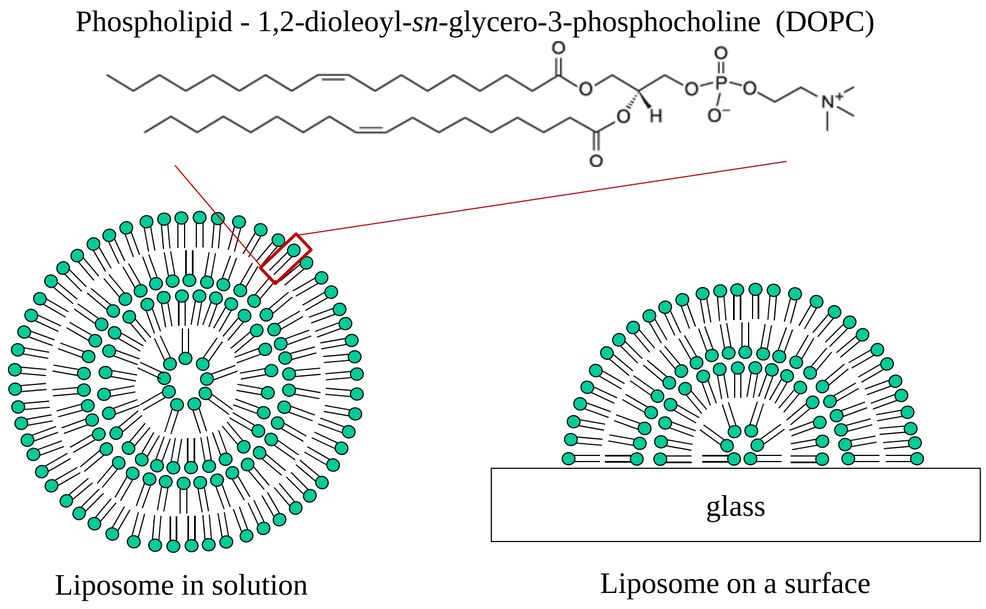
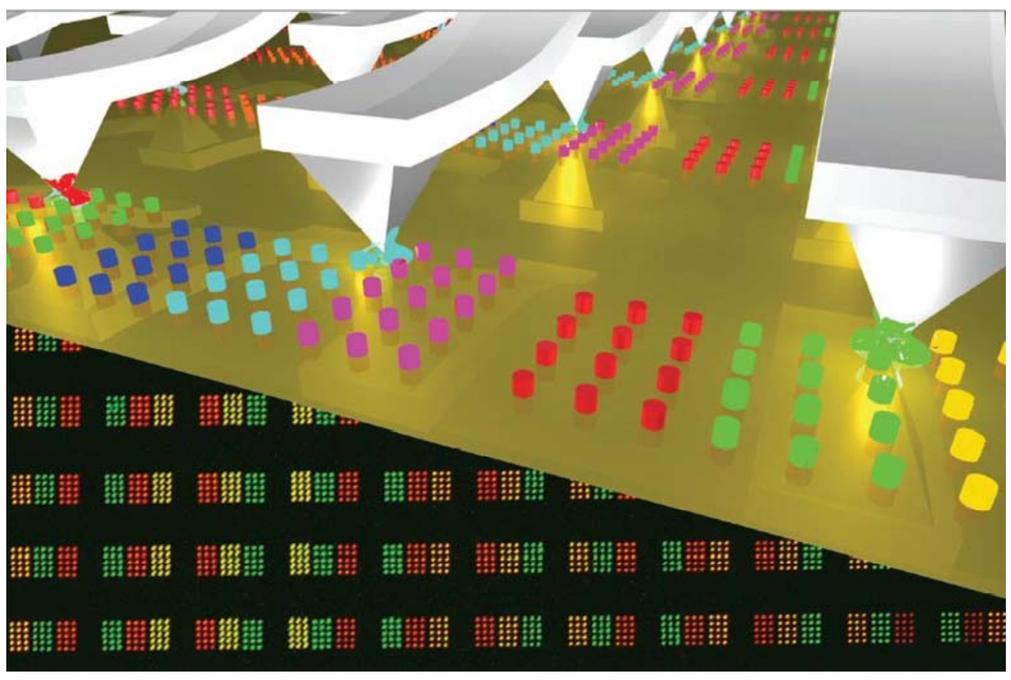
Nano and micro structure-function relationships in liposome function

Hypothesis: the functional properties of liposomes can be tuned by controlling their micro and nanostructure.

