# CAD assisted navigation for precise end-pointing in physical failure analysis of microelectronic devices

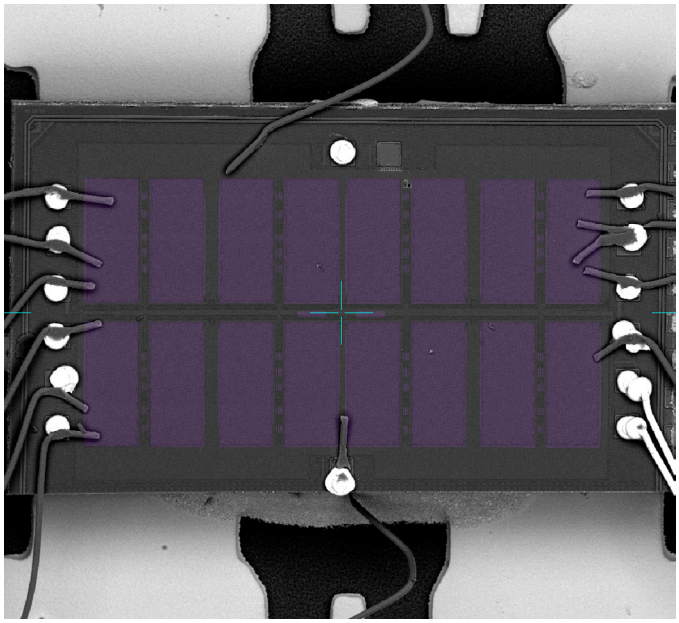
**In this application note, we show the advantages of using Graphic Design System navigation software tools to assist FIB-SEM sample preparation in physical failure analysis. Using SYNOPSYS Avalon software, GDS circuit maps can be overlaid on live SEM and FIB images to enable fast sample navigation and precise end-pointing during FIB work. We present two examples illustrating both functionalities**

## Introduction

Physical failure analysis (PFA) is used routinely in the semiconductor industry for determining root cause failure in electronic components. For years, FIB-SEM systems have been the technique of choice in fabs and semiconductor labs for sample preparation for both their site-specific milling and high resolution imaging attributes, critical techniques for successful PFA of electronic devices.
A FIB-SEM system enables highly localized sample preparation and fully controllable, precise end-pointing which are essential characteristics for failure isolation and root-cause analysis. Moreover, FIB-SEM is compatible with the relentless trend of miniaturization in electronics.

The capabilities of FIB-SEM for site-specific PFA provide distinct advantages when used in combination with dedicated circuit design and failure analysis software. And when integrated into the FIB-SEM operating software, these software applications serve as powerful tools for sample navigation, enabling quick location of areas of interest or specific features for FIB analysis, and for precise end-pointing during FIB processes.

TESCAN's policy of open architecture in both software and hardware allows the user to customize the best configuration for their specific application. SYNOPSYS Avalon represents one example from the wide portfolio of TESCAN integrated solutions. SYNOPSYS Avalon is a robust CAD navigation software system for failure analysis, design, debug and low-yield analysis and effectively assists with rapid navigation to a region of interest. Avalon can import CAD design data from all key design tools and several user-proprietary formats while providing visual representations of circuits that can be annotated, exploded, searched and linked with ease.



SYNOPSYS Avalon is fully integrated into **TESCAN Essence™** GUI as an extension of the **TESCAN Positioner module.** This enables easy, real-time correlation of circuit layout data from the external Avalon MaskView software with live SEM and FIB imaging. Once connection to a local server with Avalon is established, a CAD overlay on the live SEM-FIB windows guides the user to the desired location where analysis needs to be performed—with only a single mouse click. Such functionality is valuable for accelerating daily, routine FIB work as often the most time-consuming part of the process is locating a specific feature or desired area of interest. Specific layers in multi-layered GDS layouts can be shown or hidden according to the user requirements. In addition, SYNOPSYS Avalon is compatible with a wide range of instrumentation to make correlation possible across different analytical platforms.

## Highlights and advantages

Navigate to the region of interest using GDS files. GDS files are created by various CAD programs as a standard interchange format between IC design applications. Files contain information about the layout of a circuit, including the layers, geometric shapes, and text labels.

Guide the site-specific cross-sectioning process with the help of CAD design overlay on FIB and SEM images. GDS files can be accessed via the TESCAN Positioner module that establishes live connection to SYNOPSYS Avalon, so the circuit layout overlay appears on the live SEM and FIB images. Stand-alone CAD design reference images (JPEG, PNG, etc.) can also be used as an overlay.

