NSCRIPTOR™ 2D nano PrintArray™

Dip Pen Nanolithography® (DPN®) is the process of writing nanoscale patterns of molecular "ink" onto a sample substrate via a coated SPM tip. NanoInk’s NSCRIPTOR™ DPN System is a fully-integrated hardware and software system that is optimized for the DPN process. The 2D nano PrintArray™ shifts the paradigm of scanning probe lithography by providing a high-throughput solution to flexibly pattern nanoscale features. Taking single-tip DPN as the starting point, the 2D nano PrintArray retains the direct write, high resolution, ambient deposition, chemical and material flexible attributes of DPN, while multiplying the desired pattern 55,000 times across a 1 cm² area. It is the only way to flexibly create so many nanoscale patterns – for etch resist, templating, or biological applications – across such a large area.

With the 2D nano PrintArray you can:
- Design complex patterns in InkCAD™
- Replicate these and flexibly pattern a variety of nanoscale materials over cm² areas
- Massively Parallel 2D Nanopatterning preserves the attributes of single-pen DPN
- Templating techniques have been demonstrated with proteins, viruses, and carbon nanotubes.
- Direct-writing has been demonstrated with MHA, ODT, and phospholipids.

Applications of this method are constantly evolving, and the above represent only a sampling of what is possible.

**Design Considerations**

The 2D nano PrintArray has been designed for universal applicability on any NSCRIPTOR. It is wireless and easily mounted on the scanner; strong magnets secure it to the scan head without any external wires or external attachments. It is a stand-alone unit for fast, easy 2D nanopatterning.

<table>
<thead>
<tr>
<th>Probe Type</th>
<th>Writer $k$ (N/m)</th>
<th>Writer width (µm)</th>
<th>Writer length (µm)</th>
<th>Writer-Writer pitch (µm) in X</th>
<th>Writer-Writer gap (µm) in X</th>
<th>Writer-Writer pitch (µm) in Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>2D nano PrintArray</td>
<td>~ 0.20</td>
<td>15</td>
<td>60</td>
<td>20</td>
<td>5</td>
<td>90</td>
</tr>
</tbody>
</table>

(NOTE: Unsharpened tip radius: 35 +/- 10 nm; Sharpened: 15 +/- 5 nm)

courtesy Northwestern University
SEM image showing multiple rows of cantilevers attached to the silicon ridges. The inset shows individual cantilevers, while also highlighting the 7.5 µm tall tips and inherent cantilever curvature (~6°).

Optical microscope image of the 2D nano PrintArray (tips facing up) showing the pitch, spacing, and high yield. 832 individual tips are shown, roughly 1.5% of the entire array.
2D nano PrintArray Critical Dimensions

The 2D nano PrintArray cantilevers are silicon nitride, designed for contact mode. They are attached to a silicon handle wafer as shown below. The viewport depicted is used for planar leveling, described below. These critical dimensions afford the tips roughly 4 µm freedom of travel, corresponding to approximately 0.03° of planar leveling tolerance, which is easily achievable using a combination of z-motor motion and z-piezo correction.

2D nano PrintArray NSCRIPTOR Mounting

The 2D nano PrintArray is fabricated first as a silicon chip in part of an array. It is then diced, and a precision-machined ABS plastic wedge is affixed to its top side with high-bond strength glue. This wedge is specifically designed to fit with the NSCRIPTOR’s scanner assembly, thereby producing a nearly level device from the start. Super-strong neodymium magnets implanted in the wedge ensure secure attachment to the scan head.
The device is then easy to handle and manipulate, and will stay securely attached to any metal or magnetic surface. Subsequently, it is mounted on the NSCRIPTOR scanner using the tip-exchange feature.

Once attached, it is straightforward to adjust the 3 Z motors to achieve macroscale planarity:

2D nano PrintArray Leveling and Software

Nanoscale leveling to within the tolerances dictated by the device’s critical dimensions is achieved through a combination of software control, and optical viewing of cantilever deflection.

The figure to the right shows the 2D nano PrintArray from a top perspective, as viewed when attached to the scanner. The cluster of viewports allow the user to see through the opaque silicon handle wafer, and are specifically arranged to fit within the optical viewing area of the NSCRIPTOR; all that is necessary is to examine the cantilever.
deflection through several windows (specifically 3) to establish surface planarity.

This is accomplished as shown below, where (c) and (d) clearly differentiate the cantilevers’ color appearance when above the surface and when in contact. The method is fundamentally enabled by the inherent force independence of DPN, and the low $k$ flexible silicon nitride cantilevers. The array is subsequently manipulated in the same fashion as NanoInk’s 1D multi-pen arrays, with sophisticated lithography enabled by our InkCAD software.

With the device mounted and leveled, it is easy to generate nanoscale features over large areas. Throughputs range from $1 \times 10^7 \mu m^2$ per hour to $3 \times 10^{10} \mu m^2$ per hour. Inks used so far have included MHA, ODT, and the phospholipid 1,2-dioleoyl--sn-glycero-3-phosphocholine (DOPC). Substrates have included silicon, glass, titanium, and hydrophobic polystyrene, with lateral resolution down to 100 nm.

The 2D nano PrintArray will ship to users with a goal of >95% intact operable cantilevers.

For more information including pricing, please contact NanoInk Sales Department at sales@nanoink.net or 847-679-NANO.
Optical images of Nanolink logo following the successful process of mounting, leveling, printing, etch-resist, and optical inspection. Only a fraction of the 55,000 printed logos are shown.