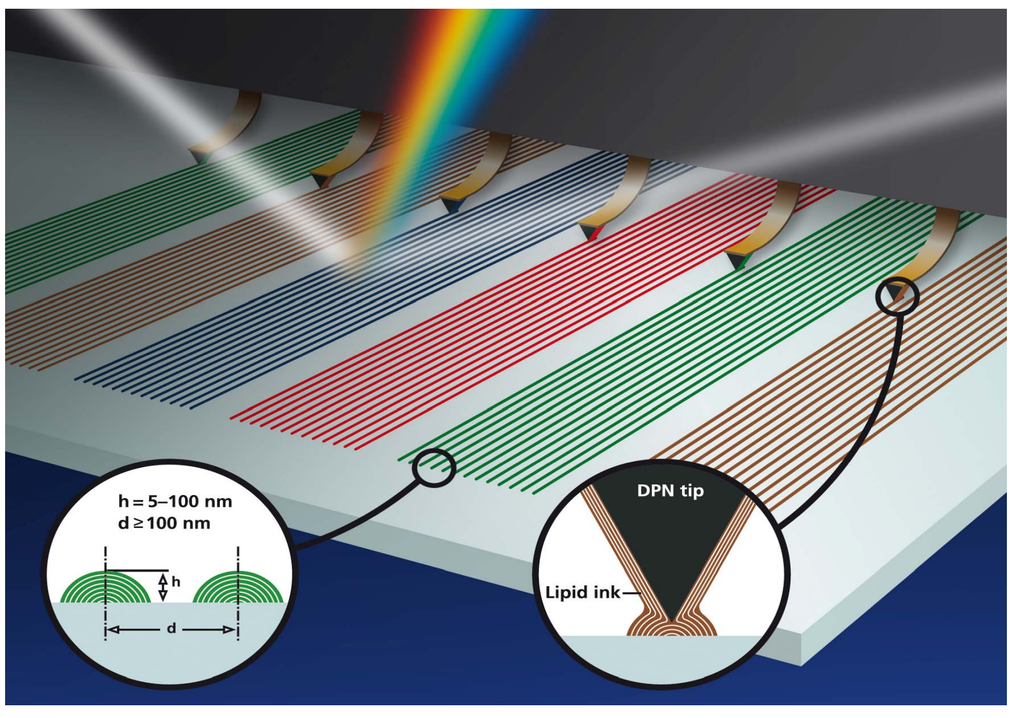
Background and motivation: liposomes are artificially prepared vesicles made of lipids, which are widely used in the biomedical industry for gene and drug delivery. In research they are also used as artificial cellular systems. In aqueous solution phospholipids spontaneously self-assemble to form lipid bilayers, that are structurally and functionally similar to biological membranes. In this project, liposome structure and function on surfaces are characterized in order to identify how liposome nano and micro structure relates to liposome function.



Method: Surface supported liposome arrays are created in this project using dip-pen nanolithography (DPN). DPN is a constructive printing method based on atomic force microscopy. Using lipds as the ink for DPN allows nanometer control of the lipid structure, and can also be carried out in parallel using multiple lipid inks, as shown in the figure below.[1,2]

