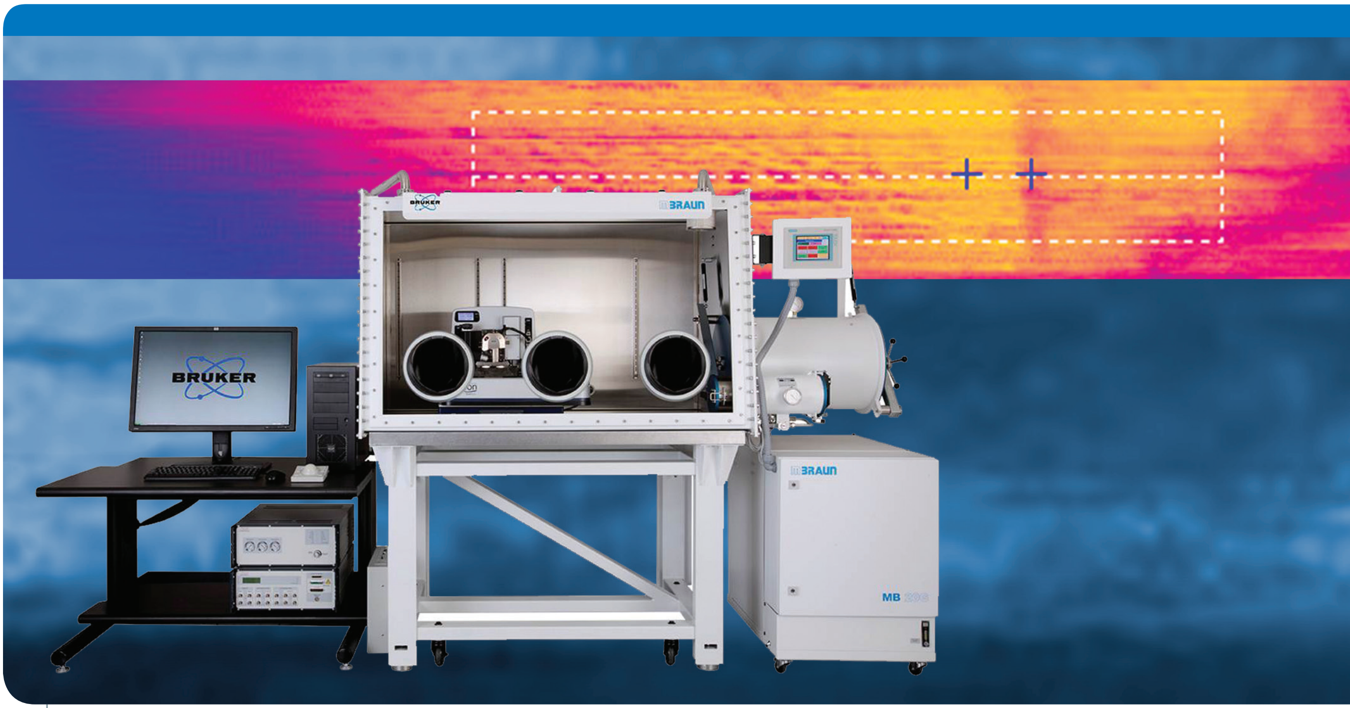


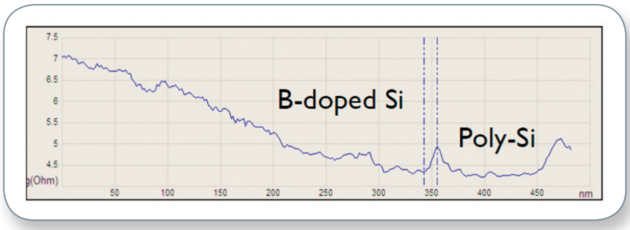
Dimension Icon SSRM-HR

Highest Resolution Carrier Profiling Solution

Bruker's Dimension Icon® SSRM-HR AFM configuration extends the spatial resolution and repeatability of scanning spreading resistance microscopy (SSRM) carrier profiling to address the stringent needs of current and future ITRS technology nodes. The system's proven performance has lead IMEC and other leaders in the semiconductor industry to choose Bruker as a partner. Detection of a 5Å wide buried oxide layer in the SSRM signal serves as spatial resolution benchmark, proving previously unattainable performance. Repeated scans across dopant staircases exhibit SSRM signal variations within a few percent, showcasing repeatability that enables the most accurate carrier profiling. The SSRM-HR solution is specifically designed to capitalize on and retain the leading performance and productivity of the Dimension Icon platform.

