A requirement for every TEM investigation is the preparation of electron transparent samples. TEM preparation by focused ion beams (FIB) is nowadays widely used to produce site specific sections from the region of interest. Various approaches for TEM sample preparation using FIB have been developed. The most flexible are lift-out techniques where a lamella is directly made from the original sample, transferred to a support grid and finally thinned to electron transparency.

In this paper, we demonstrate an improved workflow for TEM sample preparation by FIB for extremely thin and distortion-free lamellas. By using a special TEM grid with clamps and an active griper for sample transfer the welding and cutting procedure necessary for the standard lift out technique (Fig. 1 left) can be avoided [1]. An additional advantage is the fixation of the TEM lamella on both sides, thus reducing the bending of the lamella in the final stages of the thinning. The special design of the holder allows preparing the sample from different directions without damaging the clamps. A TEM grid holder construction with an additional rotation axis perpendicular to the sidewalls of the TEM lamella is presented where the angle of incidence can be varied independently for the front and the backside (Fig. 1 right). The result of this kind of preparation is an electron transparent window inside a mechanically stable bar of the specimen (Fig. 2). The transparent window has a trapezium shape with adjustable angles between 0 and 90 degrees. A possible variation of the angles can be used to control and reduce curtaining effects often appearing in structured multi-material systems. To control the residual thickness of the lamella inside the window, thickness measurements are performed during thinning by electron backscatter imaging using a cross beam instrument (NVision, Zeiss). Thus, the plan parallel shape and the thickness of the sample can be controlled during the final milling to reach a well-defined homogeneous lamella thickness [2]. TEM investigations of the samples prove the reduction of curtaining and wrapping in the ultra-thin transparent window (Fig. 3).

The workflow was successfully applied to different material systems which are discussed in the present contribution. The efficiency of the process and the high quality of the TEM samples are shown.

References:
Fig. 1: Left: SEM image of the lamella transfer into the special clamp holder by active gripper. Right: Sample holder mounted on a Kleindiek RotTip to realize a second tilt axis.

Fig. 2: Left: Color coded thickness map of a semiconductor sample. Right: TEM overview of the sample. Curtaining is hardly visible.

Fig. 3: Left: Bright field image of the grain structure of a Tungsten plug. Right: HRTEM image of the silicon SiO\textsubscript{2} interface in ultrathin area of the lamella (Thickness less than 40nm).