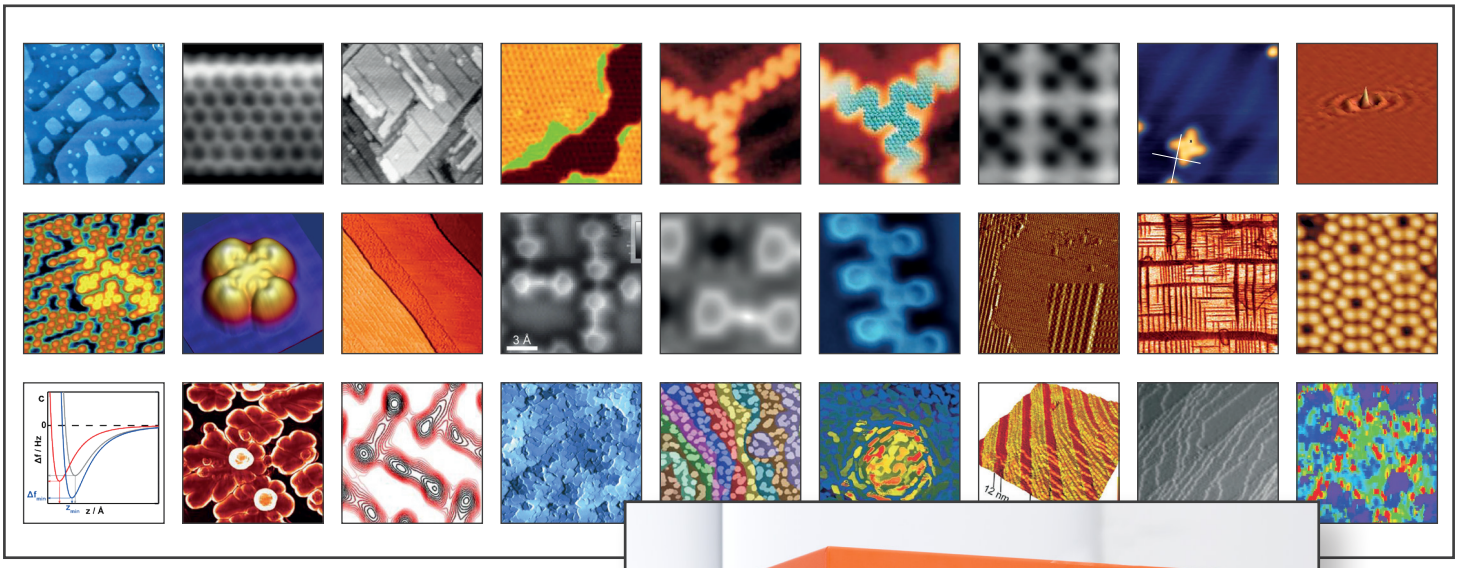
MATRIX 4

MATRIX 4 – The Standard in SPM Control



- Intuitive and flexible experiment control
- Best-in-class noise floor
- Full 64-bit software
- Modular upgrade paths
- 600 installed controllers

scientaomicron

MATRIX 4

MATRIX 4 – The Standard in SPM Control

The MATRIX 4 Control System builds on 30 years of experience in SPM technology and unlocks the full capacity of our leading-edge Scanning Probe Microscopes.

The MATRIX architecture couples advances in high-speed, low-noise digital electronics with the requirements of the latest SPM applications to offer the user an unprecedented level of signal quality, measurement speed, and experimental flexibility. The expandable design provides solutions for future challenges in Scanning Probe Microscopy.

Best-in-class noise floor

The MATRIX control system is well known for its low noise level when compared to other SPM controllers.

Flexible Experiment Control

The MATRIX Automated Task Environment (MATE) and the remote access interface provide individual experiment control.

The remote access interface can directly be addressed by LabVIEW, C/C++, or many other applications.

Modular upgrade paths

Scienta Omicron's MATRIX concept and architecture allow for easy upgrades of functionality. Support to upgrade previous versions of MATRIX ensures modern and up-to-date SPM control.

Full 64-bit software

MATRIX 4 offers full 64-bit software with enhanced features including 4096x4096 pixel images, larger size spectroscopy files, and improved operational stability. Supports full software and remote control of all coarse movement.

