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DPN 5000 System

Introduction

NanoInk's DPN 5000 System is a dedicated, versatile instrument capable of nanopatterning a variety of materials with nanoscale accuracy and precision. With NanoInk's proprietary MEMs devices and deposition protocols, DPN 5000 System users can easily design, create, and analyze nano and microstructures on a variety of substrates. With its integrated, fully-functional atomic force microscope (AFM), the DPN 5000 System is optimized for the patterning and imaging of sub-micron sized features using molecular inks.

Applications

The DPN 5000 System is ideal for nanoengineering and biomaterials applications which require nanoscale printing and imaging capabilities, such as:

- Nanoscale optical element (e.g. diffraction grating) creation
- Nanostructured functional hydrogel development
- Cell polarization studies
- Metamaterial research
- Nano and microstructure functionalization

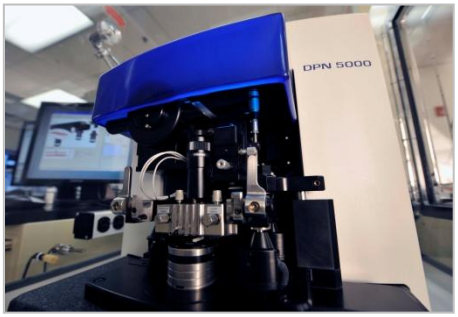

Figure 1: The DPN 5000 System.

Standard Components

- DPN 5000 System scanner, stage, and controller
- Multi-pen Arrays, Inkwells, and Substrates
- Printing Solutions Kit (MHA & ODT)
- On-site system installation
- 3 days user training
- Getting Started Guide, User Manual & CD
- 1 year warranty, parts & labor

Optional Components

- Global Environmental Chamber (EC-004-06/07)
- Option, 2D nano PrintArray™ (DPN-0302-01/02)
- Option, Extended AFM Modes Kit (DPN-0310-01)
- Option, Heating & Cooling Sample Stage (DPN-0309-01)
- Option, Micropositioning Stage (DPN-0311-01)
- Option, Plasma Cleaner (DPN-0312-01/02)

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- Option, Extended Limited Warranty (DPN-0050-01)
- Vibration Isolation, both passive (ATB-001-01) and active (ATB-0200-00)
- Various Printing Kits, including but not limited to Protein, Acrylic Polymer, and PEG Hydrogels

Features and Benefits

Along with the ability to nanopattern a variety of materials with nanoscale accuracy and precision, the benefits of the DPN 5000 System include:

- Rapid fabrication of patterns with nanoscale features
- Immediate characterization of nanoscale patterns using fully-functional, integrated AFM
- Scalable patterning with NanoInk's Multipen "pen" tip arrays
- Nanoscale registration and substrate mapping capabilities
- Controlled patterning environment via environmental and vibration controls

Rapid, Precise Fabrication

The DPN 5000 allows the researcher to easily fabricate variety of patterns with nanoscale features without the need for a master. NanoInk's InkCAD™ Software is the engine behind this rapid prototyping capability, supporting true CAD performance, enabling the design and execution of patterns ranging from simple arrays of dots to sophisticated formats imported from GDS II file formats. Users can also calibrate diffusion characteristics of molecular printing materials using InkCal™ and then use this data to control pattern feature sizes. High resolution, closed- loop x, y z flexure stages begin printing newly designed patterns within minutes of design finalization.

Immediate Pattern Characterization

With a fully-functional AFM customized for nanolithography, DPN 5000 System can characterize printed patterns immediately after deposition or at a later time. The AFM scanner features a focused low coherence laser ideal for low noise lateral force microscopy (LFM) imaging, and a photodetector with a large working range and z-sum switch to accommodate laser alignment on NanoInk's multi "pen" array tips coated with ink. At any point during their workflow, users can seamlessly switch to NanoInk's dedicated AFM software, SPM Cockpit™, for further characterization using contact, AC, EFM, MFM, or force distance modes.

Scalable Patterning

Parallel patterning with multiple pens maximizes DPN 5000 System pattern substrate area. A single NanoInk Multi-pen Array sample contact event can simultaneously deposit tens to millions of features. To ensure consistent printed features across an array, the DPN 5000 System incorporates a coarse Z-tripod stage with 3 independently adjustable Z-motors and manual z-piezo control which enable the user to level both 1D and 2D pen arrays.

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Nanoscale Registration and Substrate Mapping

Nanofabrication is a multi-step process that often involves repeated steps such as deposition, etching, plasma cleaning, and analysis, requiring the user to temporarily remove either the sample or pen "tip" array from the system. To continually return to particular nanoscale locations, the DPN 5000 System uses InkCAD Software NanoMap and MicroMap to overlay optical and AFM images of sample locations and tracks them to global system coordinates. Users simply point and click - the system automatically returns to the desired location for further fabrication or imaging, saving hours of searching for a particular nano or microstructure.

Controlled Patterning Environment

The ability to control humidity and temperature plays a critical role in the ability to reproducibly deposit DPN lithographic features. The DPN 5000 System features environmental control options include a global environmental chamber with computer controlled temperature and humidity sensors, and a closed-loop localized heating/cooling sample stage. In addition, the DPN 5000 System is compatible with commercial passive and active vibration isolation tables for applications that require this level of environmental control.

