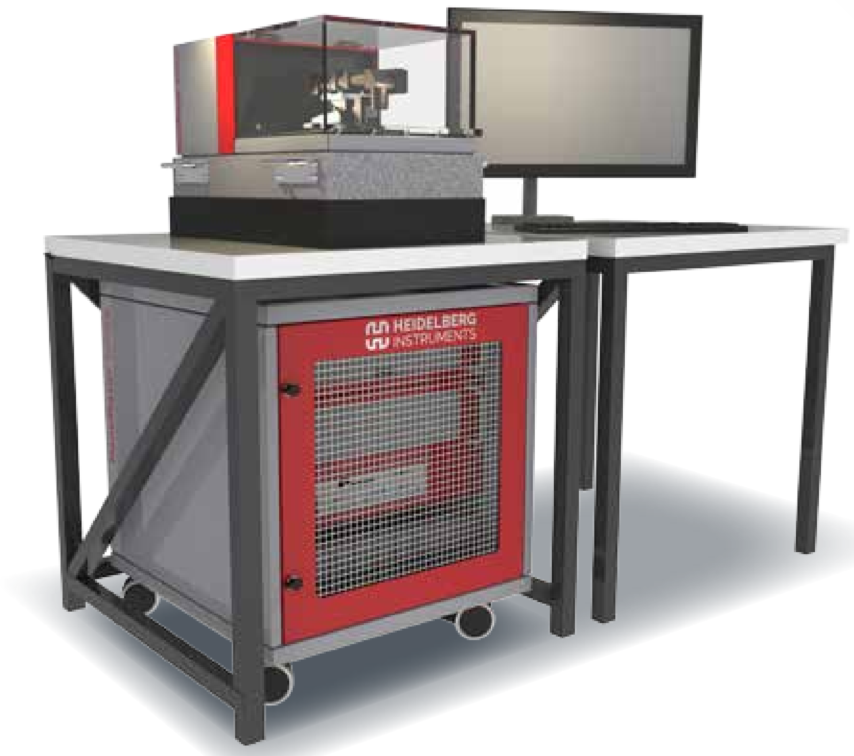
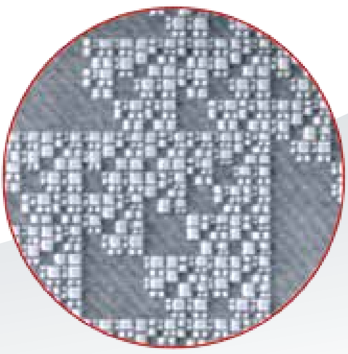
HEIDELBERG INSTRUMENTS

NanoFrazor Scholar

Advanced Nanolithography for Everyone





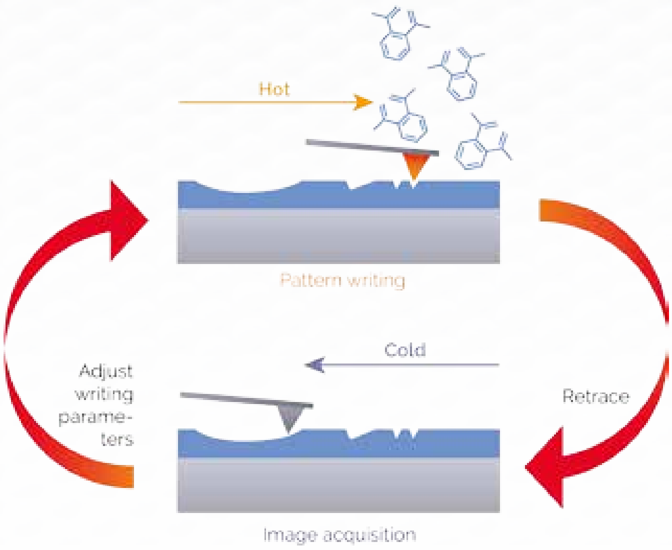
www.himt.ch

NanoFrazor Scholar

TABLETOP DIRECT WRITE NANOLITHOGRAPHY & AFM

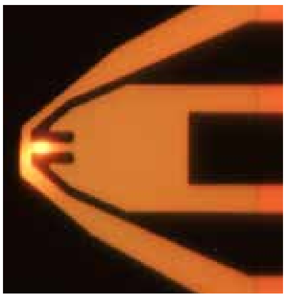
The NanoFrazor Scholar is an entry-level nanopatterning system with many unique capabilities. It is particularly well-suited for academic research groups as a simple tool to easily create their own high-quality nanopatterns and devices.

