APPLICATION NOTE

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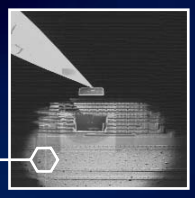


Optimized Sample Transportation

In-situ semiconductor sample lift-out, loadlock and transfer between systems for additional analysis

Fast and easy lift-out and moving of wafer samples

Proper sample preparation and flow is critical in most—if not all—analytical techniques. To assist with the flow of TEM samples from a full wafer to the TEM, FEI offers the NanoLift™ option, an *in-situ* sample lift-out, load-lock, and transport mechanism used for transferring cartridges containing multiple samples.

Introduction

While inspecting defects on wafers in a DualBeam™ further in-depth analysis is occasionally needed on remote Transmission Electron Microscopy (TEM) or Scanning Transmission Electron Microscopy (STEM) systems. Previously, creating thinned TEM samples required either destruction of the wafer or at the very least, scrapping of the wafer to the failure analysis lab. Samples were often damaged by inexperienced lift-out operation. This process then would slow the throughput of the product development and production.

As semiconductor devices continue their march to smaller and smaller dimensions, and new materials are introduced to the semiconductor process, the need for atomic resolution in imaging and chemical analysis continues to expand. All roadmaps are pointing towards more and more (S)TEM imaging.

Problem

In order to meet the need for higher throughput and increased sampling, a system is needed to create a thin sample from a wafer, while allowing the rest of the wafer to continue in-line. An easy-to-use, reliable sample removal method as well as a secure, controlled transport methodology would protect the newly created sample.

Solution

FEI's NanoLift, as part of FEI's UltraView™ solution, enables creation of high resolution TEM samples and provides a transport mechanism to other tools in the lab. Using FEI's intuitive system, a sample is created from a wafer, and transferred to a grid, unloaded from the wafer tool, transported to a smaller system for thinning then transported on to a high resolution system for analysis.

Process: Full Wafer Tool

On the wafer tool, the system will:

- Navigate to a featured region of interest
- Cut a prism-shaped chunk by a completely script-controlled process
- Attach the chunk to a lift-out needle and remove it from the substrate
- Transport the chunk within the tool to the transport grid

Up to six samples will fit on the grid. Since there is no limit to the substrate material, the wafer can proceed with the process fabrication. The process allows the user to control all aspect on the samples including removal location, size and sample orientation.

The sample grid is then transferred to a vacuum sealed capsule. The capsule is removed from the wafer tool, without breaking the vacuum or damaging the sample. The sample, if needed, will be transported to a small stage DualBeam system for additional thinning.

Process: Small Stage DualBeam

On FEI's small DualBeam system, the sample is:

- Transported from the capsule to a patented FlipStage™ on the Strata 400 STEM
- Thinned in an open area, minimizing the redeposition of sputtered materials
- Imaged by a detector that captures images providing sub-nanometer information on the sample

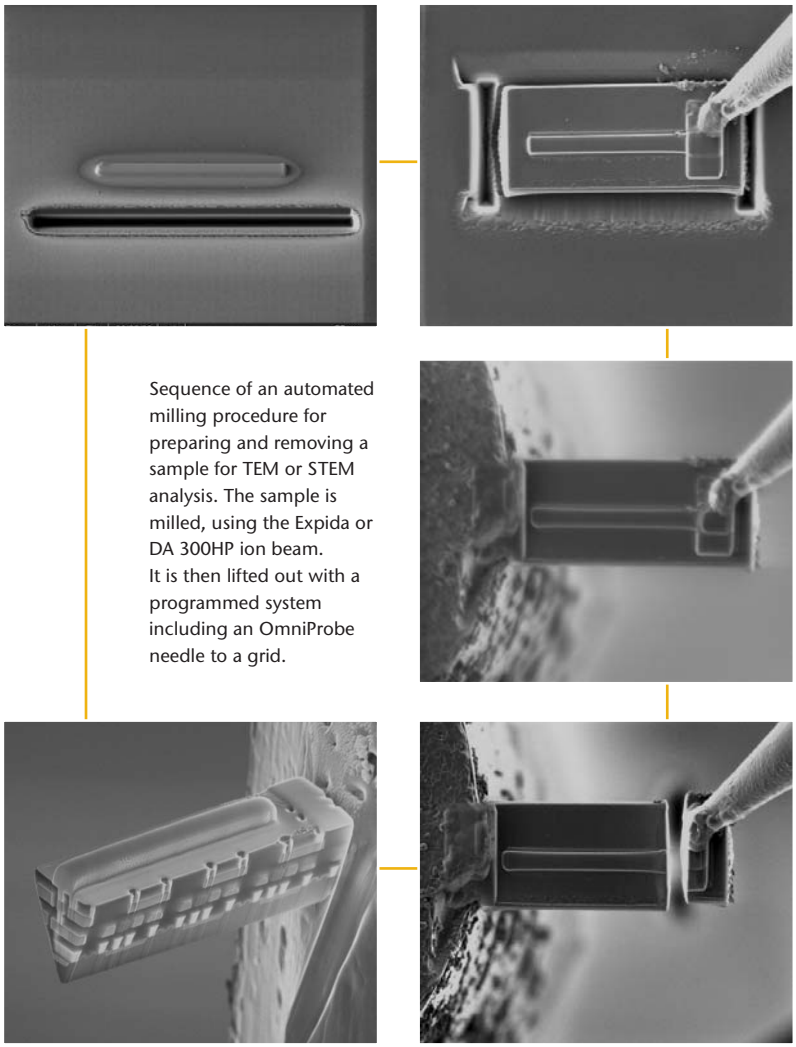
Process: TEM

If additional information is requirement, the thinned sample can be easily passed on to the TEM. On this system, atomic resolution data is obtained from the sample.

The speed of this process is faster than traditional manual methods. Two samples can be created in an hour, with time to data less than one hour, depending on the use case.

Conclusion

By automating the process of sample extraction and extended analysis, the time for defect root cause analysis is reduced and the data is more reliable as there is less human interaction.



Sequence of an automated milling procedure for preparing and removing a sample for TEM or STEM analysis. The sample is milled, using the Expida or DA 300HP ion beam. It is then lifted out with a programmed system including an OmniProbe needle to a grid.

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