Micropatterning of Electrospun Polyurethane Fibers through use of Soft Lithography Molding

David Dempsey[1], Christian Schwartz[2], Robert S. Ward[3], Ananth V. Iyer[3], James P. Parakka[3], Elizabeth Cosgriff-Hernandez[1]
[1]Biomedical Engineering, Texas A&M University, College Station, Texas
[2]Mechanical Engineering, Texas A&M University, College Station, Texas
[3]DSM-PTG, Berkeley, California

Statement of Purpose: In recent years electrospinning has become a popular technique in tissue engineering primarily because of its ability produce scaffolds with interconnected pores for cell culture. The major limitation, however is that the pores produced are typically too small to promote favorable cell migration. In addition, basic electrospinning setups consisting of a flat plate collector will produce randomized fiber mats leaving the investigator little control over how cells will proliferate in the resultant scaffold. Previous research has focused on aligning fibers using collector setups such as a rotating mandrel or parallel plates. We propose a method to produce electrospun bioresorbable polyurethane fiber mats with patterns useful for tissue engineered vascular grafts by controlling surface topography of the fiber collector. In this study, soft lithography was used to control surface topography so that a bioresorbable segmented polyurethane could be patterned.

Methods: *Soft Lithography:* Sylgard 184 PDMS elastomer kit was used as received from The Dow Corning Company (Midland, MI, USA). Using a standard photolithography process, an SU-8 mold characterized by raised square patterns, 12µm high, of side lengths measured at 50, 100, 200, and 500µm was formed for the PDMS. A basic soft lithography process outlined by Xia was then used to make the PDMS replica. [1] The PDMS, mixed at a 10:1 base to curing agent ratio, was spin coated on the SU-8 mold at 500rpm for 25 seconds to ensure a thin even layer of PDMS was coated on the mold before curing at 85°C for 20 minutes. The resultant PDMS replica was expected to display features opposite that of the SU-8 mold and were confirmed with an optical profilometer.

Electrospinning: BioSpan®, a commercially available poly(ether urethane)urea (PEUU), and an experimental bioresorbable poly(ester urethane) (PEsU) used in this study, were synthesized by DSM-PTG. N,N'-Dimethylacetamide (DMAC), was used as received from Sigma Aldrich (Milwaukee, WI, USA), to make 15w/w% polymer solutions. The PDMS collector was attached to the front face of a copper plate positioned 20cm away from the tip of the blunted 23g1 syringe needle. The polymer solutions were dispensed at a rate of 0.2mL/hr as a voltage of 8.5kV was applied using a high voltage source purchased from Gamma High Voltage (Ormond Beach, FL, USA) for 3 hours. Morphology of the resultant fiber mats were observed with a scanning electron microscope.

Results: *Soft Lithography:* The successful fabrication of patterned PDMS collector substrates was verified with optical profilometry, **Figure 1**. Surface topography features consisting of 50, 100, 200, and 500µm grids were fabricated using soft lithography. Each grid pattern had raised grid lines approximately 20µm wide and 12µm high. The profilometer images also show consistent height among several features with little to no visible difference in height or width of the grid lines.

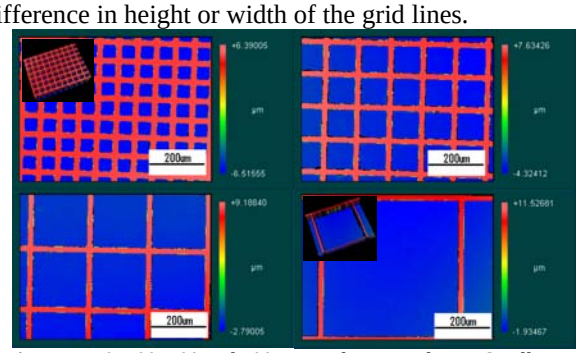

Figure 1: 50, 100, 200 and 500 µm grid patterned PDMS collectors

Electrospinning: Successful patterning of electrospun PEsU fibers was verified with scanning electron microscopy, **Figure 2.** Evidence suggests that the Electrospun PEsU fibers mimic raised topography features on the collector substrate placed in front of the standard ground. Electrospun PEUU fibers however, were found to have no patterning effect thus showing that this phenomenon is potentially material specific.

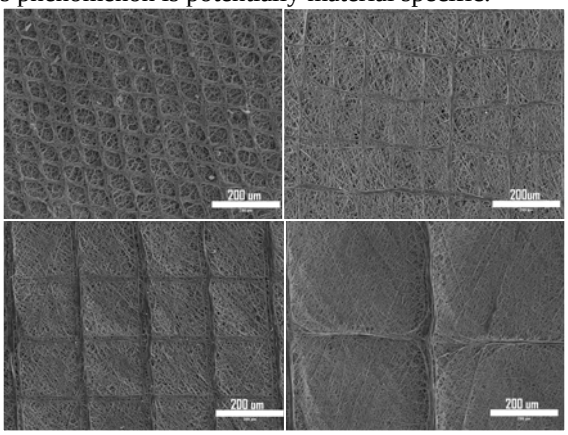

Figure 2: Resultant 50, 100, 200 and 500 µm fiber grid patterns

Conclusions: We have successfully demonstrated a novel technique to pattern electrospun PEsU fibers. This technique is of particular interest in vascular tissue engineering due to its ability to potentially allow more control over compliance of the scaffold as well as the degradation profile and cell-scaffold interaction. Further investigation of the effect of fiber patterning on mechanical properties, degradation rate, and cellular alignment is currently in progress.

Acknowledgements:
The authors would like to acknowledge the technical assistance provided by Dr. Arum Han and his student, Chiwan Koo. DSM-PTG acknowledges Bezwada Biomedical LLC for supplying diisocyanate used in synthesis of bioresorbable PEsU.

Reference:

[1] Xia Y. Annu. Rev. Mater. Sci. 1998; 28: 153-184