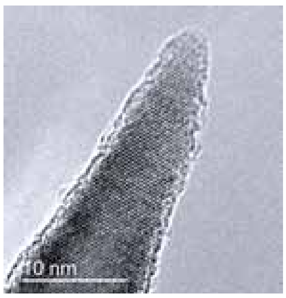
NanoFrazor lithography systems are based on thermal scanning probe lithography. Core of the NanoFrazor technology is an ultra-sharp heatable probe tip which is used for writing and simultaneous inspection of complex nanostructures. The heated tip creates arbitrary, high-resolution nanostructures by local sublimation of resists. Standard pattern transfer methods like lift-off or etching can be applied.



Patented "Closed-Loop Lithography" ensures high patterning accuracy

NANOFRAZOR CANTILEVERS



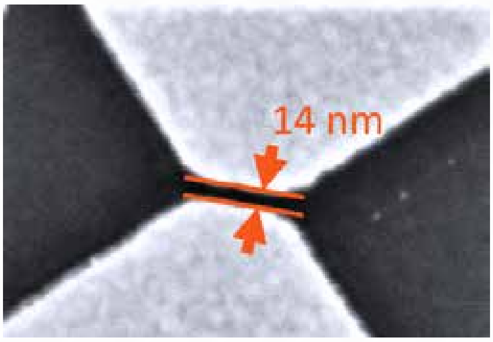


- Ultra-sharp Si tip
- Integrated tip heater
- Integrated force actuation
- Integrated topography sensor
- Fast exchange and calibration

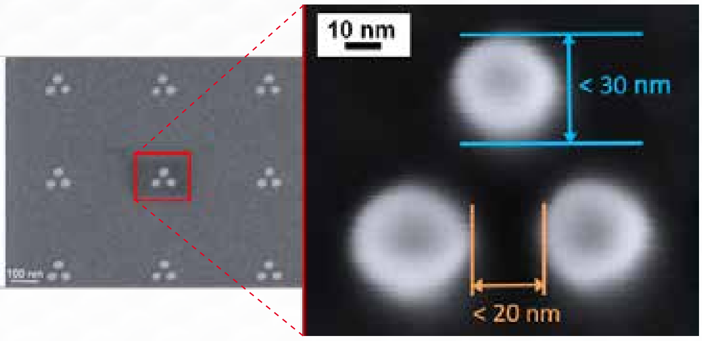
RAPID PROTOTYPING OF NANODEVICES

- Thermal probe lithography is the fastest of all scanning probe lithography methods (few µs exposure per pixel).
- Direct resist removal and in-situ inspection enable fast turnaround times.
- Detection of features buried under resist (e.g. 2D material flakes, nanowires, ...) for quick and accurate overlay of electrodes.

ULTRA-HIGH RESOLUTION



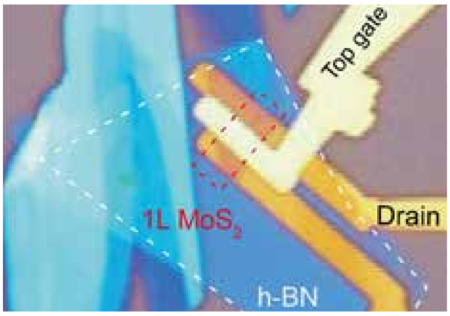
Gap between two metal electrodes made with a simple lift-off process



Trimers etched into gold

NANOPATTERNING OF SENSITIVE MATERIALS AND DEVICES

NanoFrazor lithography	Charged particle lithography (EBL or FIB)
The tip only heats the top resist layer. Material below the resist (e.g. 2D materials, topological insulators, nanowires, etc) remain completely unharmed during patterning of the resist. The NanoFrazor can be incorporated inside a glovebox. This facilitates nanolithography on samples that deteriorate in air.	Exposure to high-energy charged particles damages samples by unwanted creation & scission of covalent bonds, vacancies, trapped charges or lattice defects. Such defects deteriorate the device performance when using sensitive materials or designs.

