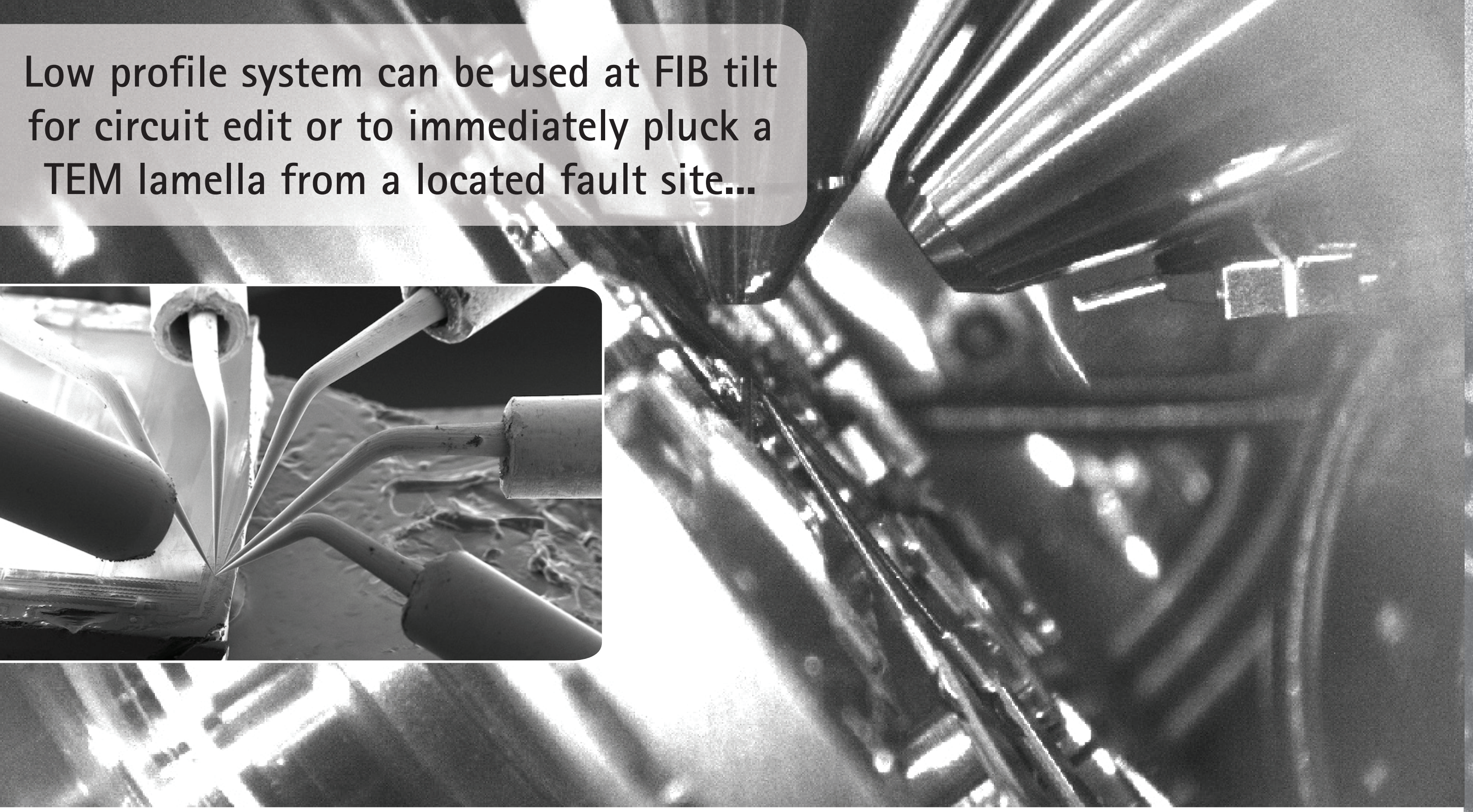
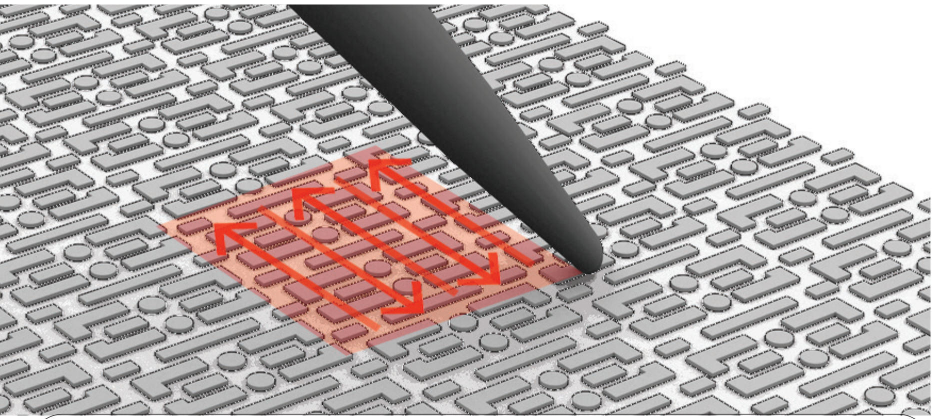