Preserve extremely beam-sensitive samples where even low-kV, low current, fast scanning would damage structures. In such cases navigation and end-pointing can be done entirely with SYNOPSYS Avalon.

Navigate to selected positions on wafers or individual dies via recorded positions in CSV files, which also can be imported and exported with the TESCAN Positioner module.

Correlate between TESCAN FIB-SEM systems and other analytical platforms through SYNOPSYS Avalon. This is particularly useful in workflows that involve different analytical instruments in which FIB-SEM work is an intermediate or final step. An example of this is the TESCAN Large-Volume Workflow that uses laser ablation followed by Xe Plasma FIB post-processing. In this case, SYNOPSYS Avalon is integrated into both the laser ablation tool and the FIB-SEM system.

## Applications

In this application note we present two examples of FIB-SEM sample preparation using SYNOPSYS Avalon for navigation and end-pointing.

### Example 1: Navigation to the region of interest targeted for cross-sectioning

In this first example, we show how using CAD navigation assists in locating the region of interest. We imaged the sample using SEM at 30 keV and 1 nA which made some undersurface structures visible (Figure 1), allowing correlation between the SEM image and the GDS overlay. However, this is not always possible in practice, particularly if the samples are beam-sensitive and low keV SEM imaging (i.e., < 2 keV) is needed to avoid damaging the sample. On such samples, subsurface visualization may not be possible, so navigation is performed through the GDS overlay instead. There are cases where the sample is extremely sensitive and even the shortest exposure to low keV SEM would damage delicate structures. In this case, GDS navigation is a particularly a powerful tool for sample navigation, enabling precise end-pointing during FIB cross-sectioning using GDS overlays alone.

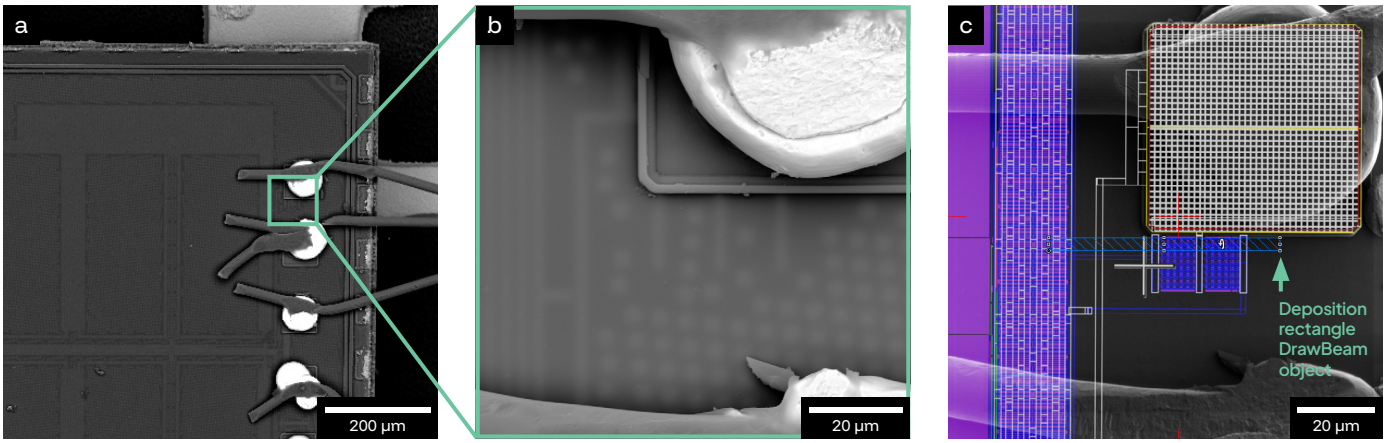



**Figure 1:** (a) Overview image containing the region of interest. (b) Region of interest. Because the sample was imaged at 30 keV, subsurface structure is visible and therefore can be aligned with the GDS overlay image to aid with navigation. (c) Circuit map overlay on the live FIB image helps with locating the area where a protective Pt layer will be deposited prior to cross-sectioning.

