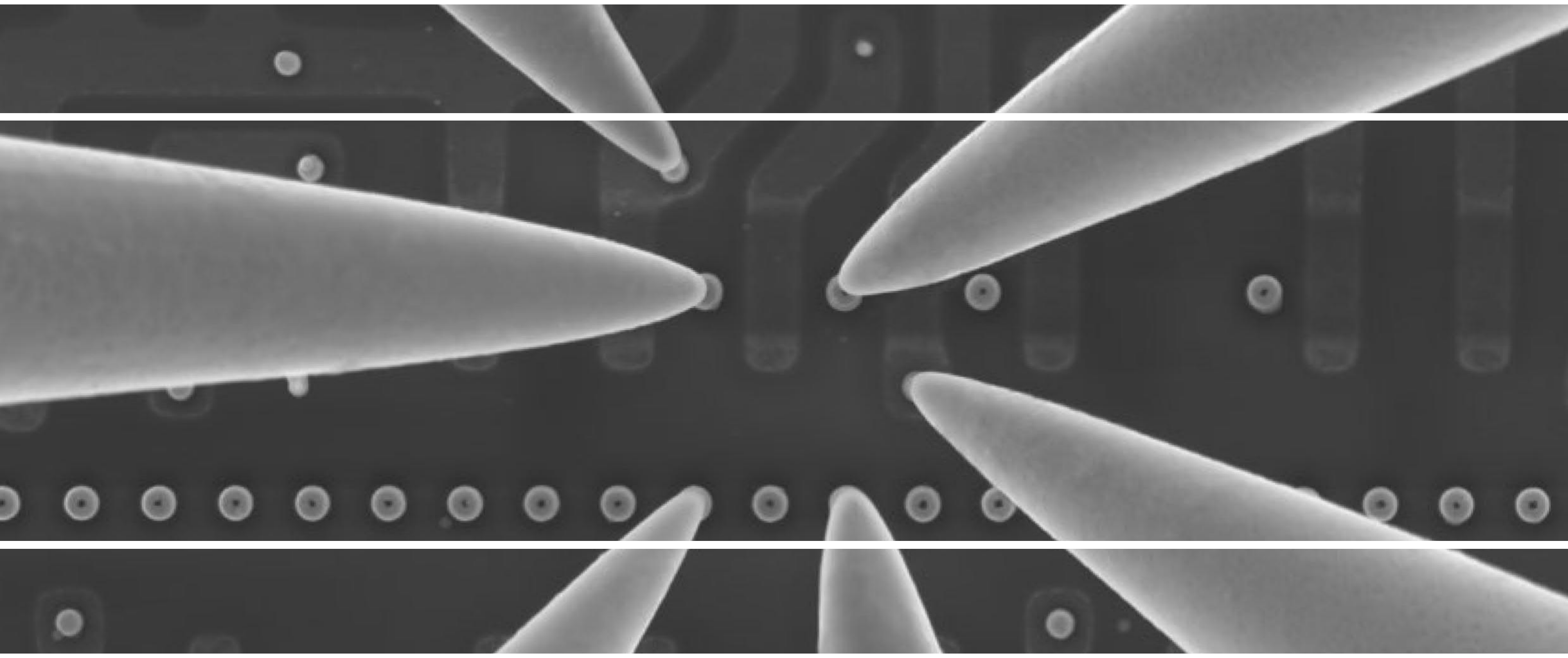
IMINA TECHNOLOGIES



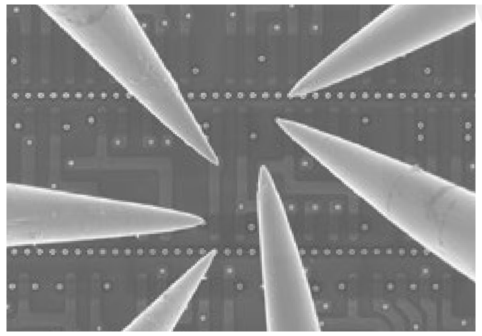
EDEN INSTRUMENTS
In Situ NanoCharacterization Solutions

NANO

Robotics Solutions for Electron Microscopes

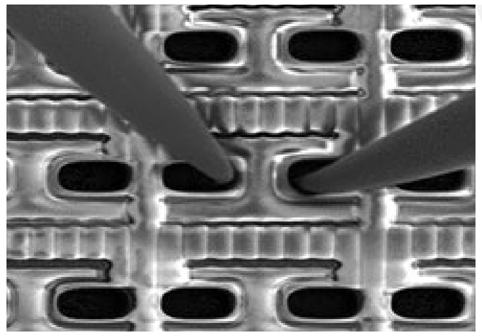
In situ probing and handling

Bring probe tips in contact with semiconductor chips, measure the electrical characteristics of integrated components, localize defects and isolate structures.