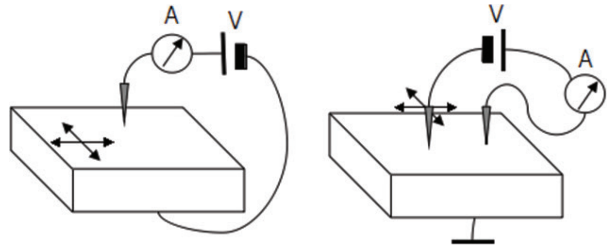
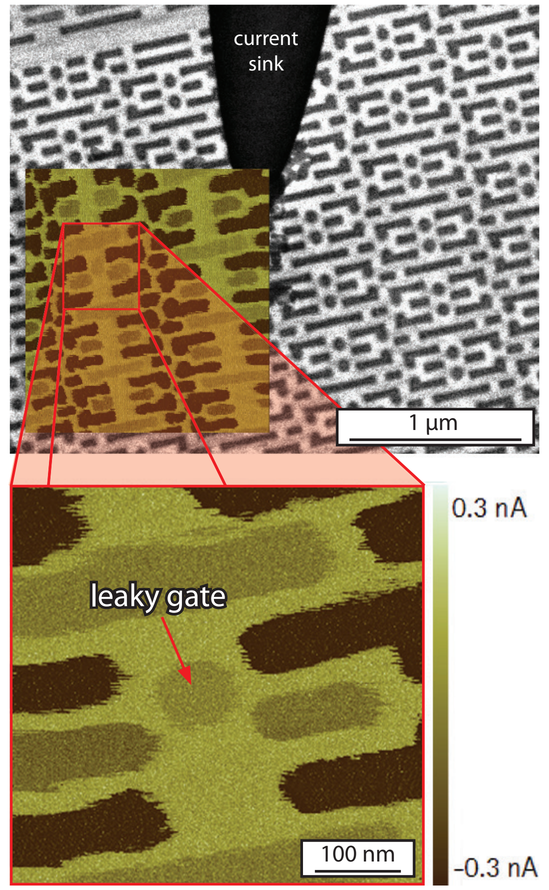