System Specifications

Patterning Specifications

<table>
<tr><td>High resolution X, Y stage control</td><td>90 µm x 90 µm closed-loop flexure stage
1 nm sensor resolution, 0.5% linearity</td></tr>
<tr><td>High resolution Z-stage</td><td>8 µm range
1 nm sensor resolution, 1% linearity
Full tip control including Tip-Lift, and Tip-Extend</td></tr>
<tr><td>Pattern registration to substrate</td><td>100 nm</td></tr>
<tr><td>Throughput</td><td>System throughput is application-dependant; typical* examples for printing on gold an array of 50 nm spots of alkanethiols spaced 100 nm apart, spot density of 100 spots/µm^2, with printing done using single "pen" tip, 1D "pen" tip array, or 2D "pen" tip array:
<table>
<tr><th>"Pen" Type</th><th>"Pen" Tips/ Array</th><th>Time (min)</th><th>Patterned Area</th><th>Number of Spots</th></tr>
<tr><td>AFM probe tip</td><td>1</td><td>30</td><td>100 µm^2</td><td>10,000</td></tr>
<tr><td>1D pen array</td><td>26</td><td>30</td><td>2,600 µm^2</td><td>260,000</td></tr>
<tr><td>2D pen array</td><td>55,000</td><td>30</td><td>5.5 mm^2</td><td>550 million</td></tr>
</table>
*With the DPN 5000 System's manual "pen" tip re-loading process, throughput with liquid printing materials can be more limited depending on re-inking requirements.</td></tr>
<tr><td>Feature sizes</td><td>50 nm to 10 microns; InkCal provides control of feature sizes</td></tr>
<tr><td>Coefficient of variation</td><td>5-20% for feature CVs across "pen" tip array for nanoscale features of molecular printing materials</td></tr>
<tr><td>Leveling</td><td>Manual leveling, 3 independently adjustable Z motors level scanner assembly with substrate, tip 3.5° and tilt 7°</td></tr>
<tr><td>Re-inking of pen arrays</td><td>Manual re-inking</td></tr>
<tr><td>Sample stage</td><td>Maximum sample size: 2" in diameter, < 1.5" thick</td></tr>
<tr><td>Coarse XY sample stage motors</td><td>Minimum 3 µm step size, 1" x 1" travel; maximum 2.5 mm/sec slew rate</td></tr>
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Imaging Specifications

AFM imaging specifications	Z-noise floor 0.06 nm (in optimal vibration conditions) Z out of plane motion +/- 30 nm over 90 microns Z bit resolution < 0.001 nm XY, XZ, YZ crosstalk < 1%
Low noise LFM imaging	7 x 20 micron low coherence laser with adjustable laser focus Photo-detector with extended range & Z-sum switch
Optical imaging specifications	3 micron, 10x lens, 365x to 1140x Computer controlled zoom (4x) and focus capability 4 mm x 4 mm panning for multi "pen" tip array visualization

Software Specifications: InkCad™ 4.0 Software Interface

Multiple user compatibility	User profiles save all AFM and DPN lithography setting for individual users
Pattern Design	Supports complex, multi-layer pattern design User-defined via layered structural hierarchy Complex patterns of dots, lines, and polygons with arbitrary structures GDS II file imports Dots & Lines, Lattice, NanoWord and InkMap for easy creation of complex patterns Order of lithography previewer
Feature size control	InkCal executes, measures, and controls printed feature sizes
X, Y alignment routines	MicroMap, NanoMap, and NanoFind guide the user through the alignment process
Pen array/sample leveling routines	Routines guide the user through leveling processes
Compatibility – SPM Cockpit Imaging Software	Seamless handoff from InkCAD to SPM Cockpit Imaging Software User settings saved through configuration files
Modes – SPM Cockpit AFM Imaging Software	Full AFM imaging suite, AC Mode, Contact Mode, LFM, force distance curves (standard); Optional EFM, and MFM

Consumables, Printing Materials, and Substrates

Multi-pen Arrays & Inkwells

Arrays of "pen" tips are optimized for DPN deposition of one or more printing materials in large-area patterns. "Pen" tip arrays are made of silicon nitride and contain A-frame and diving board shaped cantilevers. "Pen" tips are loaded using NanoInk Inkwell reservoirs.

Pen Type	Pen Tips/ Array
C	10
D	24
F	50
E	18
M	12
2DnPA	55,000

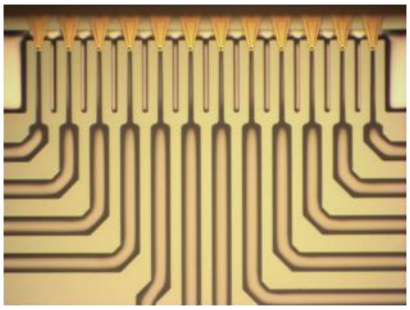

Figure 2: Type M pen array dipping into matching Inkwell array.

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Printing Materials & Substrates

The DPN 5000 System is capable of depositing and imaging molecular materials and liquids with viscosities ranging from 1-20,000 cP on a variety of substrates.

Supported printing materials:

- Proteins
- Nucleic acids
- Lipids
- Nanoparticles
- Polyethelyne glycol
- UV-curable polymers
- Heat-curable polymers
- Glycerol
- Silanes
- Thiols
- Catalysts

Compatible substrates:

- Silicon
- Silicon dioxide
- Silanized surfaces
- Amine functionalized slides
- Metals
- PDMS
- Hydrogels
- Polystyrene

Proven Protocols and Support

Leveraging years of experience and expertise in nanolithographic techniques and applications, NanoInk is committed to developing and thoroughly testing deposition protocols for a multitude of scientifically important materials (including proteins, DNA, hydrogels, polymers, silanes, thiols, and nanoparticles). These protocols, and accompanying inks, substrates and pens, are made available to DPN 5000 customers, and are accompanied by a variety of levels of customer support including e-mail, phone, remote desktop, on-site, and forums.

Ordering Information

Item Name: System, DPN 5000
Part #: DPN-1502-01

Learn more about NanoInk products and services at www.nanoink.net. Or call us at 847-679-NANO (6266).