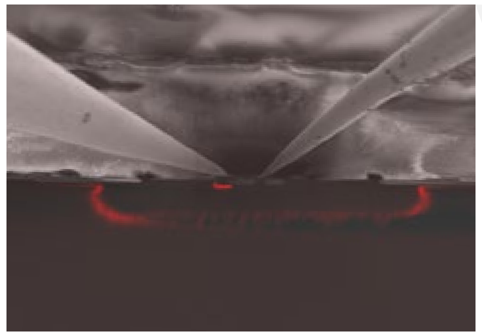
Nanoprobing

- Failure analysis and reliability testing
- Integrated circuits security threats assessment
- Chip design and reverse engineering



Semiconductor device characterization

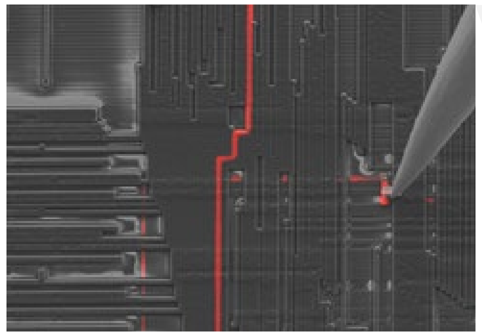
- I-V curve measurements of single transistors/diodes
- Characterization of SRAM bit cells
- Resistivity measurements of via chains



EBIC acquisition

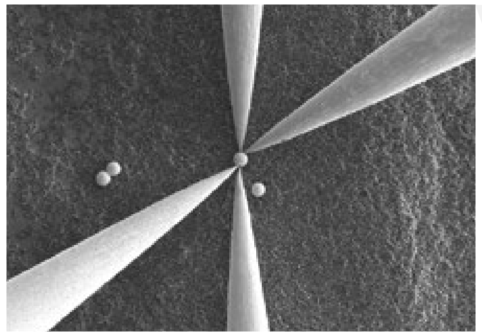
- Visualize active areas of junctions and locate defects
- Map electrical activity of samples under bias
- Validate doping profiles and areas

Applications



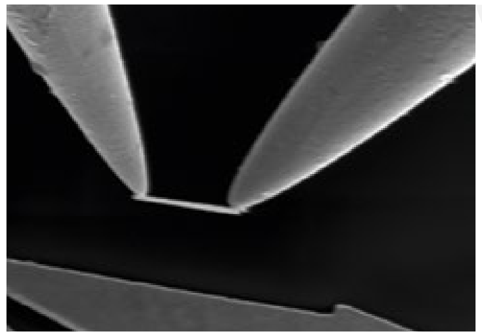
EBAC/RCI acquisition

- Localization of any open, resistive or shorting defect to the exact layer and die location
- Fabrication and long-term issue diagnostics
- Low resistance gradient mapping



Electrical measurements

- MEMS and sensor actuations and qualifications
- Optoelectronics device tests: MicroLED, solar cells
- Materials characterization: nanowires, graphene, thin-films, nanoparticles



Nanomanipulation

- Single particles isolation and positioning
- TEM sample preparation
- Micro- and nano-assembly

Scientific publications

[1] Shen, Y., Y. Xing, H. Wang, N. Xu, L. Gong, J. Wen, X. Chen, R. Zhan, H. Chen, Y. Zhang, et al., “An in situ characterization technique for electron emission behavior under a photo-electric-common-excitation field: study on the vertical few-layer graphene individuals”, Nanotechnology, vol. 30, pp. 445202, 08/2019.

[2] Liu, Y., G. Hiblot, M. Gonzalez, K. Vanstreels, D. Velenis, M. Badaroglu, G. Van der Plas, and I. De Wolf, “In-situ Investigation of the Impact of Externally Applied Vertical Stress on III-V Bipolar Transistor”, 2018 IEEE International Electron Devices Meeting (IEDM): IEEE, 12/2018.