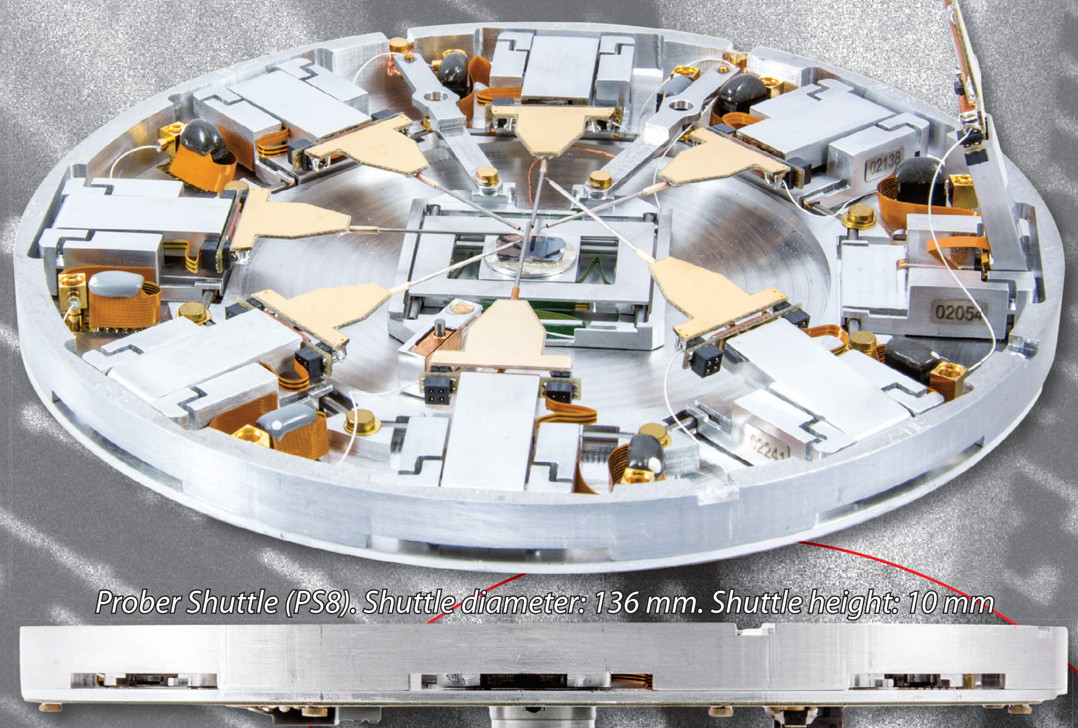
Current Imaging

Current Imaging employs a biased probe tip that is in contact with the sample to gently brush over the surface while performing a scan pattern. At each point of the scan, the sample's current response to the voltage bias is recorded and displayed as color value - thus generating a map of current flow in the sample. A multitude of configurations are possible allowing for great flexibility in defining the current path that is to be visualized. E.g. a single needle can be placed on the sample's Region of Interest (ROI) and the sample stage used to generate the scan (top schematic in the image above). Another setup uses two needles: one as voltage source, the other as current sink and one of the needles is used to perform the scan (lower schematic in the image above).To the left, an example is shown: The current map generated by the scanning probe tip is superimposed onto the SEM image (the image's colours were inverted in order to enhance the contacts' visibility).
The gate contacts do not register in the Current Imaging result – except for the failure-site, where the current leakage resulting from a defective gate electrode is visible.

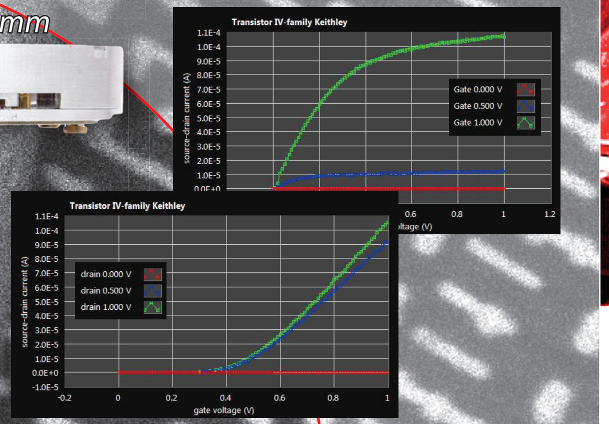


Introduction

With ever diminishing line widths and structure sizes, failure analysis is becoming more and more challenging. In light of these developments, it is essential to have the right tools in order to efficiently address the tasks of Electronic Fault Isolation and Failure Analysis



Prober Shuttle (PS8). Shuttle diameter: 136 mm. Shuttle height: 10 mm



Setup

The Prober Shuttle, fitted with MM4 micro-manipulators with integrated low noise (triax) signal leads, is ideal for performing EFI tasks inside SEM, FIB, or FIB/SEM tools. Its compact design yields extremely low drift and high stability. The Prober Shuttle's low profile allows the entire unit to be loaded onto the microscope's sample stage using the load lock - thus maintaining vacuum in the main vacuum chamber providing a clean environment for probing experiments.

After mounting a sample to the Prober Shuttle's substage and fitting the micromanipulators with probe tips, the Prober Shuttle is loaded into the microscope.

A software assistant guides the operator and facilitates fast, safe, and reliable tip touch-down. Subsequently, failure site localisation can comme micromanipulator, followed by further analyses e.g. transistor characterisation as shown here.

The addition of a compact heating/cooling stage expands the range of test conditions accessible with the platform.

Key Features

- Reliable results for electrical probing
- All EBIC applications included
- Current Imaging included
- Realtime Contact Monitoring
- in situ Tip Cleaning
- High Repeatability
- Very Low Drift
- Sub 7 nm Ready!
- Low Profile System
- Integrated Substage
- Can be used at FIB angle
- Can be moved between different SEM/FIBs within minutes