Proven performance with 600 build instruments

With 600 units shipped, MATRIX truly enables forefront research around the world.

All generations of MATRIX are still supported and can utilize these new hardware and software developments.

Benefits and Properties:

- Intuitive and flexible Experiment Control
- Best-in-class noise floor
- Full 64-bit software
- Modular upgrade paths
- 600 installed controllers

Spectroscopy

MATRIX 4 offers a broad range of tools for spectroscopy applications including single point or volume spectroscopy. Any channel can be recorded as a function of V, Z, or a combination of both. Hardware advancements including a multiprocessor approach and the proprietary MATRIX Bus System ensure accurate timing and synchronization.

The spectroscopy panel provides the convenient ability to set parameters such as start and end values, number of data points, grid settings, slew rates, delay times etc. In addition MATRIX 4 offers advanced and customizable spectroscopy modes.

Standard Point spectroscopy actions are initiated using the 'mouse tools' in data display windows.

The available operating modes include

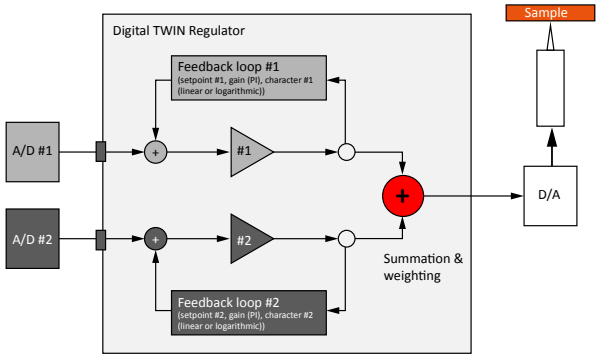
- I (V), dI/dV
- z-ramps (Z)
- Combinations of I(V) and z-ramps

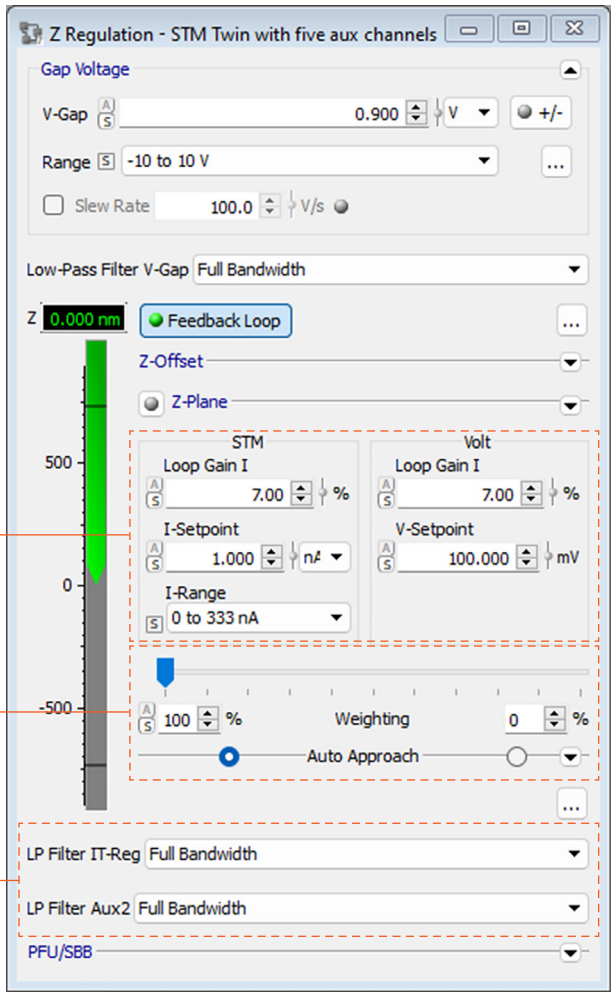
Digital Regulator

The digital feedback employs a two-branch design to optimize distance regulation on one branch by various filter settings while the second branch carries and acquires the primary physical signal. Sophisticated low-noise DAC technology provides true physical 20-bit resolution (monotonic within 1 LSB) over the full z-scanner range. By employing advanced oversampling and filtering algorithms, noise is significantly reduced and effective z-resolution is enhanced to more than 24 bit. Instead of mixing or switching input signals, the TWIN regulator uses two independent fully featured feedback loops, allowing for separate but simultaneous optimization of the two regulation signals.