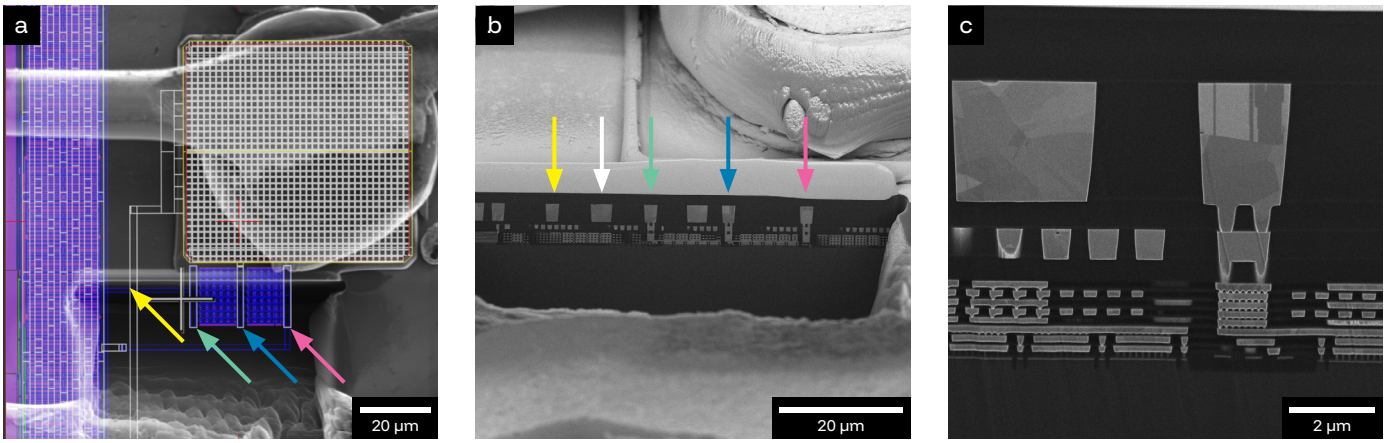



**Figure 2:** (a) FIB image overview and GDS overlay after cross-sectioning. (b) SEM overview of the cross section. Colored arrows are used to schematically correlate some of the features exposed on the cross section to those on the GDS overlay shown in 2(a). (c) Detailed view of the cross section.

## Example 2: Using GDS overlay to navigate to the region of interest and for precise end-pointing during cross-sectioning

In this second example, we show how GDS navigation and live overlay assists with end-pointing for site-specific sample preparation. We selected a specific feature of interest that is visible from the top when imaged using SEM at 30 keV (Figure 3). A bulk trench cross section is prepared close to the feature of interest. Our strategy is to use the GDS overlay to guide the process of gently polishing the cross section wall until the desired endpoint is reached. In this case, we used live SEM monitoring in combination with the GDS overlay, allowing us to stop at the exact feature. As mentioned previously, it also is possible to use “blind” end-pointing which utilizes only the GDS overlay. Figure 4 shows the incremental polishing steps, until the endpoint is reached (Figure 5).

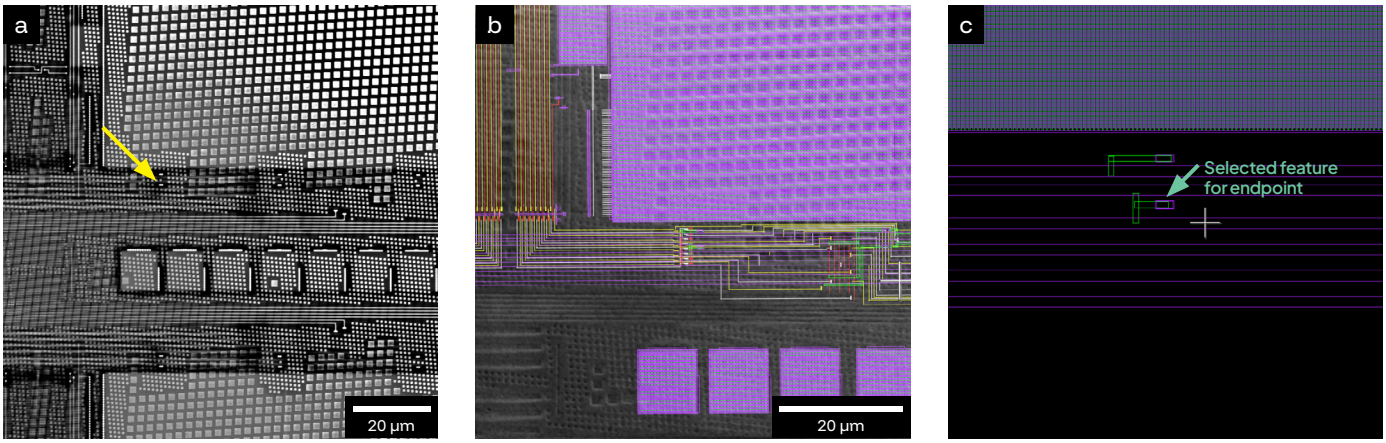



**Figure 3:** (a) SEM image overview (30 keV) shows subsurface structures. The feature targeted for end-point is marked with a yellow arrow. (b) The GDS overlay is correlated to the live FIB image to mark the desired location for cross-sectioning. (c) Detail of the region with the target feature marked for endpoint. Only relevant circuit layers are displayed in the GDS overlay to isolate the endpoint.