Further information

- Contact us at info@kleindiek.com
- Find your local agent at www.kleindiek.com

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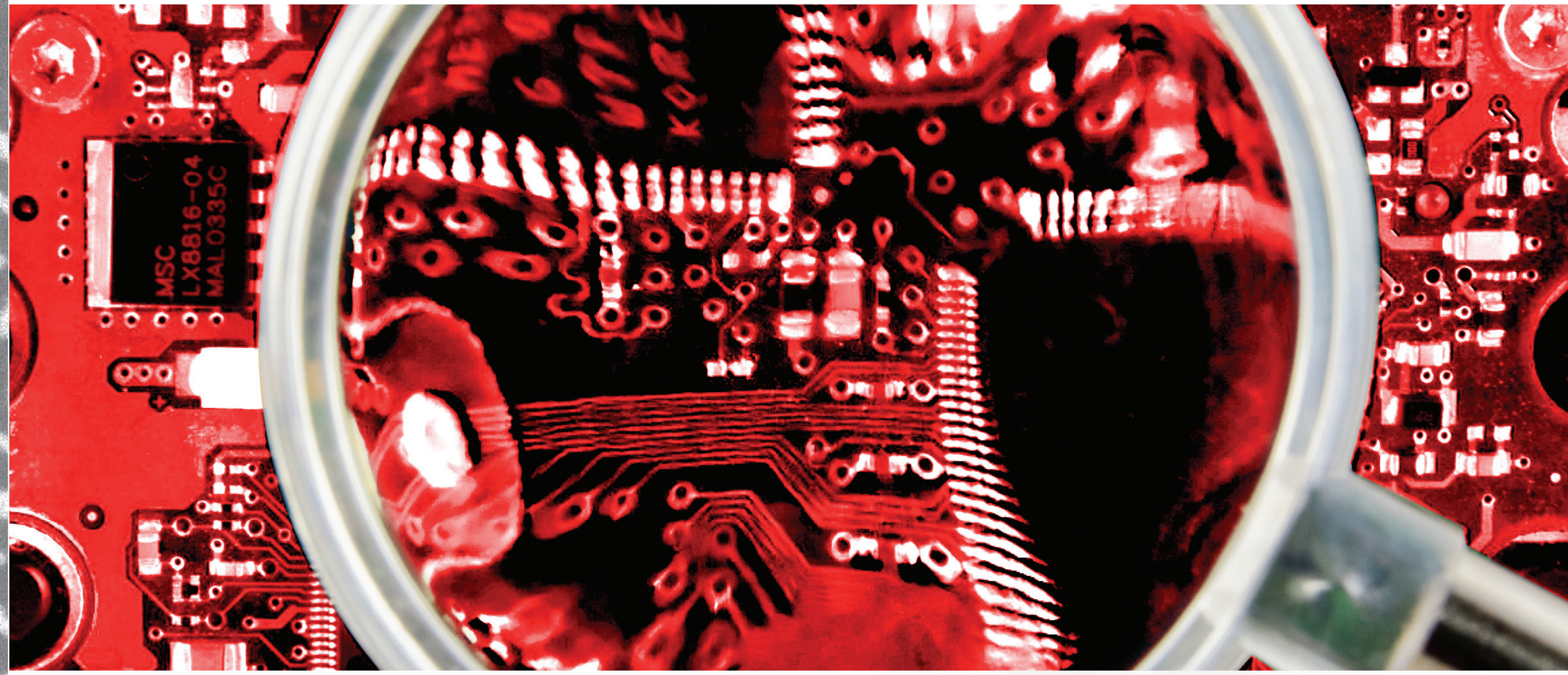
100 nm

Electronic Fault Isolation and Failure Analysis



Detecting hidden information using Electron Beam Induced Current (EBIC) and related methods as well as Current Imaging (CI)
Characterizing faults using high-precision nanoprobes on current and future technology nodes

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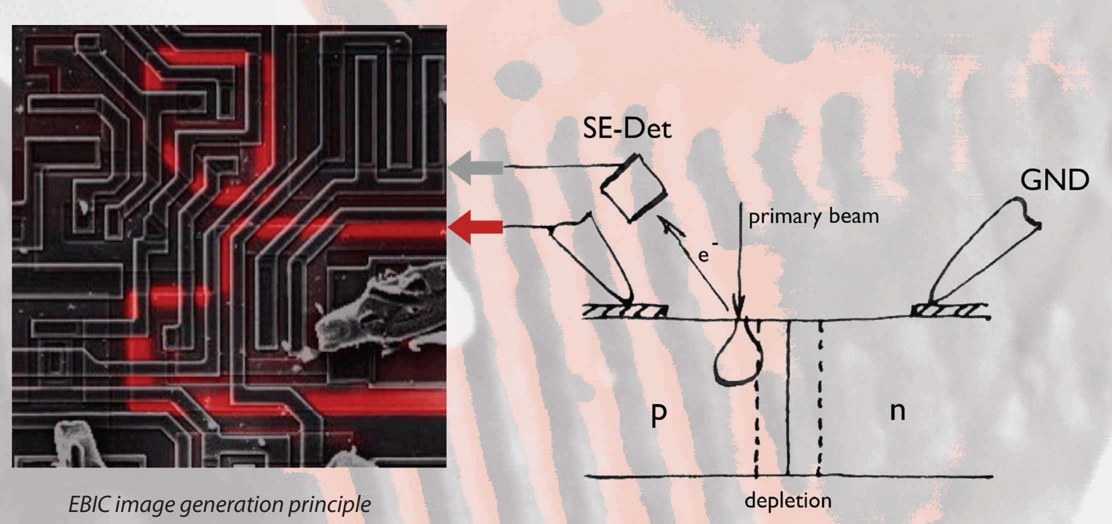
EBIC



