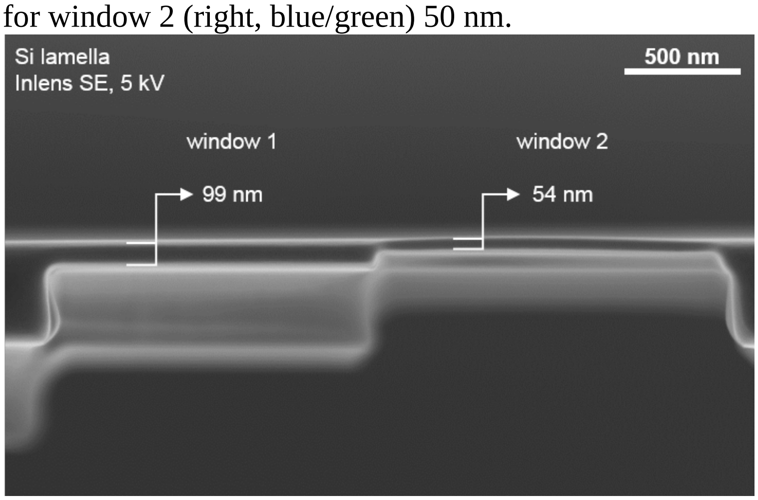

Figure 2. 5 kV Inlens SE top view image of the same silicon lamella as in Figure 1. The thicknesses of windows 1 and 2 were measured as 99 and 54 nm, respectively.

https://doi.org/10.1017/S1431927617002203 Published online by Cambridge University Press