[3] Kjeldby, S. B., O. M. Evenstad, S. P. Cooil, and J. W. Wells, «Probing dimensionality using a simplified 4-probe method», Journal of Physics: Condensed Matter, vol. 29, pp. 394008, 10/2017.

[4] Pettersen, S. R., A. E. Stokkeland, H. Kristiansen, J. Njagi, K. Redford, D. V. Goia, Z. Zhang, and J. He, «Electrical four point probing of silver thin films coated onto micron sized polymer spheres», Applied Physics Letters, vol. 043103, 07/2016.

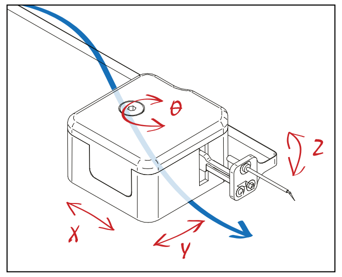
[5] Peter Krogstrup, Henrik Ingerslev Jørgensen, Martin Heiss, Olivier Demichel, Jeppe V. Holm, Martin Aagesen, Jesper Nygard and Anna Fontcuberta i Morral, “Single-nanowire solar cells beyond the Shockley–Queisser limit”, Nature Photonics volume 7, pages 306–310 (2013).

For more examples of use, visit our list of application notes at www.imina.ch/applications.

Revolutionary mobile robot motion technology

Technology

Imina Technologies' core technology resides in the unique integration of piezoelectric actuators into the miBot™, the world's **most compact 4 degrees of freedom robot** with nanometer resolution of positioning.



Contrary to traditional manipulators, the miBot is a **mobile robot.** It is virtually untethered and free to move over the surface of its stage. Since it has no mounting screws, the miBot can be coarsely positioned by hand in arbitrary positions and naturally adapt to changing samples geometries and microscope configurations.

The different operating modes of the piezo actuators provide up to centimeters travel range with **scalable positioning resolution from micrometers to nanometers.** The coarse positioning mode saves time when approaching the region of interest, while the fine positioning mode allows for a precise contact landing of the probes at the destination.

The high stiffness of the miBot's monolithic design makes this precision instrument robust to vibration and guarantees smooth motion. Additionally, the small size of the miBot provides **unmatched stability** ensuring steady contacts over time on even the smallest samples.

The miBot moves along its natural axes; no rotational and translational motions are coupled. This makes it **extremely intuitive to control,** significantly accelerating the training time. In turn, the ease of use of the miBot greatly reduces the possible risk of damaging sensitive samples and gives the operator confidence to carry out delicate positioning maneuvers.

- **High mechanical and thermal stability guarantees stable positioning over long periods of time, from 0° up to 55° tilt angle.**
- **Flexible installation for straight forward adaptation to different experimental setups and specimens.**
- **Easy to control for reduced risk of sample and probe damage and fast access to measurements.**
- **Compatible with high resolution imaging using magnetic lenses (sample immersion) to contact samples under low accelerating voltage and short working distances.**
- **Combination of coarse and fast movements over centimeter distances and fine movements at the nanometer.**

Integrated nanoprobing solutions for SEM and FIB

Imina Technologies' *NANO* solutions are turnkey for electrical characterization of microelectronic devices, *in situ* semiconductor failure analysis and manipulation of single structures in SEM and FIB chambers. **Fully controlled from Precisio™** software suite, comprehensive workflows provide operator assistance from setting up the system, to landing probe tips on the device under test, acquiring and processing measurements and reporting.