Therefore, the TWIN regulator dramatically improves the efficiency of research work by enabling a seamless transition between modes, external signals can be filtered for feedback operation.

The TWIN regulator also opens up chances for unique experiments by combining different feedback signals. The MATRIX software already comes with a selection of predefined experiments for using the TWIN regulator like using an external input as second feedback channel.





Optimized regulator with independent adjustable P & I contribution

Dual Regulator mixing ratio of signal branches. Signal selection for auto approach

Independently filter input signals for feed-back loop operation

Channels

Numerous internal and external channels for all signals can be set automatically ore individually for initial delay and oversampling.

The maximum sampling rate of 400 kHz, is usually used to oversample the acquired data reducing noise and improving resolution.

Manipulation

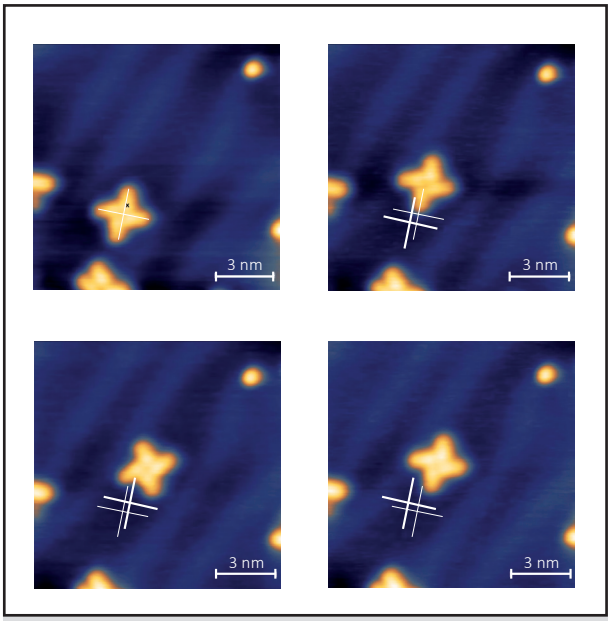
Manipulation and lithography applications are an essential part of the MATRIX 4 tool box.

An exciting example of molecule manipulation using MATRIX controllers was demonstrated in the international molecule-car race in April 2017 in Toulouse (France). Vehicles consisting of a few hundred atoms were powered by electrical pulses during the 3 hour race.

MATRIX 4 allowed them to successfully navigate on a racecourse made of gold atoms, 100 nanometers in length. Four of the six nanocars were simultaneously driven with the LT NANOPROBE.

The race, which was organized by the CNZS, was a scientific and technological challenge made possible through the advancements of the MATRIX 4 SPM controller.

The race teams in the remote control room.

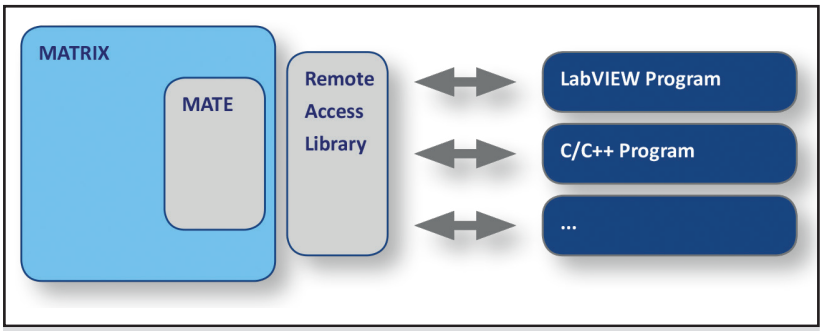


Manipulation of a 4-Acetyl-biphenyl (ABP) molecule [1,2] on Au(111), driven by inelastic tunneling effect. Data obtained during the TU Dresden team training session for the nanocar race at the PicoLab in Toulouse. Data by courtesy of F. Moresco, TU Dresden, Germany.