EBIC image generation principle

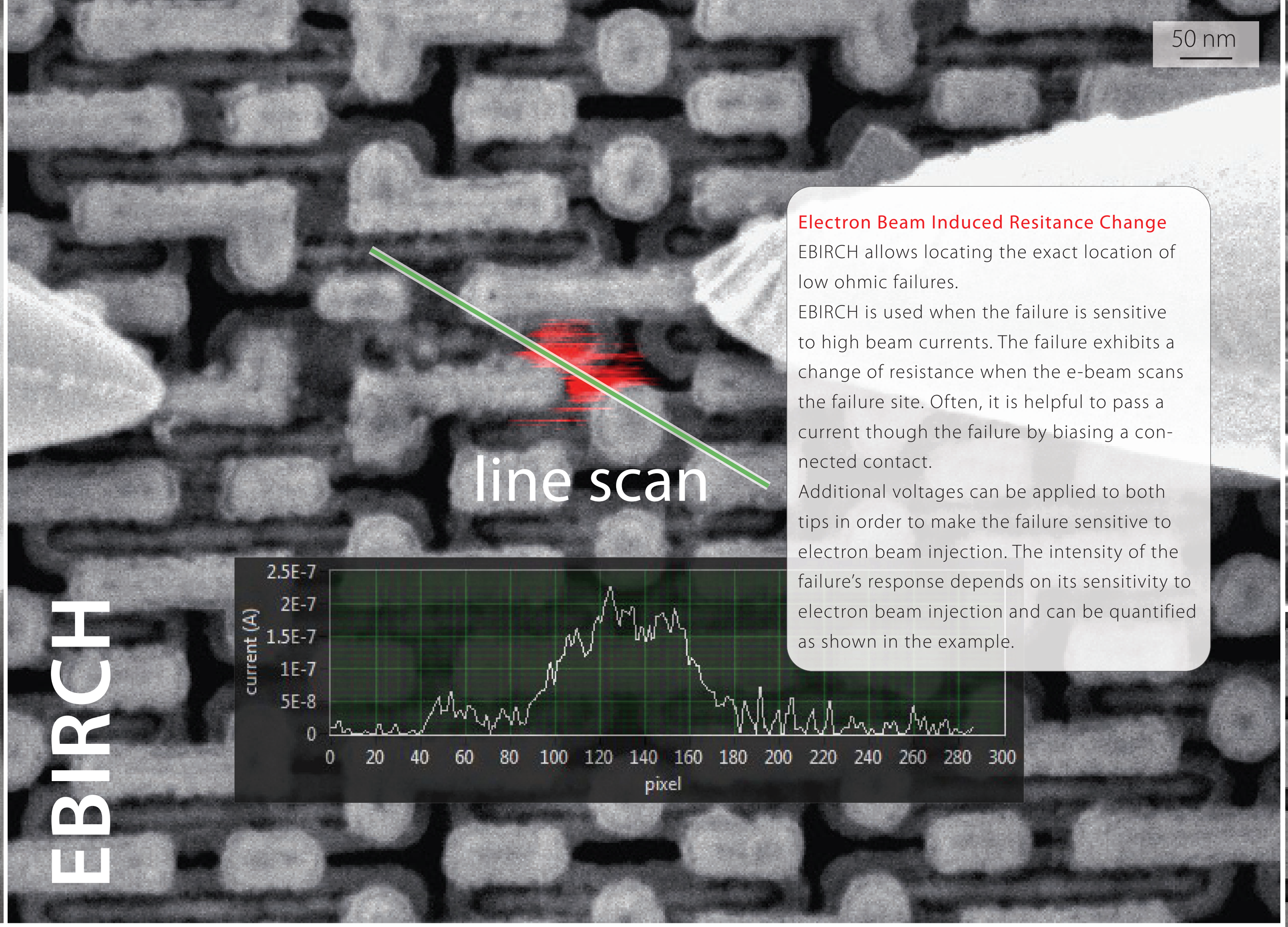
EBIC and EBAC

Two powerful yet simple analysis techniques for detecting failures in semiconductors are Electron Beam Induced Current (EBIC) and Electron Beam Absorbed Current (EBAC).
While EBIC uses the current that arises through generation of electron hole pairs in *p-n* junctions, EBAC detects only those electrons remaining in or diffusing to metal layers.

