APPLICATION NOTE

Cross-Section EBIC Analysis of a Transistor Array

INTRODUCTION

Electron Beam Induced Current (EBIC) characterization on cross-section of a semiconductor device is one of the few failure analysis (FA) techniques available to localize defects in depth of the layers. EBIC maps electric fields in devices. It therefore highlights PN junctions which gives information on the doping profiles and concentrations as well as on the diffusion and recombination of minority carriers. Localized defect such as crystalline dislocations can also be identified as dark/bright spots.

Cross-section EBIC requires delicate sample preparation to expose a plane cuts through the semiconductor device with a very smooth surface. After it is sectioned, the sample is attached on a cross-sectioning paddle which is mounted on the system's head of a polishing machine. After polishing, the sample is observed under a scanning electron microscope (SEM) to validate that the plane of interest is reached and smooth. This operation can be repeated until the result is satisfactory. Finally, the prepared sample is moved to the nanoprobing system for EBIC observation.

In this application note, we describe a process that saves a great amount of time to prepare a semiconductor device for cross-section EBIC analysis. Instead of moving the sample back and forth from the cross-sectioning paddle, to the SEM sample holder, and then to the nanoprobing system, it is glued once on the cross-sectioning paddle and kept there during all the preparation and observation time. This is achieved by using the Imina Technologies' *Large Sample Adapter* with the *Nanoprobing Platform*. With this assembly, measurements of millimeters high and/or wide samples (e.g. 2" wafers) becomes possible.

METHOD

A silicon chip was mechanically sectioned and glued on the paddle of a cross-sectioning tool (Figure 2). The sample was then polished once on a *MultiPrep™ Polishing System* (Allied High Tech Products, Inc.). The sample still attached to the paddle was then placed in upright position at the center of a *Nanoprobing Platform (SM100)* equipped with a *Large Sample Adapter (LSA41)* (Imina Technologies SA) (Figure 3).

Imina Technologies products in use:

- Nanoprobers miBot(TM) BT-14
- Nanoprobing Platform SM100
- Large Sample Adapter LSA41

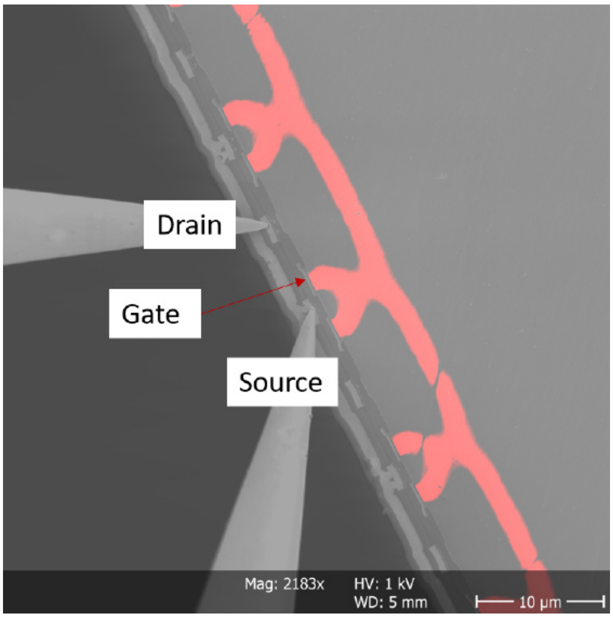

Figure 1. SEM image of a transistor array cross-section with an overlaid EBIC image highlighting in red the P/N junctions between the wells.

The nanoprobing platform was then mounted on the sample stage of the SEM (ZEISS Sigma FE-SEM). The probing tips of two miBot™ nanoprobers were coarsely positioned by hand close to the cross-section.

A quick observation of the cross-section plane showed it was necessary to perform a second polishing step to make an array of transistor clearly visible. As the sample was kept mounted on the cross-sectioning paddle, the realignment of the section plane with the polishing machine was not necessary and this step only took 10 minutes before the sample was again imaged in the SEM. This time, the transistor pads were visible on the cross-section plane.

After a 10 minutes in situ plasma cleaning cycle was run to remove any trace of hydrocarbon contamination (XEI Scientific, Inc.), the probes were gently landed on the source (EBIC probe) and drain (ground probe) terminals of a transistor. While keeping the probes in electrical contact with the sample, the parameters of the electrical analysis system (Point Electronic GmbH) were tuned. The beam acceleration voltage was set to 1kV to make electrons only interact with the cross-section surface. Also, the gain and offset of the current amplifier were adjusted to maximize the EBIC image contrast.

RESULTS

Figure 1 shows an EBIC (red scale) image overlaid to a secondary electron (gray scale) image. Electric fields at PN junctions between the source and drain wells of different transistors are visible in red. The depth of wells and their doping profile can hence be inferred from this image (the larger the red stripes, the lower the doping concentration). Also, clear/dark spots in the EBIC image would reveal the localization of defects (none is visible on this figure).

CONCLUSIONS

In this note, we describe the successful utilization of Imina Technologies' Large Sample Adapter with the Nanoprobing Platform to perform cross-section EBIC, an indispensable failure analysis technique to localize defects inside semiconductor chips. Without having to make any compromise on measurements reliability and stability, this method saves a lot of time as the sample is probed while being still mounted on the cross-sectioning paddle used for polishing during the sample preparation phase.

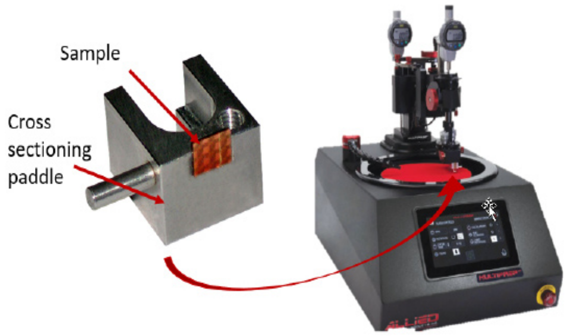

Figure 2. Sample attached to the cross-sectioning paddle of a polishing tool (source: Allied High Tech Products, Inc).

Figure 3. Imina Technologies' Large Sample Adapter mounted on the Nanoprobing Platform (left). The sample attached to the polishing cross-section padde is placed at the center of the assembly (right).