References: [1] F. Moresco et al., ACS Nano, 7, 191 (2013); [2] F. Moresco et al., ACS Nano, 9, 8394 (2015)

Scripting by MATE

The MATRIX Control System includes the MATRIX Automated Task Environment (MATE) as standard. The MATE environment provides a flexible and effective way of designing advanced experiments using either the internal script editor or external software packages. Using either solution any user can expand upon the capabilities of standard experiments, automate repetitive tasks, and change the behaviour of experiments at execution time. Combined with a Remote Access Library, any application that is capable of calling C-language functions can utilize the full set of MATE features for controlling experiments remotely. With MATE Remote Access, National Instruments LabVIEW, Matlab, Python, custom C/C++, or other applications can read/inquire and write/modify the values of experiment parameters, react to changes of such parameters, call functions of MATRIX Experiment Elements and objects, and even interact with MATE scripts. A comprehensive and easy-to-use set of C-language functions allows any software package to control MATRIX experiments.



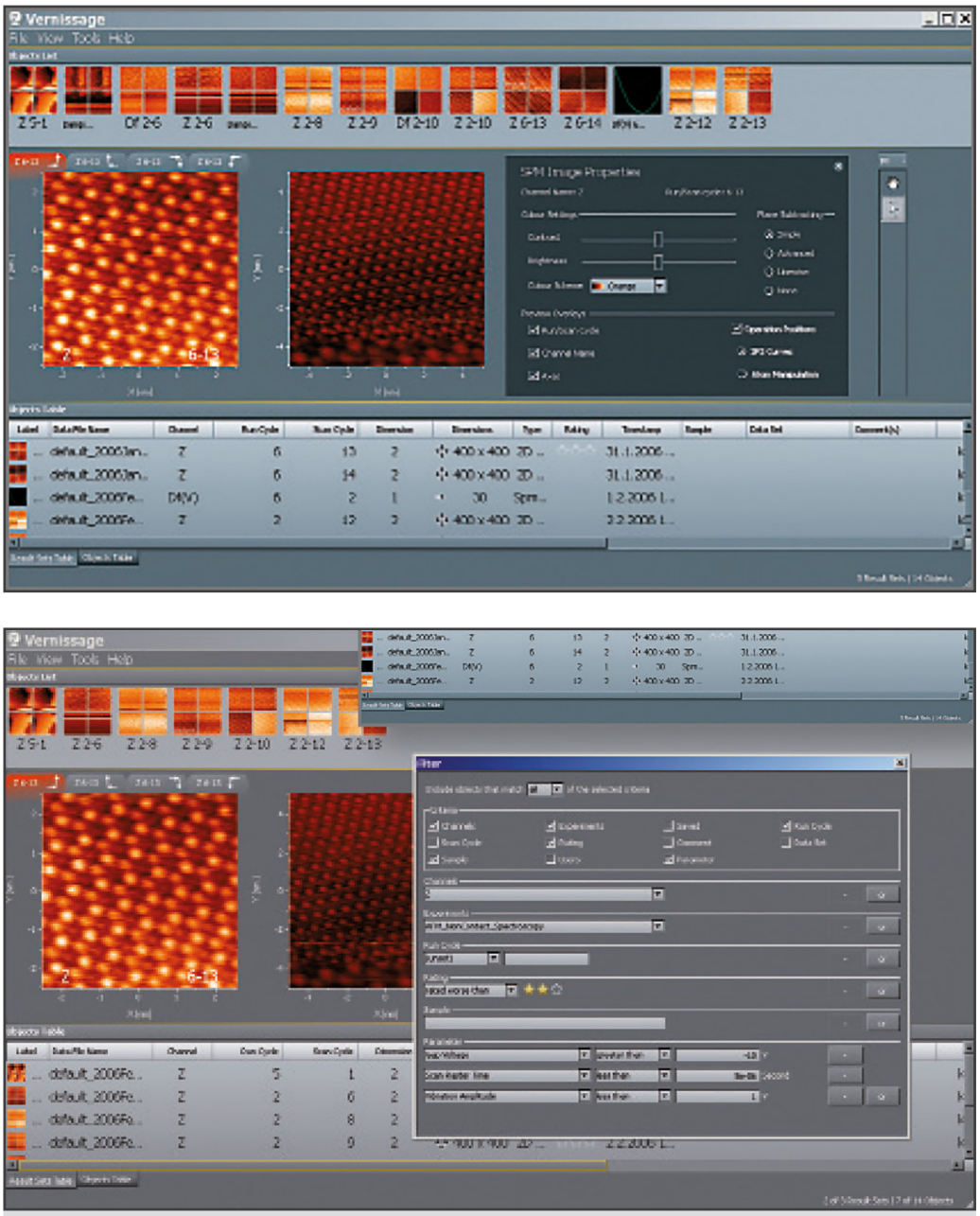
The MATRIX Automated Task Environment (MATE) allows to control MATRIX remotely by script or third party software.

