TERA Fab™

series

TERA print

Introducing the world's first beam pen lithography tool.

POWERFUL

Pattern cm^2 areas with diffraction unlimited resolution in a high-throughput manner (up to 20,000 tips act in parallel).

VERSATILE

Change a pattern instantaneously as no photomask is required.

Pattern features ranging from sub-250nm to microns in deliberate fashion using the same tip array.

Independently control each tip in the array.

Create the same microscale pattern with each tip or a macroscale pattern with thousands of tips acting in an orchestrated manner.

ENABLING

Rapidly prototype active circuits and functional devices.

Write patterns in registry with existing patterns and nanostructures.

Perform highly localized photochemical reactions and synthesis in air and liquid.

And more...

YET SIMPLE

Start patterning after only a few hours of training, made possible through an intelligent, easy-to-use design of the instrument's hardware and software.

Beam Pen Lithography

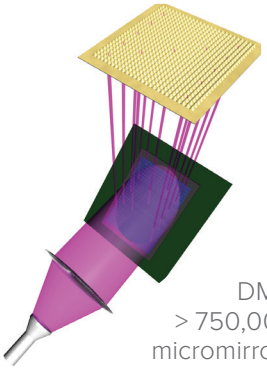
A new and powerful way to rapidly prototype and fabricate nanostructured patterns and devices.

The beam pen lithography (BPL) technology that lies at the heart of the E-series platform, which was invented in the Mirkin group at Northwestern University, provides several key capabilities. BPL is a highly scalable and versatile photolithographic approach that enables the creation of arbitrary patterns over a large area and with a diffraction-unlimited, sub-250nm resolution.

A key advantage of BPL is the ability to do mask-free photolithography using a two-dimensional array of pyramidal-shaped tips coated with an opaque material, with apertures at the apexes of the tips with a diameter as small as only a couple hundred nanometers. Essentially, the tip arrays can be used to direct and focus light, enabling our users to perform near- or far-field photolithography in a highly parallelized manner.

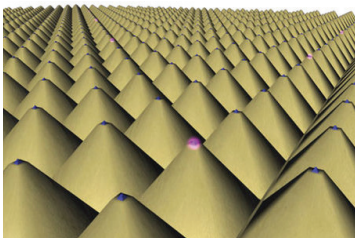
Additionally, we have integrated a digital micromirror device (DMD) that permits the independent actuation of each probe with two different LED light sources, ultimately enabling our users to generate nanopatterns of any design across square micrometer to centimeter areas.

This tool can be used to prototype functional electronic devices in a mask-free fashion and, in addition, provides a unique platform for performing high-throughput nano- to macroscale photochemistry relevant to biology and medicine.

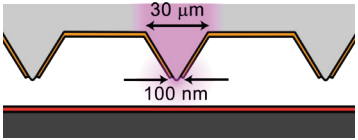


DMD
> 750,000
micromirrors

massively parallel BPL tip array with millions of tips



< 250nm resolution



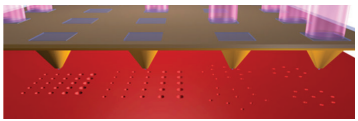
Enabling a wide variety of applications

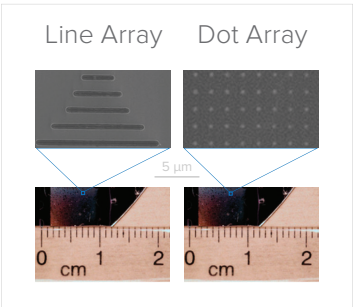
in electronics, biology, medicine, and chemical synthesis.

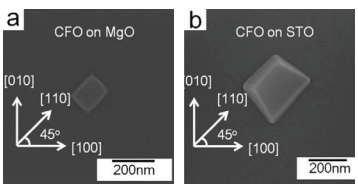
Confined Chemical Synthesis

BPL enables the synthesis of millions of complex nanostructures over large area with nanoscale resolution and well-controlled shape, spacing, and pattern symmetry. By generating millions of attoliter volume nanowells that serve as “nanoreactors”, inside which nanostructures are synthesized from their precursors, the generation of nanometer scale oxides in single crystalline or textured forms and epitaxial to the underlying substrates has been demonstrated.