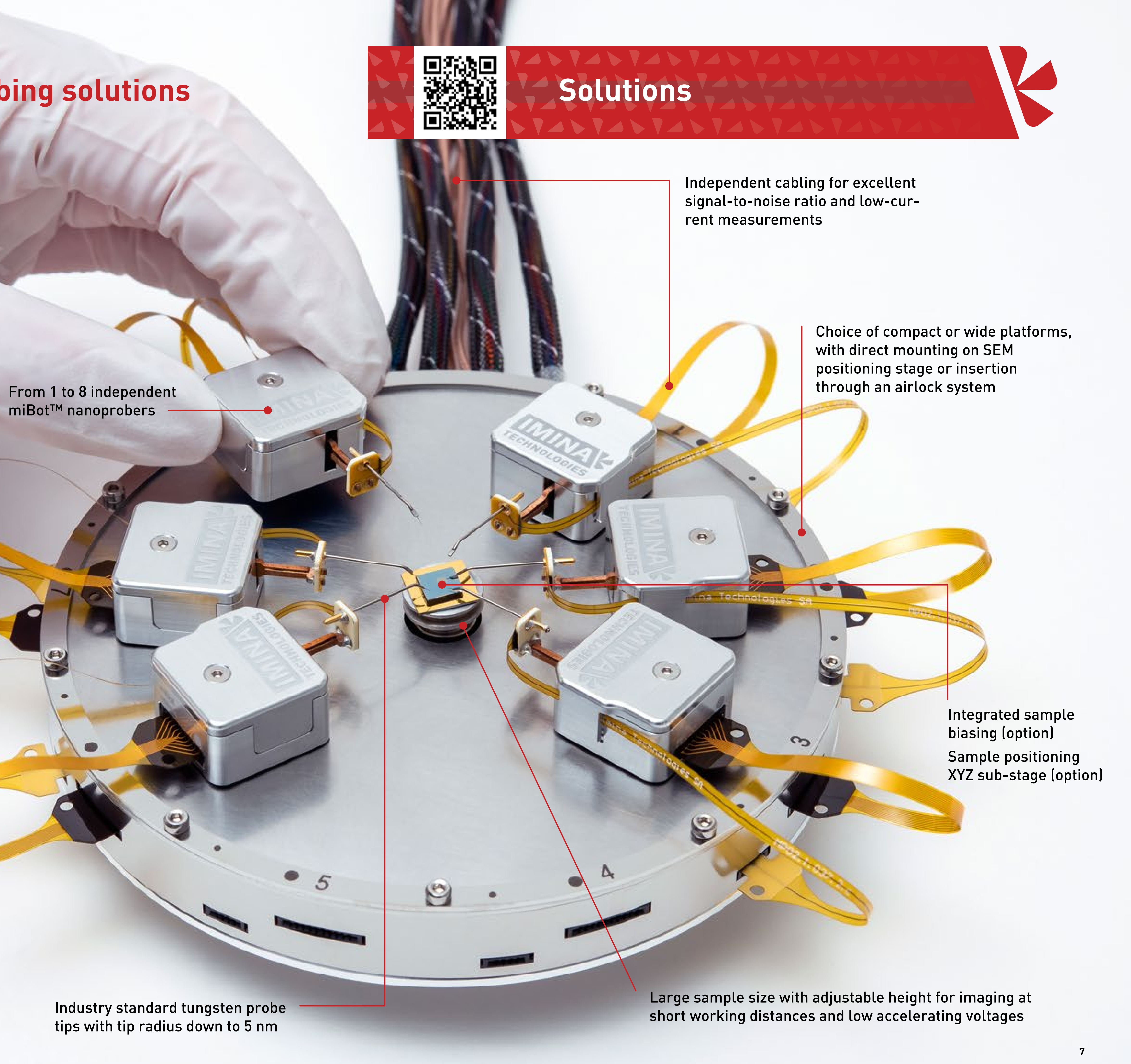
Up to 8 miBot™ nanoprobers can be delivered with various configurations and options to adapt to application specific requirements and equipment setups.

The compact and light platforms for the robots are **compatible with any electron microscope** and can either be mounted on the SEM sample positioning stage, or be loaded via the SEM load-lock.

The compatibility with high resolution imaging using magnetic lenses enables the operator to perform nanoprobing experiments with the most advanced scanning electron microscopes on the market and take advantage of the highest resolution imaging capabilities, even at accelerating voltages below 0.5 kV.

As the whole **platform and robots can be tilted,** *in situ* FIB circuit editing and nanoprobing can be performed simultaneously providing faster and more accurate failure analysis results.

No permanent modification of the chamber is required and the installation and removal of the system only takes a few minutes. This avoids to dedicate an SEM for nanoprobing. Also, various extra accessories exist to easily operate the main components of a *NANO* solution under optical microscopes such as probe stations and inspection tools, increasing the value of your investment.