Vernissage

The ability to manage huge amounts of data sets is crucial for successful research work! Simply use the MATRIX software tool ‘Vernissage‘ for this job.

Vernissage is a databased tool and supports data preview, browsing, advanced filtering and sorting. Also provided are dedicated plug-ins for data export.
Supported formats include: JPG, TIFF, BMP, ASCII, IGOR Pro and the Scienta Omicron Flat File Format (FFF).

Vernissage is included in the MATRIX Control system, but runs independently from the MATRIX data acquisition software. As a proprietary Scienta Omicron product MATRIX users can install the software on as many computers as required. This offers users an efficient and cost-effective way to manage and work with data.



Vernissage allows to brows, filter, select and export your data. Configurable views give access to all relevant data parameters.

Technical Data

MATRIX 4 STM Control System STM Signal Conversion:

Two branch design for signal measurement and signal feedback

- ADC resolution 16-bit; 400 kHz sampling rate, switchable low pass (300 Hz, 1 kHz, 3 kHz, 10 kHz, 30 kHz)
- Gap voltage range: +/- 10 V and +/- 1 V (Standard configuration) 16-bit resolution, external input for modulation with switchable low pass (300 Hz, 3 kHz, 20 kHz, 56 kHz, full BW)
- Maximum spectroscopy acquisition time per spectroscopy point: 19 seconds
- Simultaneous over-sampling of all ADCs

Channels:

- min. 24 internal plus 6 external measurement channels in the basic STM configuration
- external inputs for gap voltage (modulation spectroscopy)

Regulator:

- DAC: true 20-bit resolution over full z-scanner range, monotonic within 1 LSB, low noise
- Z-imaging with dynamic resolution of >24 bit
- 2 independent digital processor inputs, configurable link to any digital signal source
- 2 independent analogue processor inputs, 16 bit, 400 kHz with switchable low pass: 1 kHz, 3 kHz, 10 kHz, 30 kHz, 100 kHz
- External offset input (ZOFFSET) with switchable low pass: 3 kHz, 10 kHz, 20 kHz, 60 kHz

Up to 12 ADCs:	3 x 4 independent analogue input channels, ADC: 16-bit resolution, DC...400 kHz. Simultaneous oversampling of all ADCs
XY Scanner:	3 x 2 independent analogue output channels, DAC: 16-bit resolution, DC ... 400 kHz switchable regeneration low pass (300 Hz, 3 kHz, 30 kHz, 100 kHz) • Scan Generation & Data sampling • Digital scan generation • Output channels for external devices • Image rotation • Hardware supported zoom

A superior hardware technology allows for 200 kHz acquisition rate (5 µs per image pixel) which equals to 10 images per second at 100 x100 pixel in forward/ backward operation for fast scan operations. With a const. sampling rate of 400 kHz, noise is automatically reduced.

CRTC:	Trigger control input/output
Piezo driver:	Output voltage range +/- 135 V low noise (< 300 nVrms/√Hz, 100 kHz bandwidth)
Coarse positioning:	16-channels, variable step size and frequency, control by remote-box MATRIX-SPM-Software or scripting
Signal access:	Through front panel mounted BNC connectors
Configuration includes:	MATRIX Control System, Software, Vernissage Data Management Tool, Windows 11 PRO (64-bit) control computer, 1 x 27" LCD monitor

Functions included

TWIN Regulator:	Two independent branches for feedback parameters with independent settings for feedback value and loop gain (i.e. It & Aux channel, etc.)
Spectroscopy:	Single point & grid, voltage & z-ramps, varied z-spectroscopy, dual mode spectroscopy, user specific spectroscopy with MATE (MATRIX Automated Task Environment), multiple curves, reversal ramp, modulation switches, trigger signals to synchronize with third party equipment, gap pre-set (parameters VGap, current set point, feedback loop gain can be set to different values for a spectroscopy measurement)