Highest Performance Solution

- Highest spatial resolution
- Most repeatable carrier density mapping
- Most accurate device imaging



SSRM signal of a 500nm line scan across 5Å-wide buried oxide layer, proving highest spatial resolution. The location of the buried oxide layer is clearly apparent at the 350nm location as a more than twofold increase in the spreading resistance.

SSRM Semiconductor Device Characterization

SSRM characterizes a sample's local spreading resistance by probing it in contact mode atomic force microscopy while applying a DC bias, and measuring resistance with a logarithmic amplifier. To reduce the serial contribution of the contact resistance in a single-probe measurement, a relatively high tip-sample force is employed. In the case of a silicon sample, this leads the tip to not only break through the oxide but also possibly to transform silicon at the contact point into a metallic phase. The spreading resistance image contrast obtained in this manner reflects variations in carrier density at the surface, with lower spreading resistance corresponding to higher carrier density. These capabilities make SSRM useful for 2D carrier profiling and many other semiconductor applications, including those utilizing compound semiconductors as well as silicon-based devices. By using a logarithmic amplifier, SSRM can cover the entire range of dopant densities (~10^{16} to 10^{20} cm^{-1}) within a single image without parameter readjustments.

Limitations of Conventional SSRM

However, SSRM spatial resolution has been found to be typically limited to >10nm. A key contribution to the limited spatial resolution comes from the fluid meniscus formed between tip and surface in ambient conditions. By spreading the force exerted by the tip over a larger area, the fluid meniscus lowers the pressure exerted by the tip. As a consequence, even higher force needs to be employed. This high pressure is exerted over a significantly enlarged area where the contact is made, which deforms the sample and severely limits spatial resolution. In addition, the effective electrical contact area varies as high force and high DC current modifies the sample surface, limiting line-by-line reproducibility. This degradation of spatial resolution is detrimental to the application of SSRM in integrated circuits, where relevant length scales continue to shrink in accordance with the International Technology Roadmap for Semiconductors (ITRS). While SSRM can provide key information, such as the exact source-drain profile across transistors, spatial resolution down to single nanometers is a key necessity for revealing exact gate length and any asymmetries.

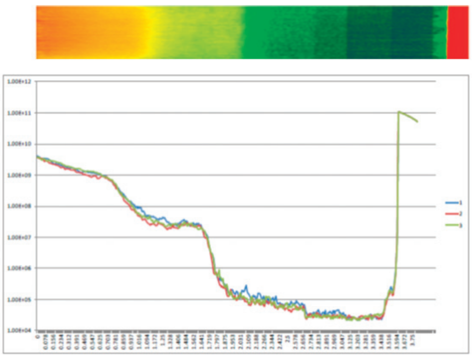


Image (top) and line graph (bottom) of 4µm scan across dopant staircase. Line-by-line comparison shows high data repeatability, and therefore ability to perform accurate carrier profiling.

Bruker's Solution

Bruker's Dimension Icon SSRM-HR resolves these limitations by seamlessly integrating the industry-leading Dimension Icon platform with 1ppm environmental control during imaging, a high-vacuum antechamber for sample preparation, sharp diamond tips, and Bruker's SSRM application module.

The resulting control and localization of tip-sample forces enables unprecedented SSRM spatial resolution (see inset on front). A cross-sectioned buried oxide layer of only 5Å thickness is clearly detected in the SSRM data, producing more than a 2 factor increase in measured spreading resistance. This feat eludes ambient SSRM measurements and proves spatial resolution on the order of 1nm. Furthermore, the line graph above shows tight line-by-line reproducibility across a dopant staircase, with a detailed analysis confirming the variation in measured resistance to be within a few percent.

The Dimension Icon SSRM-HR provides the additional advantage of retaining the full Dimension Icon platform productivity, performance, and expandability. Users are able to take full advantage of the 1ppm environmental control in conjunction with all other advanced modes, including Bruker's unique PeakForce TUNA™ and PeakForce KPFM™.

Bruker Nano Surfaces Division

Santa Barbara, CA • USA
Phone +1.805.967.1400/800.873.9750
productinfo@bruker-nano.com

www.bruker.com

Cover images

Foreground: Dimension Icon SSRM-HR instrument.
Background: Buried oxide image.