Independent cabling for excellent signal-to-noise ratio and low-current measurements

From 1 to 8 independent miBot™ nanoprobers

Choice of compact or wide platforms, with direct mounting on SEM positioning stage or insertion through an airlock system

Integrated sample biasing (option)

Sample positioning XYZ sub-stage (option)

Industry standard tungsten probe tips with tip radius down to 5 nm

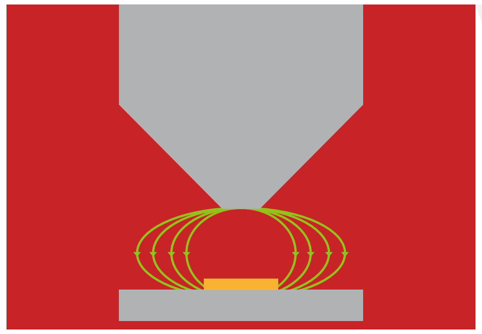
Large sample size with adjustable height for imaging at short working distances and low accelerating voltages

Advanced features for challenging applications

Designed to match the most demanding technical and operational requirements of the semiconductor industry, our nanoprobing solutions integrate smoothly within standard FA workflows and feature numerous benefits to reduce the time to data.

Short working distances

Nanoprobing with working distances <2mm between the specimen surface and the SEM pole piece can be achieved. The properties of semiconductor samples can thus be preserved by working at low accelerating voltage (<0.5kV).



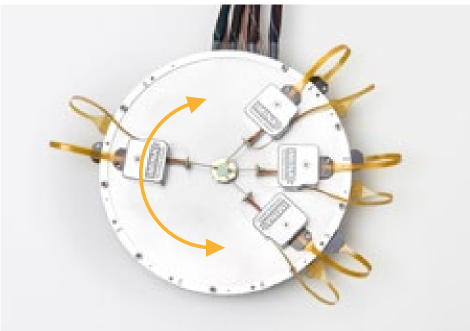
Magnetic immersion imaging

Critical components of the nanoprobing system are non-magnetic, enabling full compatibility with high resolution imaging of electron microscopes immersion-lens columns.

Tilted angle

Compatible with operations at FIB tilt angle (54°), the nanoprobers can be positioned in X, Y, Z and maintain steady electrical contacts with the device under test. Hence making possible simultaneous FIB circuit editing and nanoprobing.

Features

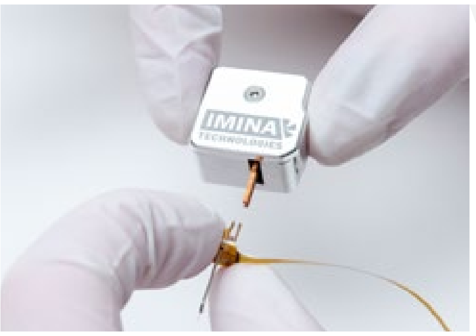


Flexible platform configurations

Modify the nanoprobing setup by adding or removing robots and by adjusting their position and orientation by hand or *in situ*. Naturally adapt to different sample size and geometry in no time.

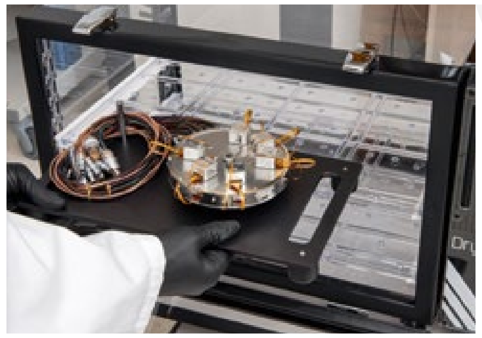
One software to control, measure and report

Step by step operator assistance to position the nanoprobes, run and process electrical test measurements is provided through the unified and intuitive software application Precisio™.



Probe holders: quick tips replacement

Robot probe holders compatible with industry standard probe tips. Wide range of tungsten probe tips available with tip radius from 1 um down to 5 nm. Easily exchange probe holders or replace with optical fiber holders.



Fast installation and removal

Install and remove the nanoprobing platform from the SEM chamber in minutes, avoiding the need to dedicate an SEM to the probing system. Compact storage solution is available to minimize ex-situ contamination and maintain the system ready to use.

