Cell Regulation by Ion-Beam Induced Nanostructures

Z. C. Yang[1], A. M. Kacic[1], N. Samuelson[2], C. L. Cooper[3], J. P. Allain[1,4] and L. M. Reece[4];

1. School of Nuclear Engineering, Purdue University, West Lafayette, Indiana;
2. Weldon School of Biomedical Engineering, Purdue University, West Lafayette, Indiana;
3. Department of Basic Medical Sciences, Purdue University, West Lafayette, Indiana;
4. Birck Nanotechnology Center, Purdue University, West Lafayette, Indiana.

Statement of Purpose:
A strong correlation, although not completely understood, exists between surface topography and cell function [1-5]. Both the topography of the nanopatterned surface and its surface chemistry play a critical role in cell function including regulation of growth factor signaling and intracellular signaling important for proliferation and spreading [1]. Directed irradiation synthesis can induce nanopatterning on the surface of metals, semiconductors, and polymers [6-7]. This approach can have significant implications to the design of nanostructured surfaces used for cell engineering and cell biology. It provides a novel way to modify surface properties of biomaterials by tuning the surface morphology, surface chemistry and mechanical properties and ultimately regulating cell behaviors at the molecular and cellular scale. This study is intended to explore the potential of surface ion-beam driven nanopatterning of metal surfaces to regulate cell behaviors.

Methods:
In this study, thin films (100-200nm) of gold were deposited on silicon wafers using e-beam deposition and magnetron sputtering. Low-energy (50-500 eV) heavy-ion (Ar, Xe) singly-charged particles are used to induce nanostructures in the gold thin-film bio-interface layer with different ion fluence. HUVEC (Human Umbilical Vein Endothelial Cells) were used for cell tests. The MTT assay was used for cytotoxicity tests. Comet assay was used to test DNA degradation. Scanning Electron Microscope (SEM) was used to visualize cell adhesion on nanostructured surfaces and controls.
Also, complementary surface-sensitive techniques were used to perform in-situ atomic scale characterization of elemental, chemical, and electronic properties at a recently built experimental facility at Purdue University. The techniques used included: low-energy ion scattering spectroscopy (LEISS), angular-resolved photoemission spectroscopy (ARPES), X-ray photoelectron spectroscopy (XPS), and ultraviolet photoelectron spectroscopy (UPS).

Results:
Nanostructures with diameters ranging from 10nm to 200nm were formed on the gold surfaces under ion beam irradiation with different fluence. As the fluence increased, the size and the spacing between nanostructures increased. Comet assay results and SEM images reveal correlation of nanoscale height with increase in adhesion and sustainable viability. For nanostructure heights of 10-20nm, there is an increase in cell adhesion rates as well as the promotion of the cytoskeleton. SEM images of the cell on nanostructures also show the cell align themselves along the ridges.

Conclusions: Directed irradiation synthesis can provide for tunability of the surface topography at the nanoscale and thus regulate cell behavior. Results show that **n**anostructures can improve cell growth by acting as directional cues. Cells are directed through the ridges/grooves of the nanostructures and will align themselves with the direction of these ridges.

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