This method provides a general solution that allows one to rapidly screen structural parameters of nanostructures, such as oxides, comprising three or more elements with exciting new properties.



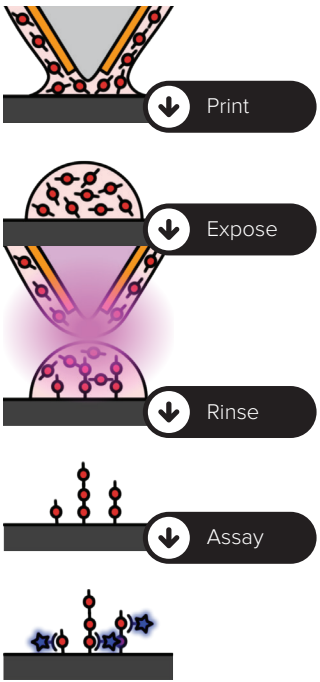




Highly Localized Photochemistry

This tool is especially promising for biochemical applications because of its ability to immobilize and photochemically synthesize/modify many types of biological structures with feature sizes that are similar to those found in biological and living systems. Using the thousands of independently actuatable tips in a BPL array to localize light on a surface, one can precisely control the exposure and, therefore, the rate of the photochemical reactions at each position – introducing the ability to generate multiplexed arrays.

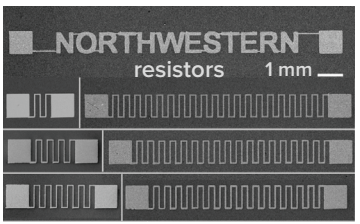
BPL provides the means to induce photochemical reactions in hydrogels, brush polymers, oligonucleotides, carbohydrates, and other molecules.

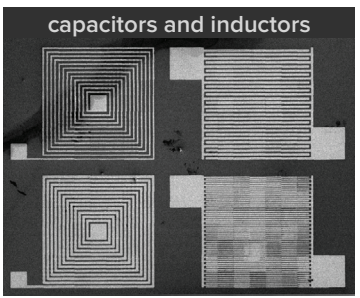


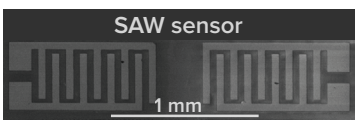
Functional Electronics

The ability to fabricate devices and circuits is another powerful capability of the E series. By coordinating the action of multiple tips, complex structures such as resistors, capacitors, inductors, and surface acoustic wave transducers, can be rapidly produced in a mask-free fashion.

BPL efficiently addresses multiple scales, enabling the fabrication of, for example, 4-mm-long, 2-µm-wide resistors or capacitors comprised of an array of <200nm wires connected by 2-µm-wide lines. Importantly, such circuit elements are fully functional, exhibiting Ohmic behavior in current-voltage characterization.







TERA-Fab™ E Series: Beam Pen Lithography (BPL) Nanofabrication System

HARDWARE

STAGE

X-Y scan range (closed-loop)
100µm x 100µm typ., 95µm minimum

Z travel range (closed-loop)
100µm typ., 95µm minimum

X-Y-Z tolerance (closed-loop)
1nm typ.

Integral nonlinearity (X-Y-Z)
0.1% typ.

Repeatability
<10nm typ.

Manual X-Y positioning stage
12mm x 12mm travel range

Motorized Z axis
12mm travel range
0.75µm bidirectional repeatability
2mm/s maximum speed

Θ_X-Θ_Y 2-axis angular positioning
±3.5° angular range
$4x10^{-5°}$ angular resolution

OPTICS

Motorized X-Y positioning stage
35mm x 35mm travel range

Motorized Z focusing axis
50mm travel range

Digital Light Processing (DLP) system
DLP5500 0.55" XGA Chipset
1024 x 768 resolution

Light Sources
UV-LED Light Engine (405nm) 4-6W
Green LED Light Engine (532nm) 12.5 W

5x Objective M Plan APO
34mm working distance
2µm resolving power
1.28mm x 0.96mm field of view

Camera
12 Megapixel resolution (4000 x 3000), 1/1.7" sensor, 1.85µm x 1.85µm pixel size

ADDTIONAL FEATURES

- Easy access noise isolation enclosure
- Integrated damping and vibration isolation
- Humidity and temperature sensors
- Magnetic sample holder capable of accommodating samples
  > 20mm x 20mm

