Micro Nano Patterning

Dip-Pen Nanolithography

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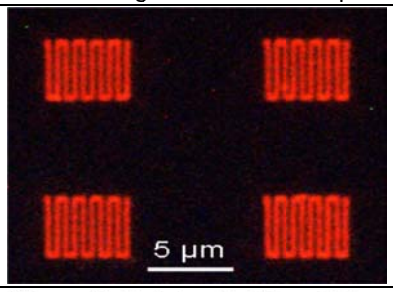
Material class:	Silicon	Polymer	Metal	Ceramic	Glass	Organic	Other
	X	X	X	X	X	X	X

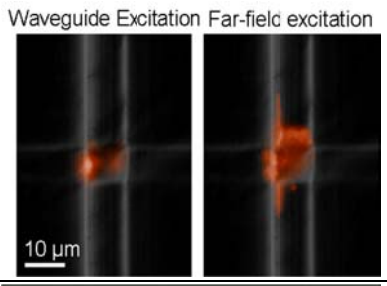
Short technology description:

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 KIT takes advantage of these DPN aspects.

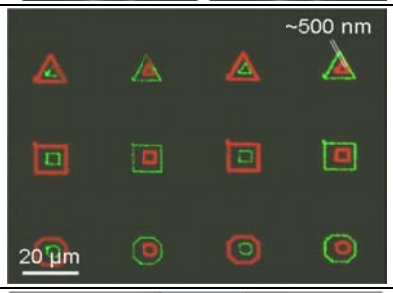
Typical structures and designs:



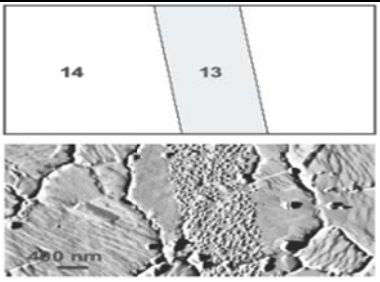
Fluorescently labelled phospholipids patterned on a polystyrene surface with a half-pitch of 250 nm [1]



Phospholipids deposited onto a pre-fabricated PMMA lab on a chip integrating waveguides and microfluidic devices [2]



Functional phospholipids patterned on a glass surface are used to template two proteins at sub-cellular scales [3]



DNA patterned by DPN on a gold surface is used to selectively adsorb nanoparticles [4]

Special features:	– 20 nm resolution for thiols on gold, or 100 nm for phospholipids – Throughput on the order of cm2/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
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) – Alignment marks must be used to align with pre-patterned substrates – Tips are typically spaced 35 µm in a 1D array or 20 µm x 90 µm in a 2D array. Custom arrays available.
Material examples:	– Alkanethiols on Gold – Phospholipids with - Fluorescent headgroups - Biotinylated headgroups - NTA-headgroups - Other lipids suitable for liposomes – Substrates for lipid patterning: - Glass - Silicon - PMMA - Polystyrene - Metals (e.g. Au, Ti)
Publications:	[1] Lenhert, S., Fuchs, H. & Mirkin, C. A. in Nanoprobes (ed. Fuchs, H.) 171-196 (Wiley-VCH, Weinheim, 2009) [2] Lenhert, S., Sun, P., Wang, Y. H., Fuchs, H. & Mirkin, C. A. Massively parallel dip-pen nanolithography of heterogeneous supported phospholipid multilayer patterns. Small 3, 71-75 (2007) [3] Mappes, T. et al. in Digest of IEEE/LEOS 215-216 (Acapulco, Mexico, 2008) [4] Sekula, S. et al. Multiplexed lipid dip-pen nanolithography on subcellular scales for templating of functional proteins and cell culture. Small 4, 1785 - 1793 (2008) [5] Plutowski, U., Jester, S. S., Lenhert, S., Kappes, M. M. & Richert, C. DNA-based self-sorting of nanoparticles on gold surfaces. Advanced Materials 19, 1951-1956 (2007)
Outlook:	Two new instruments are being acquired: the DPN 5000 and the NLP from Nanoink, Inc., available from Sept 2009.