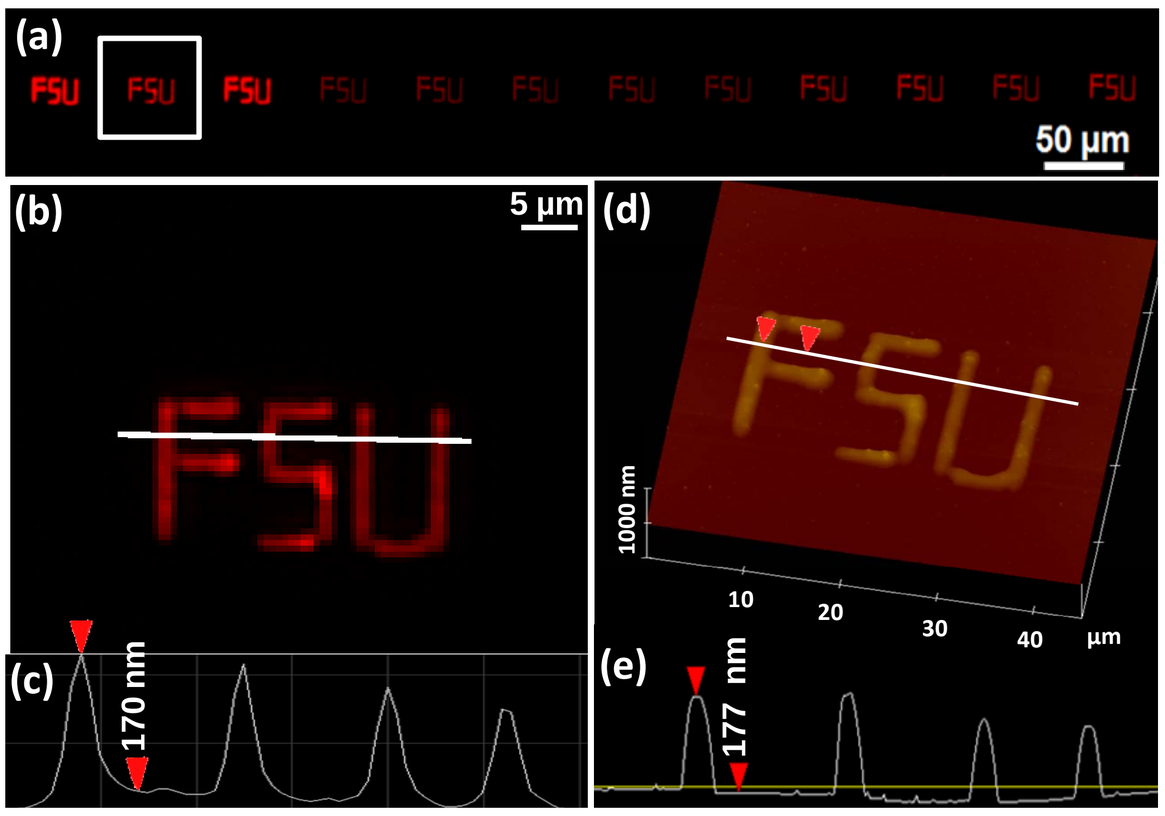


An example of functional lipid nanostructures fabricated by this method are lipid multilayer gratings which are illustrated in the figure below. The multilayer heights of these structures are critical to their function.[3]



References:
1. Lenhert et al., *Small*, 2007.
2. Lenhert et al., *Small*, 2008.
3. Lenhert et al., *Nature Nanotechnology*, 2010.

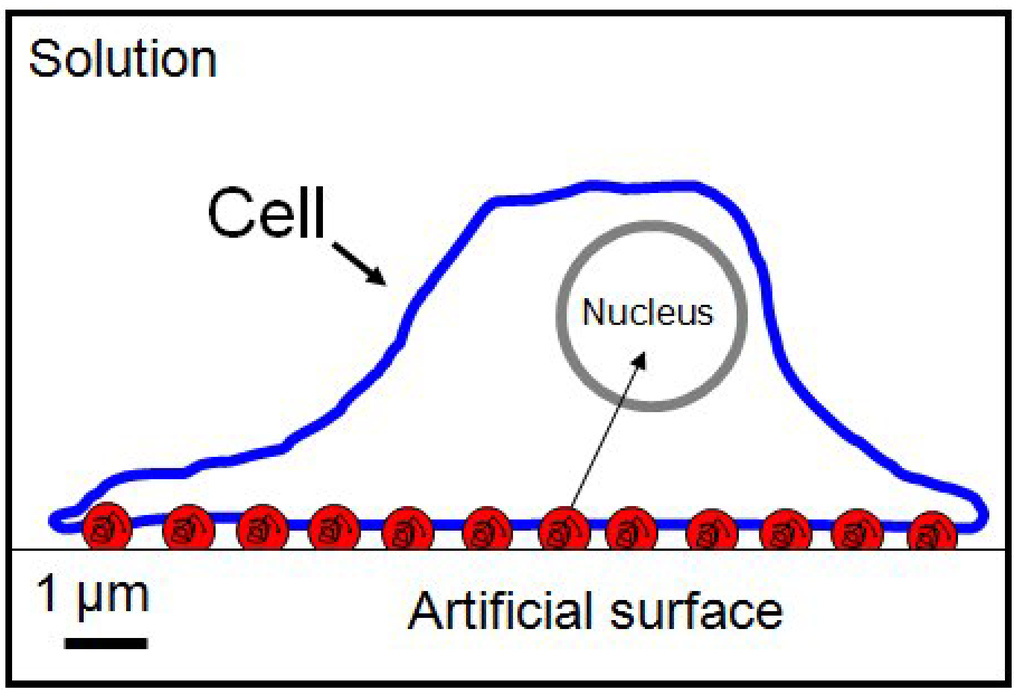
Results: A high throughput optical characterization method was developed that can rapidly provide height or thickness measurements of surface supported liposome structures using a standard fluorescence microscope.



The figure above shows how fluorescence microscopy can be used to rapidly determine height values for micro and nan-structured surface supported liposomes. (a) shows a fluorescence image of "FSU" written several times, at different height values. (b) and (c) show the results of appying our method to measure the heights of the highlighted FSU pattern. (d) and (e) show an atomic force microscopy image of the same area as (b) and (c). The heights obtained by our method and AFM in this experiment differed by only 4%.

The results are described in more detail in:
O. A. Nafday, S. Lenhert, High-throughput optical quality control of lipid multilayers fabricated by dip-pen nanolithography, *Nanotechnology*, 22, 225301 (2011) and
U.S. Provisional Application 61/383,775.

Future directions: The results of this project are a crucial step in the development of a lab on a chip, gene delivery platforms and synthetic cellular systems. In the fall of 2010 we started a project with the company NanoInk, Inc., for the development of this technology for surface based delivery of materials to cells, as illustrated below.



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