Imaging using EBIC

EBIC images are created from electrons that penetrate through the semiconductor's oxide and metal layers to the *p-n* junctions generating electron hole pairs. These are separated by the diffusion voltage and measured as a current that flows through the probe. The signal is fed back to the SEM to obtain a current map of the sample.

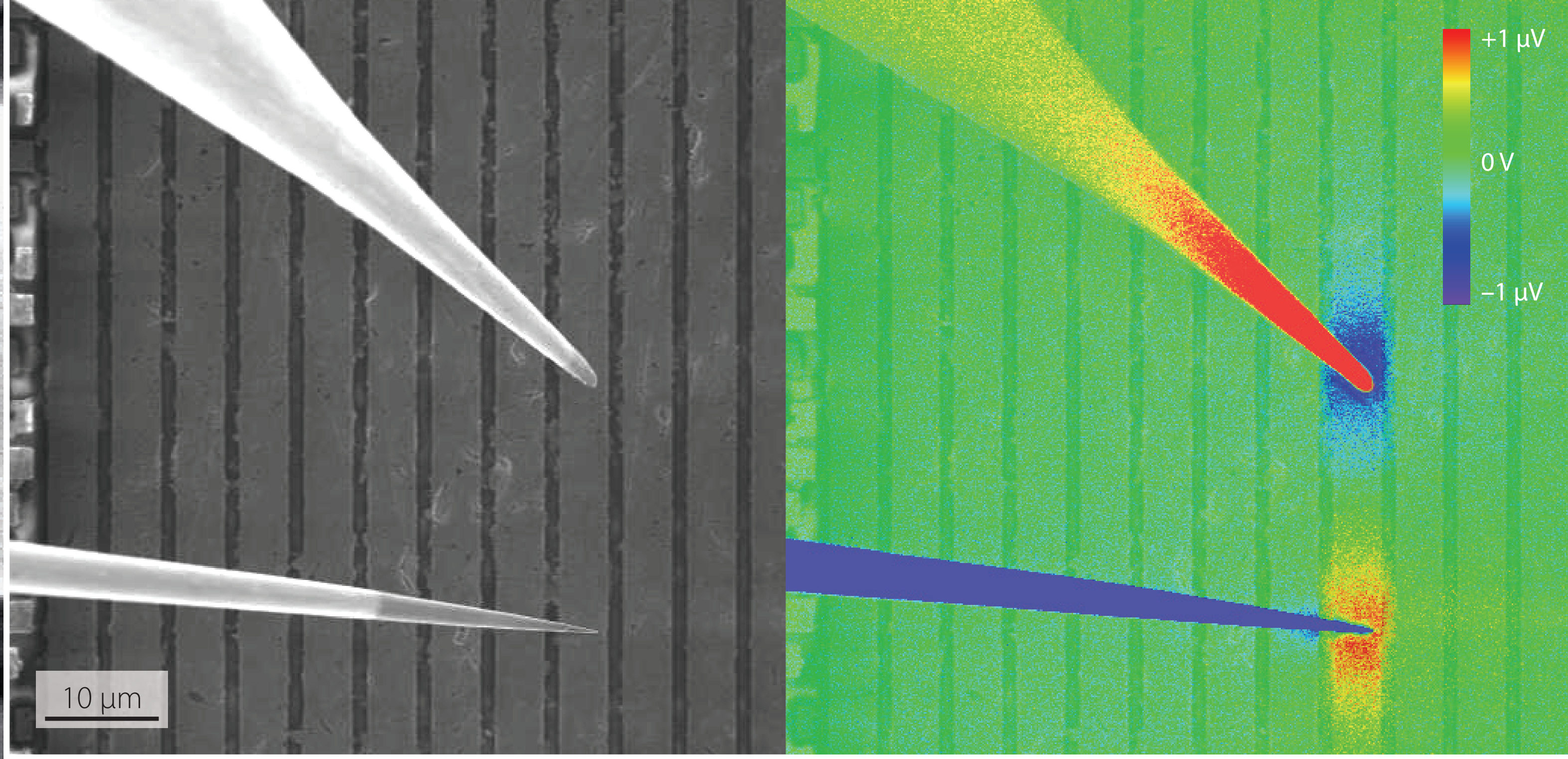
EBIRCH



Electron Beam Induced Resitance Change

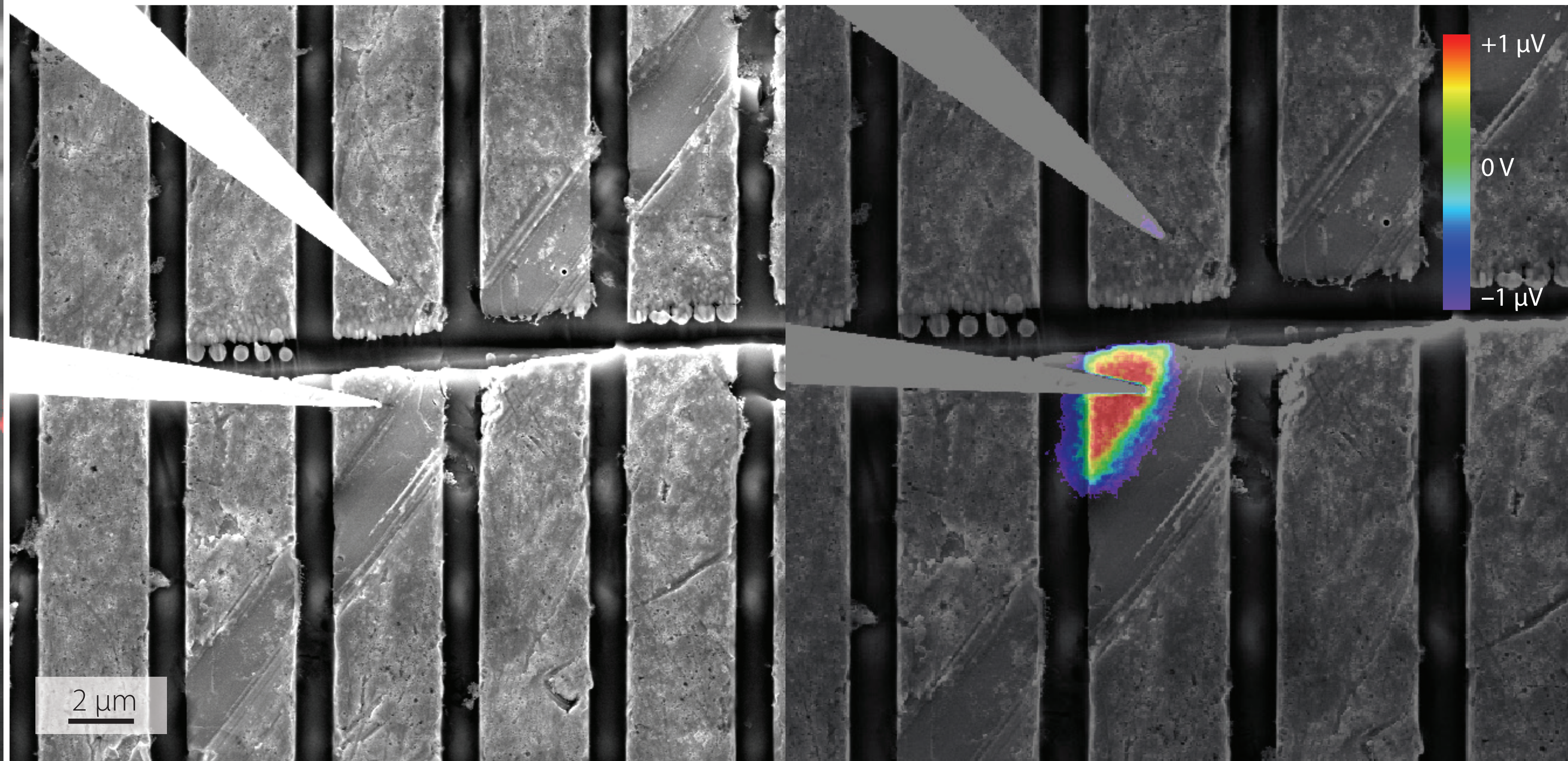
EBIRCH allows locating the exact location of low ohmic failures.
EBIRCH is used when the failure is sensitive to high beam currents. The failure exhibits a change of resistance when the e-beam scans the failure site. Often, it is helpful to pass a current though the failure by biasing a connected contact.
Additional voltages can be applied to both tips in order to make the failure sensitive to electron beam injection. The intensity of the failure's response depends on its sensitivity to electron beam injection and can be quantified as shown in the example.

