Dip-Pen Nanolithography & Polymer Pen Lithography

Dip Pen Nanolithography (DPN) uses the tip of an Atomic Force Microscope (AFM) to deliver molecular inks to a surface. Being a constructive (bottom-up) approach to lithography, DPN has several unique capabilities. First, it can be readily carried out using parallel tip arrays enabling both high throughput and high areal resolution. Second, since no etching or post-processing is typically required, prepatterned surfaces composed of a variety of materials can be used. Finally, DPN is capable of integrating of multiple materials (or inks) with both high resolution and high throughput [1]. In particular, the use of lipid-based inks developed at the Karlsruhe Institute of Technology takes advantage of these DPN aspects. DPN with lipids was used in diverse fields from sub-cellular arraying [2,3] to sensors [4,5].
The related technique of Polymer Pen Lithography (PPL) combines the strengths of microcontact printing (large area parallel printing, inexpensive stamp materials) with the advantages of DPN (pattern flexibility, multiplexing) [6].

Contact

See KNMF website or contact the KNMF User Office.

Features

- 20 nm resolution for thiols on gold, or 100 nm for phospholipids
- Throughput on the order of cm^2/min using massively parallel arrays
- Compatible with biological molecules (e. g. DNA, protein & phospholipids)
- Phospholipid based inks can write on a variety of surfaces – metals, insulators, hydrophobic, hydrophilic, etc.
- Capability of integrating multiple ink materials on a single substrate
- Compatible with pre-structured surfaces
- No undercuts
- No hollow parts
- A one step fabrication process

Materials

- Alkanethiols on gold
- Phospholipids with
  – fluorescent headgroups
  – biotinylated headgroups
  – NTA-headgroups
  – other lipids suitable for liposomes
- Azides on alkyne-functionalized surfaces ("Click-Chemistry")
- Substrates for lipid patterning:
  – glass, silicon
  – PMMA, polystyrene
  – Metals (e.g. Au, Ti)

Limitations/constraints

- There must be a driving force for the ink to flow from the tip to the sample
- Parallel integration of different inks requires that the different inks have similar transport properties
- Each tip in a passive parallel array draws the same structure
- A high throughput quality control method must be used for massively parallel fabrication
- 80 x 80 micron scan area (per tip) for DPN 5000 system
- Alignment marks must be used to align with pre-patterned substrates
- Tips are typically spaced 35 μm in a 1D array or 20 x 90 $μm^2$ in a 2D array.
- Custom arrays available

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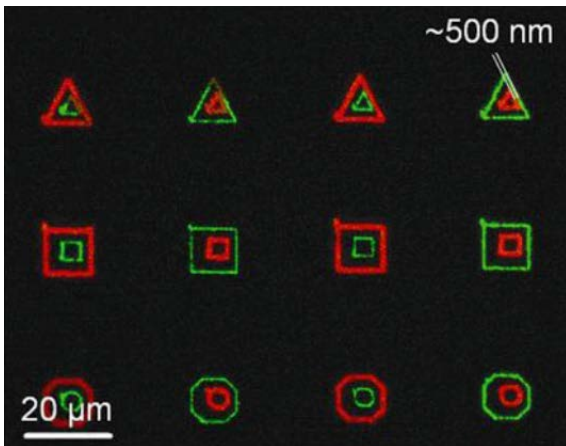## Typical structures and designs

Fig. 1: Functional phospholipids patterned on a glass surface are used to template two proteins at sub-cellular scales [2]
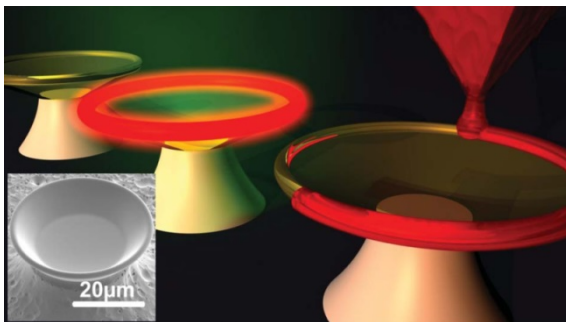

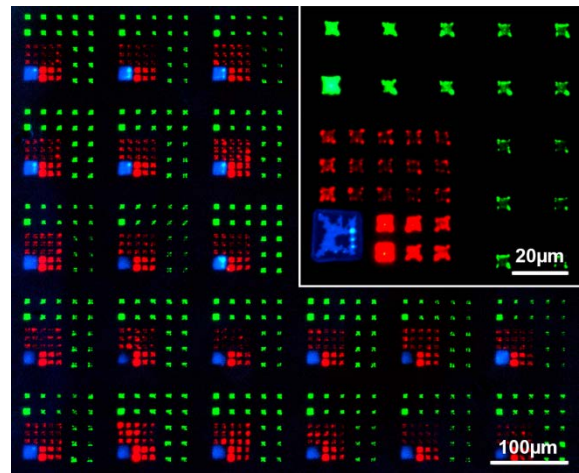*Fig. 2: Functionalization of pre-existing sensor structures by DPN with lipids [5]*

Fig. 3: Multi-color micro patterns generated by PPL with fluorescent lipids [6]
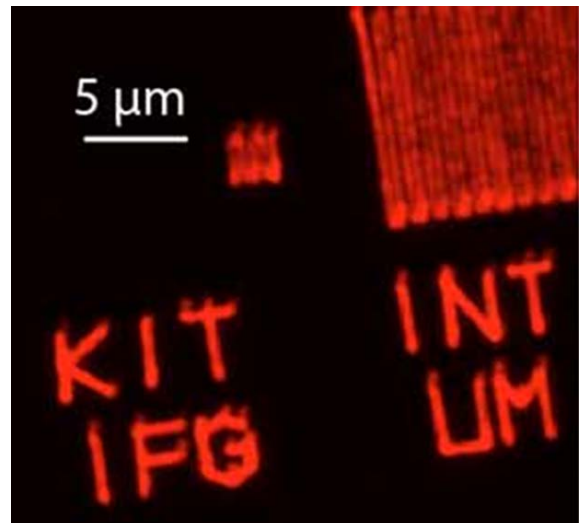

Fig. 4: Covalently linked fluorescently labeled azide ink written on an alkyne functionalized CVD coating [7]

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