Applications of Dip Pen Nanolithography®

NanoInk markets instrumentation specifically designed for tip-based lithography. The primary strengths of this technology are:

1. Directed placement of materials at defined locations with nanoscale precision.
2. Flexible "on-the-fly" pattern generation.
3. Multi-component patterning at micron and sub-micron scales.

The primary applications that can be addressed using NanoInk's instruments are:

1. Benchtop Top-Down Nanofabrication

Top-down Nanofabrication is a commonly used technique for fabrication of nanostructures on surfaces. This method usually requires a clean room, numerous pieces of equipment and several months to fabricate one set of features. NanoInk now provides its users with technology and expertise to enable them to fabricate nanostructures in their labs. Figure 1 presents a few examples of nanostructures designed and fabricated using NanoInk instruments.

Figure 1. Gold nanostructures fabricated on silicon surface. The structures have a line width of 400nm and a height of 12 nm.

2. Directed Placement of Biomolecules onto Prefabricated Structures

The ability to place multiple biomolecules simultaneously onto prefabricated microstructures with nanoscale precision under biological friendly environmental conditions is another of the strengths of the NanoInk Instrumentation. This enables the user to functionalize MEMS based sensing elements, which have been a limiting step in the development of miniaturized biosensors and chemical sensors. It also enables the users to functionalize other microstructures that have been developed for numerous applications including lab-on-a-chip applications and cellular mechanotransduction studies. Figure 2 presents fluorescent images of a few MEMS structures that

Figure 2. Fluorescent images of protein printed on microfabricated structures. The image on the left is that of an AFM cantilever with four different proteins. The middle and right images are of polymer pillars with fluorescent proteins printed on them. The pillars in the middle image are 1.5 microns in diameter while those in the right image are 10 microns square.

have been functionalized using NanoInk Instruments.

3. Single Cell Arrays

Conventional patterning methods are limited to either patterning multi-component patterns with rather large domains or single component patterns at sub cellular scales. NanoInk technology is capable of constructing multi component patterns at sub cellular scales. This enables its users to address and study the underlying biology at a single cell level. Applications of this technology include studies of cellular migration focal adhesion, cellular polarization and proliferation studies neuronal development, and stem cell differentiation. Figure 3 presents fluorescent image of cells micropatterned on subcellular sized domains of fibronectin arrayed using NanoInk instruments.

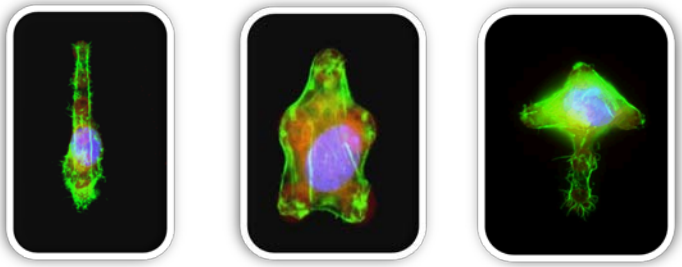

Figure 3. Fluorescent images of cells binding to micopatterned fibronectin domains. The actin filaments (green), nucleus (blue) and the fibronectin (red) are labeled.

4. Miniaturized Biomolecular Arrays

NanoInk instruments and technology enables it users to construct miniaturized capture domains for the detection of specific analytes. Miniaturization of capture domains has several potential benefits including increased sensitivity, smaller sample volume requirement, integration with lab-on-a-chip concepts, faster reaction kinetics and lower costs. This enables the users to develop early detection assays of biomarkers. Figure 4 presents fluorescent images of miniaturized, multiplexed, protein, DNA and lipid arrays generated using NanoInk instruments.

Figure 4. Fluorescent images of miniaturized biomolecular arrays. The left image is a complex pattern of four different proteins while the middle image is that of two different DNA Oligos and the right image is a two component lipid array.