EBIV

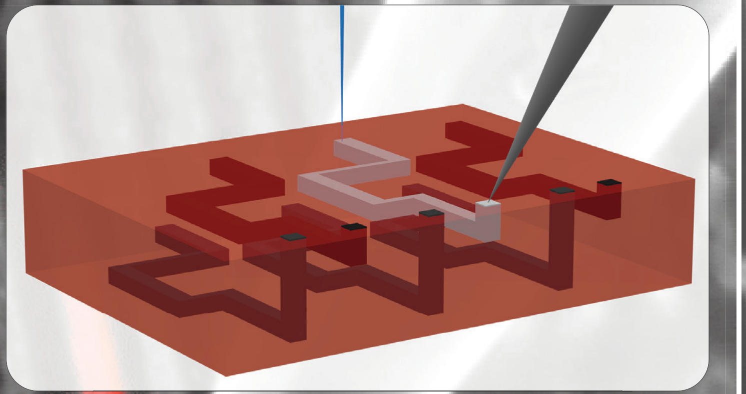


Electron Beam Induced Voltage

The EBIV technique can be used to identify slight variations in resistance within a device. The color gradiations in the above images depict varying voltages recorded on a metal line that is contacted using two probe tips that are connected to the EBIV system.
The right image above shows EBIV data superimposed on the corresponding secondary electron image (left). A voltage drop surrounding the probe tips in touch with a conductive line is visualized. The images below show the sample after it was processed with the FIB to introduce a cut in the metal lines. The registered voltage ends abruptly at the edge of the cut. Slightly below the cut, the sample surface is scratched. The EBIV image shows the voltage drop across this scratch. EBIV is capable of detecing differences in resistance of a few Ohms!



EBAC



Imaging using EBAC

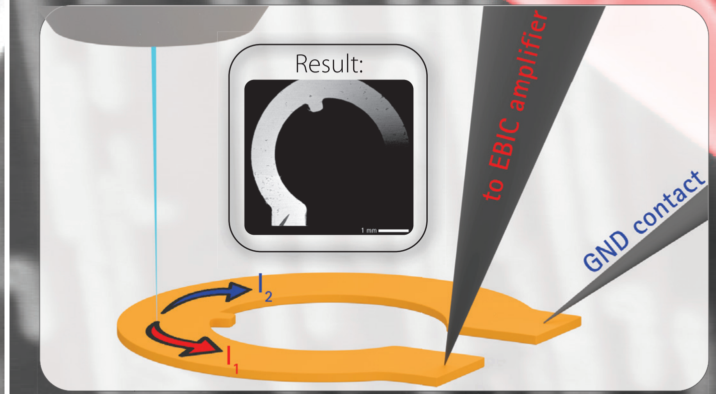
EBAC differs from EBIC in that the current for the image is generated by electrons diffusing into metal wires that are in contact with the nanomanipulators' probe needles.

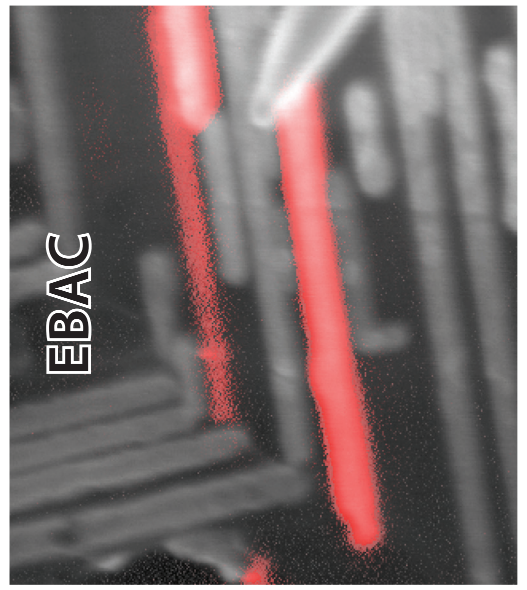
Typically, a contact is made with two wires that are spread over the whole area of interest, such as VDD or GND.

The result is a resistance image of the current flow from the electron beam position to the contact points. The higher the current, the brighter the image at the electron beam's position will be.

The higher the beam energy the more metal layers below the surface can be detected to see the metal lines that are connected to the probe tip. As the current is very small, a low-noise amplifier with high bandwidth is needed to get good images within a reasonable time.

RCI





Resistive Contrast Imaging

RCI is used to identify high-ohmic failures whenever EBAC yields inconclusive results.
RCI requires the use of two manipulators that are in contact with the sample at different points. One manipulator is connected to the EBIC/RCI amplifier and the other remains at a defined potential, e.g. GND. The current generated by the electron beam is split and its flow to each probe tip is dependant on the resistance distribution of the sample. The result is a resistance image of the current flow from the electron beam position to the contact point that is connected to the EBIC/RCI amplifier.
While EBAC (see inset to the left) shows all lines connected to the probe tip, RCI distinguishes between high-ohmic and low-ohmic connections.