Nanoprobing platforms for all chamber and sample sizes

Stage mounted platform 4-Bot [SM100]

- Compact design (diameter: 100 mm)
- Up to 4 independently driven miBot™ nanoprobers
- Sample size up to approx. 1”

Stage mounted platform 8-Bot [SM125]

- Wide design (diameter: 125 mm)
- Up to 8 independently driven miBot™ nanoprobers
- Sample size up to approx. 2”

Load-lock platform 4-Bot [LL10]

- Wide design (diameter: 100 mm)
- Up to 4 independently driven miBot™ nanoprobers
- Sample size up to approx. 1”
- Typical airlock door inner dimensions: 100 (w) x 45 (h) mm

Load-lock platform 8-Bot [LL11]

- Wide design (diameter: 112 mm)
- Up to 8 independently driven miBot™ nanoprobers
- Sample size up to approx. 1.5”
- Typical airlock door inner dimensions: 150 (w) x 45 (h) mm

Custom configurations are offered for integrating our nanoprobers with unconventional vacuum chambers, heating / cooling sample stages, or third-party analytical equipment.

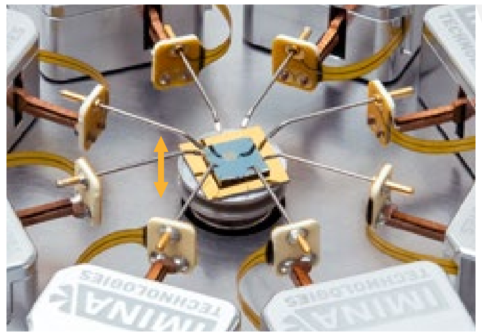
Need to probe outside the EM ?

Various solutions exist to:
- Retrofit standard probe stations
- Integrate with wafer inspection tools
- Mount under optical microscopes and AFMs

Look for details in the *MICRO* product line brochure

Upgrade your system and cover all your present and future needs

Optional components are available to ensure your system will always remain up to date and capable for your experimental needs. Not sure if you need an option right now? No worries, onsite or factory upgrades of your equipment are always possible.



Active sample holder

- Manual sample height adjustment (8 mm range)
- User defined specimen biasing

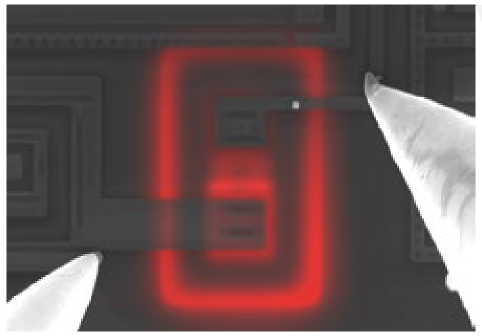
Sample positioning XYZ sub-stage

- Move the sample independently from the probes in X, Y, Z directions (travel range: 5 mm (X, Y), 330 um (Z); max. resolution: 2 nm (X, Y), 7 nm (Z))
- Reduce probes landing time and accelerate multiple device characterization
- User defined specimen biasing

Large sample adapter

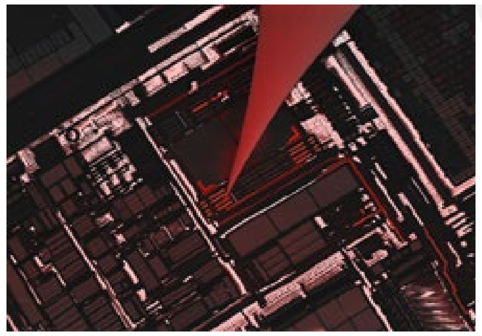
- Provides space below the nanoprobers for large/tall samples
- Ideal to probe a variety of samples such as 2'' wafers, packaged samples, cross-sections, etc.
- Different elevations are available to match most sample heights

Options



EBIC acquisition system

High performance external current amplifier and SEM image acquisition system for quantitative EBIC capabilities.

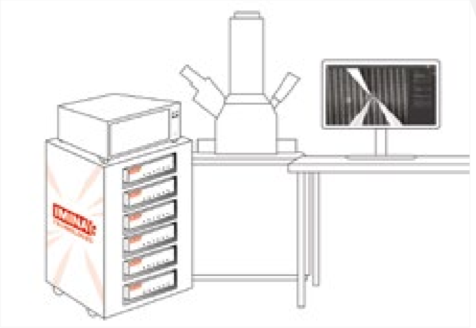


EBIC & EBAC/RCI acquisition system

Best in class *in situ* and ex situ preamplifiers combined with integrated scan generator and SEM image acquisition system for quantitative EBIC and low noise EBAC/RCI analyses.

Additional SEM integration kits

Install your nanoprobing system in minutes and operate in any of your microscopes by preinstalling the interface parts on the different chambers.



