Engineering robust bioinstructive interfaces for cell microenvironments, tissue-integration, diagnostics, biosensing and nanomedicine

MMM Bilek[*1,2,3,4], *C.T. Tran*[1,2], *A. Gilmour*[1,2], *S Cottam*[1,2], *J. Sardharwalla*[2], *L Haidar*[1,2], *S. Franklin*[1,2], *K Sato*[5], *X. Feng*[2], *D Ashok*[1,2], *A Waterhouse*[3], *G Yeo*[3], *S Fraser*[2]
[1]School of Physics, A28, University of Sydney, NSW 2006, Australia
[2]School of Biomedical Engineering, University of Sydney, NSW 2006, Australia
[3]Charles Perkins Centre, University of Sydney, NSW 2006, Australia
[4]Sydney Nano Institute, University of Sydney, NSW 2006, Australia
[5]School of Chemistry, University of Sydney, NSW 2006, Australia
Email: marcela.bilek@sydney.edu.au

Materials used in biomedicine are selected according to bulk properties, such as mechanical, electrical and optical, required for particular in-vivo and in-vitro applications. However, their surfaces almost always provide suboptimum biological microenvironments, do not interact appropriately with desired biological molecules, or promote the desired biological responses of cells.

This presentation will describe sustainable and readily scalable surface modification processes that use plasma, the forth state of matter, to enable resilient and easily tailorable biofunctionalization of all materials' surfaces. Typical time scales of diagnostic processes, cell culture and tissue integration require covalent immobilisation to prevent interface instability due to desorption and exchange with molecules in the aqueous local environment. We will examine how plasma activates a range of materials and structures for spontaneous, reagent-free, covalent functionalisation with bioactive molecules and hydrogels. Functional molecules that can be immobilised to create tailored cell microenvironments include, but are not limited to, oligonucleotides, enzymes, peptides, aptamers, cytokines, antibodies, cell-adhesion extra-cellular matrix molecules and histological dyes. The covalent immobilisation occurs on contact via radicals embedded in the surface by energetic plasma species.

After a review of the fundamental surface science, processes to modify the internal surfaces of multi-well plates, porous scaffolds and micro/nanostructures will be presented. Strategies to immobilise biological micro patterns and hydrogels onto the plasma activated surfaces and to prepare multi-functionalisable nanoparticles will be discussed, together with strategies to control the density and orientation of surface-immobilised biomolecules. Finally, an approach to add transparent conducting micropatterns for electrical stimulation and readout to our bioactive interfaces will be described, completing the toolbox for creation of bespoke platforms for biomimetic cell microenvironments, controlled tissue-integration, diagnostics, biosensing and nanomedicine.