

## Highly Ordered Chemical Patterns from Self-Assembled Colloid Crystals: A New Method for Studying Biointeractions

*Peter Kingshott*

Head of Polymer NanoInterfaces Group,  
Interdisciplinary Nanoscience Centre (iNANO), Aarhus University, Denmark.

[peterk@inano.dk](mailto:peterk@inano.dk)    [www.inano.au.dk](http://www.inano.au.dk)

The aim is to develop new material surfaces that can precisely control the locality of multiple proteins in 2 and 3D, which is highly desirable for improving the understanding of the biocompatibility of medical implants and tissue engineered devices. Generating protein patterns with controllable spacing and complexity in the nanometer to micrometer scale remains a challenge. Currently, the most widely used techniques for patterning are time consuming and expensive and most of them are restricted to single protein patterning. We present here a novel but simple method for generating highly ordered protein patterns, based on our previous findings about ordered colloidal assemblies. The experiments are performed by mixing particles of different size (50nm – 3  $\mu\text{m}$ ), material (silica, poly(styrene)), and surface chemistry, and drop casting them into confined spaces of controllable dimensions (over a few  $\text{cm}^2$ ). This results in the self-assembly of the particles into highly ordered arrays, in which the larger particles form a non-close packed hexagonal structure encapsulated by the smaller particles. The pattern morphology is changed by varying the particle size ratios and concentrations. In addition we have mixed three particles of different size to generate ordered ternary arrays. This concept is applied to particles pre-coating with proteins using unlabeled and/or fluorescently labeled human lysozyme and bovine serum albumin (BSA) as model proteins. Also, when human lysozyme coated particles are mixed with BSA coated particles, a FTIC labeled human anti-lysozyme selectively binds to the lysozyme coated particles. XPS, fluorescent microscopy, AFM, SEM analysis and zeta potential are used for characterization.

In another approach I will show a new method for generating chemical patterns by sputtering of gold through the colloid crystal layer followed by lift-off of the particles. The crystal regions of the binary pattern, composed of the smaller particles, facilitate transport of the Au sputter beam to the substrate. After particle lift-off only the regions where the small particles have been in contact with the silicon substrate are coated with Au. The large particles act as a mask and remain uncoated, and the thickness of the surrounding Au layer is controlled by the sputter time. The highly ordered chemical patterns are generated where the size of the features are tuned by appropriate choice of particle sizes (50 nm to 3  $\mu\text{m}$  diameters) and ratios. Thus chemical contrasts with Au and silica are created that can be used for chemical patterning using thiols and silanes. We demonstrate that the resultant Au layer can be coated with a protein resistant mercapto-oligo(ethylene glycol) layer ((1-mercapto-11-undecyl)-tri(ethylene glycol)) that allows selective adsorption of rhodamine-labelled albumin, only onto the Si regions of the pattern. The Au patterns and subsequent protein adsorption are characterized by AFM, SEM and fluorescent microscopy. XPS and ToF-SIMS are used to characterise the chemical modification steps of the patterning.

In summary, a novel method is introduced for generating highly-ordered chemical nanopatterns that is very fast, inexpensive, and allows patterns of biomolecules to be created over large surface areas.

## Biography



Peter Kingshott was educated in Australia having received his Bachelor and Honours Degrees in Chemistry from the Murdoch University in Perth in 1992. He completed his PhD at the University of New Wales (UNSW) while being based in Melbourne at The CSIRO Division of Molecular Science as part of the Cooperative Research Centre for Eye Research and Technology (CRCERT). The work involved designing and understanding the biocompatibility of new surfaces of extended wear contact lenses, with the specific aim of minimising protein adsorption and bacterial colonization on the lenses. This led to a 2 year postdoc position at the same institution followed by a Senior Fellow position at the University of Washington in Seattle working on surface analysis of biomaterial surfaces. Prior to moving to Denmark he worked for one year the Institute for Macromolecular Chemistry and Textile Chemistry at the RWTH Aachen in Germany. In 2000 he became a Senior Scientist at The Danish Polymer Centre at Risø National Laboratory near Copenhagen, working mainly with polymer surface design and advanced surface characterization. In June 2006 he joined the Interdisciplinary Nanoscience Centre (iNANO) as Associate Professor, and is currently working on numerous projects involving nanofibres, colloidal crystals, and nanocharacterisation and nanofunctionalisation of surfaces aimed at improving the integration of artificial materials within biological environments. Currently he has published 74 articles in internationally reviewed journals, 7 book chapters, 7 patents and has ~100 papers in conference proceedings.