Lab equipment kit

- Robust shelf to accommodate the system electronic controllers and optional parametric analyzer
- Desiccator to store the platform and avoid contamination
- Toolbox for tools and accessories
- Pre-installed modern computer workstation and monitor

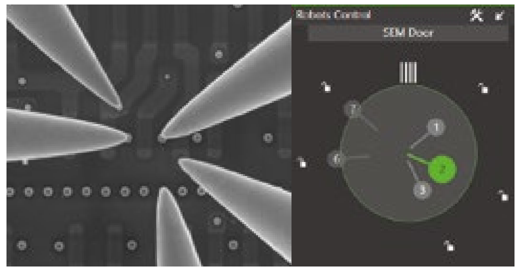
Robots control and data acquisition in a unified software suite

A streamlined computer assisted workflow with step by step operator assistance to position nanoprobes, run device characterizations and isolate defects.

Precisio™ software makes the nanoprobing user experience truly intuitive. All required controls and parameters are embedded into a streamlined workflow with step by step operator assistance to perform measurements in the most effective way.

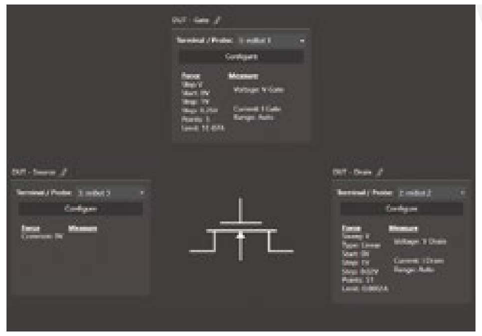
At Imina Technologies, we take great care into carefully crafting our software application to make the human-machine interaction as enjoyable as possible. Ensuring that our software is a valuable addition to your workflow instead of being a hindrance.

Precisio™ nanoprobing is designed to allow the operator to focus 100% on the application. The movements of probes are controlled from anywhere in the workflow with the light and ergonomic control pad. A customizable indicator panel always informs which of the miBot™ nanoprobers is selected, as well as the motion mode and speed. Information is graphical and makes the link between the hardware configuration and the selected electrical test recipe so that the user is never disoriented with respect to the sample. Saving time and minimizing the risk of collision of fragile probes.



From the main window, the operator is guided through the steps of setting up his nanoprobing system and test recipes, landing probe tips on the device under test, acquiring measurement data and reporting about them.

Software

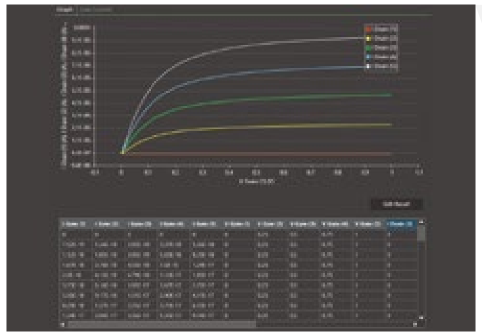


1 - Test recipes

Create new or load existing measurement projects. Select the type of device under test (transistor, diode, resistor, etc.) from a library and remotely configure your semiconductor parameter analyzer (Keithley 4200A-SCS or Keysight B1500A) to match your characterization needs.

2 - Tips contact detection

Get a visual feedback with I-V traces to optimize each probe tip contact resistance with the substrate. Individually configure the contact tests to cycle according to the specifications of the device under test. Run automatic test sequences over all probes.



3 - Measurements

Run series of pre-configured tests. Automatically plot results in meaningful charts. Get direct access raw data of each curve. Write your notes next to the measurements.

4 - Data management and reporting

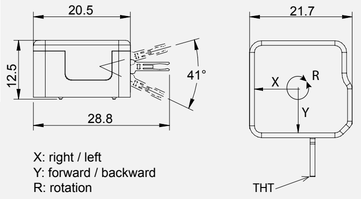
Manage a database of all your measurements across time, per samples and test recipes. Perform side by side graphs comparisons and document your findings. Export results in usual office file formats for reporting and sharing with colleagues.

