Arrayed Multifunctional Scanning Probes for Soft Nanolithography and Direct Writing of Bio Array

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We report the development and demonstrations of arrayed soft nanolithography probes for dip pen nanolithography (DPN), scanning probe contact printing (SPCP), and multi-functional scanning nanolithography. We further demonstrate successful creation of high density protein array and cell attachment.

Direct deposition of chemicals, such organic molecules, sol-gels, proteins, and DNA on substrates with nano-scale resolution is crucially important for top-down style nano engineering and fabrication. Following the inspiration provided by Feynman's seminal paper "there is plenty of room at the bottom", we have applied MEMS technology to develop scanning probe arrays to increase the capabilities of interacting with and patterning at the nano scale.

The scanning probe microscopy (SPM) instrument is very useful and effective for nanoscale patterning and lithography, due to the inherent fine scale associated with sharp SPM tips, and the ability of SPM machines to provide fine-scale imaging and spatial registration.

The DPN technique was invented in 1999 and has been expanding since then in terms of the number of materials that can be deposited. We have developed million-pen arrayed DPN probes using a mould-and-transfer microfabrication process. The arrayed probes have been successfully demonstrated for use in depositing low-weight organic compounds as well as protein molecules. The large array format increases the throughput of the nanolithography process and allows high density protein and DNA arrays to be realized.

We have demonstrated the ability to fabricate scanning probes with soft elastomeric tips. This results in a new class of soft lithography capability called “scanning probe contact printing (SPCP)”. The SPCP combines the established capabilities of micro contact printing and the DPN method, and offers a rich variety of chemistry and ease of nano-scale registration.

Further, we have recently developed a multifunctional scanning probe array that consists more than one type of scanning probes. The array depicted below consists of three groups of probes – DPN probes with silicon nitride tips, SPCP probes with elastomeric PDMS tips, and reading probes with silicon nitride tips.

Each probe is provided with a thermal bimetallic actuator that can engage individual tips for selective substrate contact. Because of the ability to individually select and use a variety of tools, this probe array is call the Swiss Army Knife scanning probe for its rich functionalities within one compact array. The ability to engage multiple tools without having to change the probes increases the efficiency of nano lithography and reduces the difficulty and time waste associated with registering multiple probes in a given operation.

Figure 1: Multifunctional, "Swiss army knife" styled nanolithography instrument system.

We have demonstrated arrayed soft nanolithography for depositing proteins and, subsequently, using the protein (such as Zein, a derivative of corn products and a biodegradable protein material), as a substrate for binding cells (such as fibroblasts).

Figure 2: (Left) Schematic diagram of arrayed nanolithography of protein; (top right) AFM image of protein array; (bottom right) cells attached to nanopatterned Zein patterns.