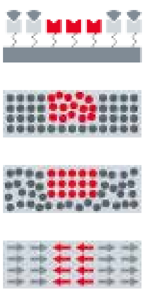


MoS_2 top-gate transistors with record on/off ratios of 10^{10}. Significantly less damage and resist residues compared to contacts made by EBL lead to vanishing Schottky barriers at the contacts.

Courtesy of Riedo group at NYU, see Zheng et al, Nat. Electronics 2019

NanoFrazor Scholar inside a custom designed glovebox from MBraun

NANOSCALE MATERIAL CONVERSION



The heated tip can alternatively be used to induce highly localized modification of materials: Deprotection of functional groups, precursor conversion, amorphization, crystallization, change of magnetic orientation, etc.

OTHER UNIQUE CAPABILITIES

- **3D grayscale lithography** with unprecedented accuracy enabled by closed-loop lithography
- **Accurate overlay and stitching** without artificial markers, achieved by in-situ AFM

NanoFrazor Scholar
SYSTEM SPECIFICATIONS

Writing performance	
Minimum structure size [nm]	20
Minimum lines and spaces [half pitch, nm]	30
Grayscale / 3D-resolution (step size in PPA) [nm]	3
Writing field size [X µm x Y µm]	50 x 50
Field stitching accuracy (markerless, using in-situ AFM imaging) [nm]	50
Overlay accuracy (markerless, using in-situ AFM imaging) [nm]	50
Write speed (typical scan speed) [mm/s]	0.5
Write speed (50 nm pixel) [µm^2/min]	500

AFM imaging performance	
Lateral imaging resolution (feature size) [nm]	10
Vertical resolution (topography sensitivity) [nm]	0.2
Imaging speed (@ 50 nm resolution) [µm^2/min]	500

System features	
Substrate sizes	1 x 1 mm^2 to 50 x 50 mm^2, 0 – 20 mm thickness (100 x 100 mm^2 possible with limitations)
Optical microscope	3.6 µm optical resolution, 1.5 mm x 1.1 mm field of view
Magnetic cantilever holder	Fast (< 1 min) and accurate tip exchange
Housing	Compact housing with separate controller rack, active vibration isolation (small footprint) or passive vibration isolation (slightly better performance) included.
Software features	GDS and bitmap import, AFM image analysis and drawing for overlay, fully automated calibration routines, Python scripting

NanoFrazor cantilever features	
Integrated components	Tip heater, topography sensor, electrostatic actuation
Tip geometry	Conical tip with < 10 nm radius and 750 nm length
Tip heater temperature range	25 °C – 1100 °C (< 1 K setpoint resolution)

System dimensions & installation requirements	
Height × width × depth	50 cm x 32 cm x 30 cm
Weight	100 kg
Power input	1 x 110 or 220 V AC, 10 A
Gas input	Compressed air (> 4 bar) for passive vibration isolation
Vibration and noise level	Ambient acoustic noise levels need to be kept below 40 dB for best performance. A strong table is required if the active vibration isolation is chosen. Floor requires vibration level VC-B.

Other considerations
Recipe book with detailed descriptions of various processes is included (regularly updated with software).
Cantilever tips degrade over time (> 50 h patterning possible). Exchange is fast and low cost for tool owners.
A cleanroom or special laboratory is not required. No vacuum needed.
Unique capabilities make it easy to receive government funding (for system itself or later research projects).

Please note: Specifications depend on individual process conditions and may vary according to equipment configuration. Write speed depends on pixel size and write mode. Design and specifications are subject to change without prior notice.

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