Specifications

Main components of a NANO solution

Nanoprobers	Up to 8 miBot™ robots with independent high resolution piezo driving electronic controller.
Platforms	1 standard stage mounted or load-lock platform for 4 or 8 miBot™, or a special integration. This includes all accessories for installation inside an EM chamber with model specific interface parts of the microscope sample stage and chamber port, and a shielded electric interface for low current, low noise *in situ* probing (coaxial I/O).
Motion controller	1 unit to control up to 4 miBot™, or 2 units to control up to 8 miBot™. This includes a control pad and a license for Precisio™ software Basic Edition (Microsoft® Windows 10, 8 and 7).
Options	Options include active sample holder, sample positioning XYZ sub-stage, EBIC and EBAC/RCI acquisition systems, additional SEM integration kits, lab equipment kits, computer, software modules Precisio™ Probing, and Precisio™ Data Management & Reporting.
Probe tips	Range of Tungsten probes with tip radius from 5 nm to 1 um, 0.51 mm (0.020”) shank diameter, and lengths of 15 mm or 20 mm. Other types available upon request.

Nanoprober miBot™ NANO



X: right / left
Y: forward / backward
R: rotation

Degrees of freedom	4 independently driven (X,Y,R,Z) per prober
Dimensions & weight	Body: 20.5 x 21.7 x 12.5 mm³ Arm: 8.3 mm (without tool) Weight: 12 g (without tool)
Max. positioning resolution	Stepping (coarse): 60 nm (X, Y), 120 nm (Z) Scanning (fine): 0.02 nm (X, Y), 0.1 nm (Z)
Motion range	Stepping (XY,R,Z): 20 x 20 mm², ± 180°, 41° Scanning (X Y Z): 440 x 250 x 780 nm³ *Note: in stepping, actual X, Y, R range are only limited by the size and shape of the stage where the miBot moves, and the length of the driving cable.*
Speed	X and Y: up to 1.5 mm.s⁻¹ Z: up to 150 mrad.s⁻¹
Forces & torques	X and Y: push: 0.3 N hold: 0.2 N Z: lift: 0.7 mNm (5 g) hold: 0.9 mNm (6 g)
Tilt angle	Holding position up to 55°
Drift	< 1 nm/min
Tool holders	Range of holders for probes and optical fibers

Specifications are measured at tool-holder tip (label “THT” on schema) and measured at 300 K with motion controller MC410/20 and robot BT-19.

Platforms

Model	SM100	SM125	LL10	LL11
Type	Stage-Mounted		Load-Lock	
Number of probes	4	8	4	8
Height (without interface part)	16.5 mm	17.5 mm	12.8 mm	16.5 mm
Width (without cables)	100 mm	125 mm	100 mm	112 mm
Weight (without cables)	180 g	220 g	233 g	200 g
Sample size	Up to ~25 mm (1”)	Up to ~50 mm (2”)	Up to ~25 mm (1”)	Up to ~38 mm (1.5”)
Sample holder	Compatible with various SEM stubs with pin size Ø 3.2 mm and length 6 mm.			

Electrical probing

Voltage range	± 100V
Max. current	100 mA
Leakage current	< 100 fA/V
Resistance	Approx. 3.5 Ω *from probe tip to flange connectors*

Low noise probing accessories and suitable measurement environments are required to achieve the best measurement performance of the system.

Operating conditions

Lowest pressure	10^{-8} mbar
Temperature range	273 K to 353 K
Humidity	< 95% (non-condensing)

Site requirements

Equipment and facilities requirements may vary depending of the system and its options.
Contact us for a complete evaluation of the requirements.

All technical specifications are approximate values and subject to change without notice.

Customer support

Imina Technologies provides tailored services for product installation, maintenance and staff training worldwide. We pride ourselves on our recognized excellent customer support that ensures the best user experience throughout our product life cycle.

Warranty plans

By default, our products are covered by a 2 years warranty against defects and workmanship.
Warranty extension plans are available upon request.

Installation and training services

Installation and commissioning at your facilities is performed by a skilled engineer.
Advanced training sessions for single or multiple users are provided by one of our application specialists.

SWAP programs

To avoid extended downtime during a repair or maintenance service on a component, enroll into a SWAP program for all, or part, of your system to get a functioning replacement delivered to your facilities within 3 business days.

Site acceptance tests

Site acceptance tests on specific samples can be requested at installation and commissioning of a new system. This service is always preceded by a feasibility study at our demo lab.

Demo lab

Our application team can perform live demonstrations and feasibility studies at our fully equipped demo lab for nanoprobing and semiconductor failure analysis. Feel free to contact us for a visit!
Cannot travel to Switzerland? Ask for a personal live web demonstration or register to one of our frequent webinars!

Services

Contact us at: applications@imina.ch

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In Situ NanoCharacterization Solutions