Public Abstract
First Name:Qi
Middle Name:
Last Name:Cheng
Adviser's First Name:Mahmoud
Adviser's Last Name:Almasri
Co-Adviser's First Name:
Co-Adviser's Last Name:
Graduation Term:SP 2011
Department:Electrical Engineering
Degree:PhD
Title:Micromachined PDMS Elastic Post Arrays for Studying Vascular Smooth Muscle Cells

This thesis describes the design, modeling, fabrication and characterization of a micromachined array of high density 3-dimensional microposts (100 by 100) made of flexible material (silicone elastomers) for use to measure quantitatively the cellular traction force generated by vascular smooth muscle cell (VSMC) with high sensitivity and accuracy. The performance of the microposts with base and without base has been carefully analyzed by finite element analysis (FEA) software CoventorwareTM. The micropost arrays were then fabricated with diameters ranged from 3 to 10 micrometer, with edge to edge spacing of 5 and 7 micrometer, and with a height to diameter aspect radio up to 13 using microfabrication techniques and replica molding. The mechanical properties of the Polydimethylsiloxane (PDMS) microposts with various geometries used in the cell culture experiment were determined experimentally including detailed measurements of Young modulus (E) and the corresponding spring constant. We have found that microposts with different sizes and geometries have different Young modulus and spring constant values, ranged between 0.534-1.38 MPa, and 0.44 pN/nm-11.72 nN/nm, respectively.

Vascular smooth muscle cells were cultured on top of the micropost arrays and incubated for 2 days before an image acquisition experiment. The micropost array was then scanned by phase contrast microscope from top to bottom. The top and bottom images were obtained by focusing on either top or bottom of the micropost. The outlines of the micropost covered by VSMC were successfully recorded as optical images and extracted using image processing in Matlab. The direction and the amplitude of microposts deflections were determined by comparing center location of micropost in top and bottom images. Hence, the corresponding force generated by cell can be calculated from deviation of the central axis of the micropost (i.e. the top vs. bottom). The force distribution map of a single VSMC was generated using the PDMS micropost array. A minimum displacement of 200 nm can be detected from optical images captured by confocal microscope. For example, micropost with highest aspect ratio (diameter, and height of 3 micrometer, and 35 micrometer) can detect the smallest traction force of 38 pN/micrometer. The micropost arrays with different geometries were used to study VSMCs. We have also found that the traction force exerted by VSM cell increases as the stiffness of the micropost increases. It demonstrates that VSM cell tends to adjust its traction force to adapt to its physical environment.

VSMCs with integrin-linked kinase enzyme (ILKE), referred to as CK4 cell, and without ILK module, referred as ILK cell, were also studied using PDMS micropost array. Finally, high temporal resolution analysis of CK4 cells was performed on PDMS micropost array.