SOFTWARE

CUSTOM SOFTWARE SPECIFICATIONS FOR MANUAL OPERATION

- X-Y-Z piezo scanning stage
  - Set movement speed for each axis individually or all axes within 1-100µm/s range
  - Move each axis individually or all axes to an absolute position or relative to current position within 100µm range
- Z position of the sample stage
  - Set movement speed of the motor in 0-2mm/s range
  - Move sample stage to an absolute position or relative to current position within 12mm range
  - Tilt pen array in Θ_X and Θ_Y directions by a specified angle with a minimum increment $4x10^{-5°}$

STAGE LEVELING

- Automated pen array engagement with a substrate
- Real-time 4 corner contact monitor for manual alignment of pen array to the substrate plane
- Custom feedback-controlled algorithm for automated alignment of pen array to the substrate plane

PATTERNING

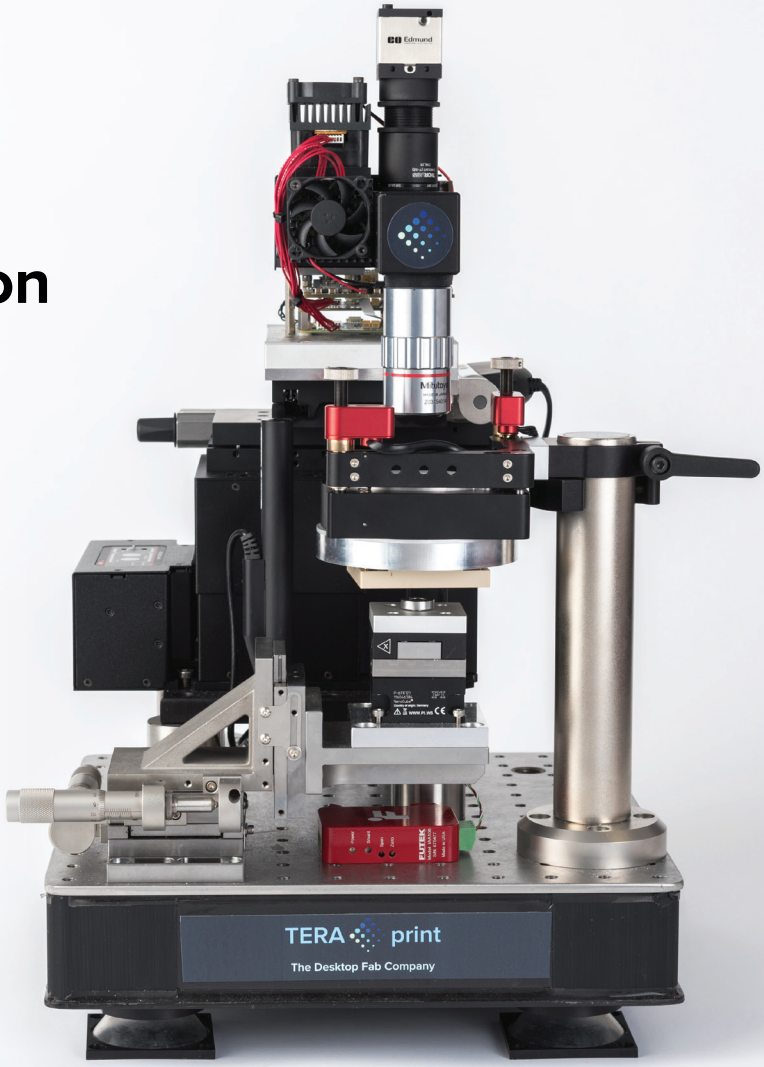
- Creation of orthogonal dot patterns
- User specified dot spacing, dwell time, light exposure time, light patterns, and patterning speed
- Ability to save, load and merge generated orthogonal patterns
- Pattern preview window
- Capability to define a custom pattern by loading an image; automatically generated sequence of patterns; user specified dot spacing, light exposure time and patterning speed

OPTICS

- Integrated digital zoom control
- Integrated light intensity control
- Ability to control the illumination area by specifying the number of active DMD mirrors

Nanofabrication Reimagined.

Large Area.
High Resolution.
Mask-Free.
All at your desktop.



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