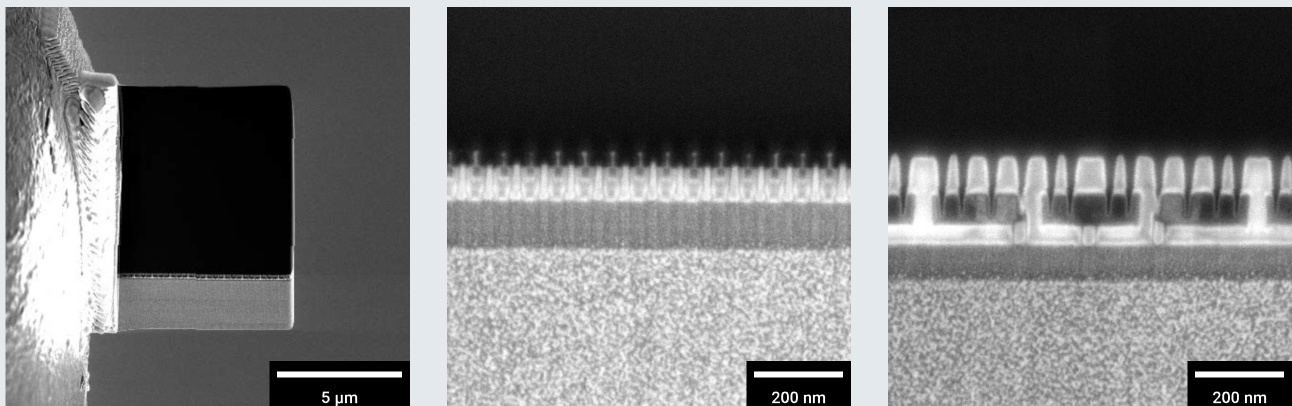
Ga FIB TEM sample preparation from a 10 nm FinFET device

Failure analysis of semiconductor devices typically involves TEM inspection which requires routine TEM sample preparation in FIB-SEM machines. Such TEM samples should be site-specific with thicknesses comparable to the technology node of the inspected device. This imposes high requirements to a FIB-SEM machine in terms of performance and capabilities of the both columns: ion column for precise milling, and electron column for precise end-pointing.

TEM sample preparation from semiconductor devices in FIB-SEM machines can be performed by using two main methods. One is TEM sample preparation fully in trench for ex-situ pick up – a technique that is preferred to quickly transfer the prepared lamella to the TEM grid while saving FIB-SEM time. The other method is in-situ TEM sample lift out from the trench and transfer by means of a nanomanipulator to a TEM grid for final thinning – a method that not only helps highly preventing sample contamination that can potentially occur during ex-situ sample manipulation but also thinner TEM specimens with higher quality can be prepared. This application note describes in situ preparation technique.



▲ **Fig. 1:** Inverted TEM sample during thining (left). Detailed SEM 2 keV In-Beam SE of the Gate-cut (centre), and Fin-cut (right).

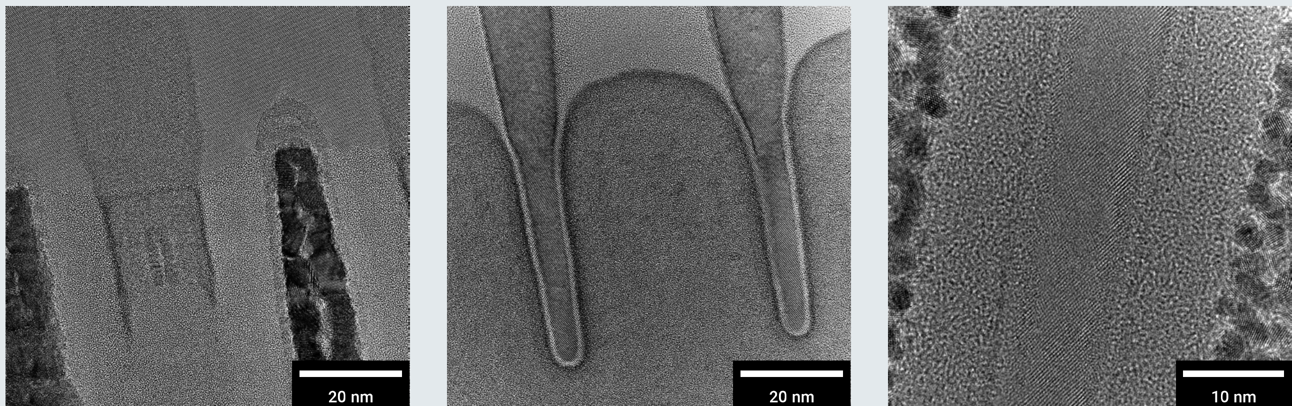
Procedure Details and Results

In order to demonstrate an example of TEM sample preparation we used the latest commercially available chip based on 10 nm FinFET devices. TEM sample preparation was performed in the TESCAN SOLARIS FIB-SEM machine fitted with the Triglav™ SEM column and Orage™ FIB column, both of which with excellent performance in the low keV regime – crucial requirements for succesful high-quality TEM speciemens preparation. The FIB-SEM platform was equipped with an Oxford OP400 nanomanipulator with probe rotation function.

The TEM samples from a 10 nm chip were prepared to inspect two main cross-sections: gate-cut and fin-cut. The sample preparation routine contained standard steps of Pt protection layer deposition, trench milling and undercut. The samples were then extracted, transferred and attached to a TEM grid by the nanomanipulator. This step involved probe rotation, which allowed obtaining TEM samples for inverted polishing geometry.

The TEM samples were thinned at the site-specific locations. The final FIB cleaning step was performed at 1 keV. During the entire thinning process the end-pointing was implemented by SEM monitoring at 2 kV with the In-Beam SE detector (Fig. 1).

The obtained samples were inspected in a TEM. We also prepared a cross TEM sample from the gate-cut to confirm its original thikness which was found to be of less than 10 nm (Fig. 2).



▲ **Fig. 2:** TEM analysis of the gate-cut sample (left), fin-cut sample (centre) and cross TEM sample (right) prepared from the gate-cut to confirm the thickness of the original sample

Conclusions

In this application example, we have demonstrated the capabilities of the TESCAN SOLARIS FIB-SEM machine for routine TEM sample preparation from a 10 nm FinFET device.

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