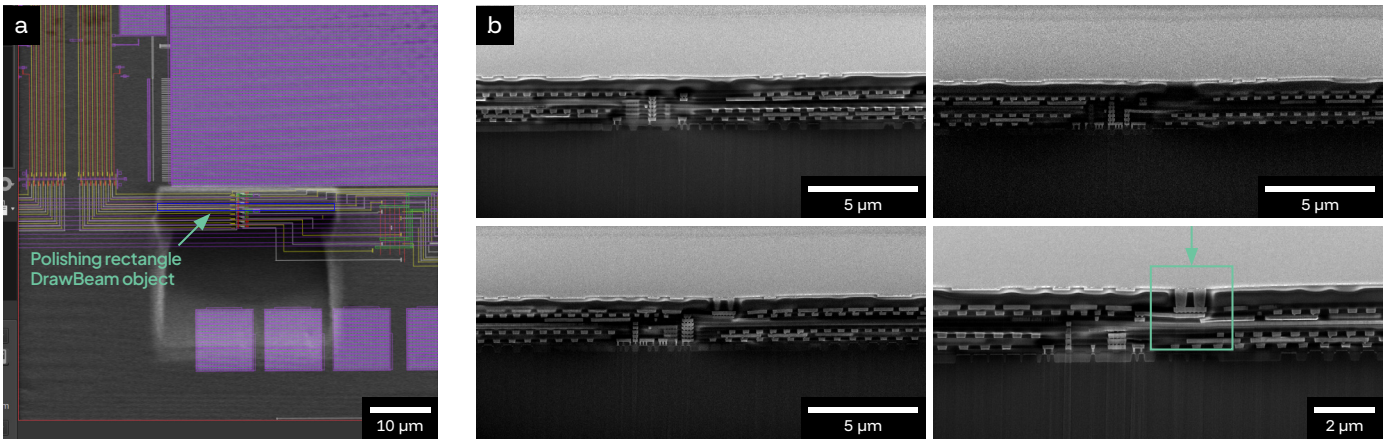



**Figure 4:** (a) Live FIB image during polishing with GDS overlay to locate the endpoint. (b) Series of live SEM images using TESCAN's FIB Observer to monitor the polishing process until the endpoint is reached, according to the GDS overlay. Process is stopped at the desired location, then imaged with SEM.

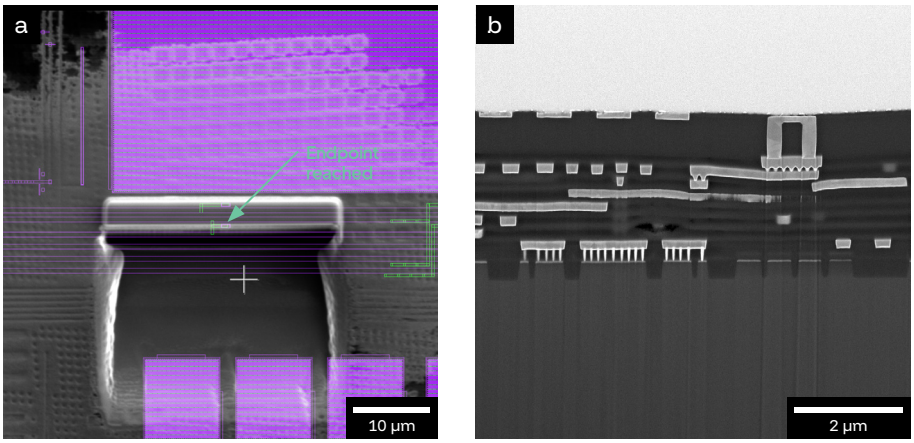



**Figure 5:** (a) Live FIB image with GDS overlay at endpoint. (b) Detail image of the cross section at the endpoint.

TESCAN GROUP, a.s.
Libušina tř. 21, 623 00 Brno - Kohoutovice / Czech Republic
(phone) +420 530 353 411 / (email) sales@tescan.com / marketing@tescan.com